Computers in Human Behavior 94 (2019) 25–34

Contents lists available at ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

Full length article

Electronic Performance Monitoring and sustained attention: Social facilitation for modern applications

Victoria L. Claypoole*, James L. Szalma

University of Central Florida, Department of Psychology, Orlando, FL, USA

ARTICLE INFO

Keywords:
Vigilance
Video-based monitoring
Performance
Social facilitation

ABSTRACT

Electronic Performance Monitoring, or EPM, has been described as the use of electronic systems to monitor and evaluate performance. Research on the effects of EPM has indicated that electronic monitoring may improve employee productivity and performance. However, most of the prior research has utilized computer-based electronic presence to examine the effects of EPM on short-duration, clerical-based tasks. Relatively little is known about how EPM can affect longer-duration sustained attention tasks, like vigilance. The present study was comprised of two experiments that sought to examine the effects of EPM on sustained attention and to provide further evidence that video-based monitoring can be an effective form of EPM. A total of 197 participants (106 in experiment one and 91 in experiment two) completed a 24-minute cognitive-based vigilance task. The results indicated that not only could EPM improve sustained attention, but also that video-based electronic presence was an effective implementation of EPM. However, the results also indicated that the most robust performance effects were associated with employing two forms of video-based electronic presence simultaneously rather than individually. Theoretical implications and practical applications are further discussed.

Technology is a central component of scientific and social expansion (Kiran, 2012). Although the term 'technology' refers to applying general scientific knowledge for all sorts of practical purposes, it has recently become synonymous with electronic systems (Tenner, 2004). As the ubiquity of technology has increased (Claypoole, Schroeder, & Mishler, 2016), and therefore the use of electronic systems has increased, it is unsurprising that many organizations utilize these systems to monitor their employees' work performance (Aiello & Kolb, 1995). In fact, the most recent report from the American Management Association (AMA) and the ePolicy Institute (2007) indicated that up to 70% of surveyed organizations used some form of electronic monitoring to manage employee productivity. Note that an updated version of this survey was conducted in 2015, but the results of this survey were not published at the time of the current publication.

Electronic Performance Monitoring, or EPM, has been characterized as the use of electronic systems to monitor (or to evaluate) performance (Aiello & Kolb, 1995; Kolb & Aiello, 1997); EPM has been employed in industrial organizations and empirically investigated since the late 1980s (Cahill & Landsbergis, 1989; Chalykoff & Kochan, 1989; U.S. Congress, 1987). Research on the effects of EPM has indicated that electronic monitoring may improve employee productivity and performance (Aiello & Chomiak, 1992; Aiello & Kolb, 1995; Griffith, 1993). However, there has also been substantial empirical evidence that suggests that EPM may actually impair, rather than improve, human performance (Aiello & Svec, 1993; Douthitt & Aiello, 2001; Hall & Henningsen, 2008; Mallo, Nordstrom, Bartels, & Traxler, 2008). For instance, Davidson and Henderson (2000) demonstrated that participants solved more simple anagrams, but fewer complex anagrams, while being monitored by a computer icon relative to participants who completed the anagram solving task alone. This novel experiment demonstrated that EPM could lead to either improved or impaired performance, but that these performance effects were dependent on the level of task difficulty (Davidson & Henderson, 2000). These performance results have been best explained by a social facilitation framework (Aiello & Douthitt, 2001; Cottrell, 1972; Zajonc, 1965), which suggests that the social presence of another person influences human performance and that the direction of these performance effects is moderated by task difficulty (Bond & Titus, 1983).

Social facilitation has been characterized by two main effects: 1) performance is more likely to be improved when in the presence of another person if the task is easy, or well-known, and 2) performance is more likely to be impaired when in the presence of another person if the task is complex, or unfamiliar (Bond & Titus, 1983; Cottrell, 1972; Zajonc, 1965). Research on social facilitation has consistently demonstrated this inverse relationship between performance and task difficulty (Bond & Titus, 1983; Feinberg & Aiello, 2006; Grant & Dajee,

* Corresponding author. The University of Central Florida, Department of Psychology, Building 99, 4000 Central Florida Boulevard, Orlando, FL, 32816, USA.
E-mail address: Victoria.Claypoole@knights.ucf.edu (V.L. Claypoole).

https://doi.org/10.1016/j.chb.2019.01.001
Received 14 May 2018; Received in revised form 21 November 2018; Accepted 3 January 2019
Available online 04 January 2019
0747-5632/

2003; Rajecki, Ickes, Corcoran, & Lenerz, 1977; Huguet, Galvaing, Monteil, & Dumas, 1999; Rittle & Bernard, 1976; Schmitt, Gilovich, Goore, & Joseph, 1986; Shaver & Liebling, 1976; Miller, Hurkman, Robinson, & Feinberg, 1979, cf Claypoole & Szalma, 2018a, b), especially when the type of social presence is evaluative is nature (Bray & Sugarman, 1980; Cohen, 1980; Cohen & Davis, 1973; Cottrell, Rittle, & Wack, 1967; Cottrell, Wack, Sekerak, & Rittle, 1968). In fact, Cottrell's (1972) evaluation apprehension theory, a predominant theory of social facilitation, explicitly argues that social presence must contain an evaluative context in order to affect human performance.

In regards to EPM, previous research has demonstrated that electronic monitoring produces performance patterns consistent with the effects of human monitoring traditionally found in social facilitation research (Aiello & Douthitt, 2001; Aiello & Svec, 1993; Douthitt & Aiello, 2001; Reither, Hegel, Wrede, & Horstman, 2012; Park & Catrambone, 2007). For instance, Aiello and Svec (1993) demonstrated that performance on a complex task was substantially impaired for subjects who were monitored by either a person or an electronic presence when compared to subjects who completed the complex task alone. Additionally, these effects have been extended to include social robots that contain anthropomorphic features (i.e., Reither, Hegel, Wrede, & Horstmann, 2012) as well as virtual humans (Park & Catrambone, 2007). For instance, Park and Catrambone (2007) demonstrated that the effects of EPM (as implemented by a virtual human) were similar to the effects of human social presence, such that participants completed a series of cognitive tasks (i.e., anagram, maze, arithmetic) faster when in the presence of another person or electronic presence (i.e., virtual human) relative to participants who completed these tasks alone. The results indicated no significant differences between participants who were monitored by another person or by the electronic presence, further suggesting that EPM and human social presence may produce equivalent effects. Thus, theories of social facilitation, especially Cottrell's (1972) theory of evaluation apprehension, may best explain the effects produced by EPM.

1. Limitations of the previous work

While previous research has demonstrated performance effects consistent with the overarching social facilitation research, some aspects of EPM are still unclear. For instance, EPM is traditionally operationalized as the presence of either an on-screen computer icon (i.e., Davidson & Henderson, 2000), or through computer-based monitoring (i.e., keystrokes, Aiello & Kolb, 1995). While EPM has also been employed through an on-screen virtual human (i.e., Park & Catrambone, 2007), and a social robot (i.e., Reither et al., 2012), it has rarely been operationalized as video-based monitoring, even though organizations have reported using video-monitoring to monitor and evaluate their employees' performance (American Management Association & EPolicy Institute, 2007). Given the prevalence of video-based EPM in real organizations, it is surprising that relatively little research has examined these effects. Moreover, as this form of EPM has been previously understudied, it is possible that video-based EPM results in fundamentally different performance effects relative to computer-based or robotic forms of EPM. Thus, further work is needed to explore how different conceptualizations of EPM, such as video-based monitoring, can influence task performance.

Furthermore, previous research examining the effects of EPM have used a limited range of task types. Most experiments using EPM focus either on clerical-based work, such as data-entry tasks, or anagram-solving tasks, even though the overarching literature on social facilitation provides empirical evidence for a variety of tasks, including, psychomotor, cognitive, and visual-based tasks, to name a few. Moreover, a growing body of work in social facilitation research has recently examined the effects of social presence on sustained attention, or vigilance, performance (Claypoole & Szalma, 2017, 2018a,b; Funke et al., 2016; Yu & Wu, 2015). However, previous research has not fully explored the effects of EPM on these types of applied tasks (cf Miyazaki, 2015; Putz, 1975).

Sustained attention, or vigilance, is an integral component of many everyday tasks, such as driving (Louie & Mouloua, 2017), and work-related tasks, such as medical screening (Warm, Matthews, & Parasuraman, 2009) and flight path monitoring (Hitchcock, Dember, Warm, Moroney, & See, 1999; Pigeau, Angus, O'Neill, & Mack, 1995). These tasks require operators to maintain their attention to displays for extended periods of time, and oftentimes to respond to infrequently occurring critical signals (Davies & Parasuraman, 1982; Mackworth, 1948). Previous research has indicated that performance decrements in these tasks (also known as the vigilance decrement; Davies & Parasuraman, 1982; See, Howe, Warm, & Dember, 1995) can lead to serious consequences, such as missed threats to security in baggage screening (Tiwari, Singh, & Singh, 2009). Thus, the effects of EPM should be further explored in cognitive tasks relevant to operational settings, such as sustained attention, where facilitating performance can reduce perilous consequences.

2. The present study

As previously discussed, most of the work on EPM has focused on short-duration clerical-based tasks (e.g., data-entry; Mallo et al., 2008). Thus, relatively little is known about how EPM affects longer-duration tasks, such as sustained attention, which are integral to a variety of organization tasks, such as medical screening (Warm et al., 2009). Moreover, the overarching research on the effects of EPM have rarely employed a video-based monitoring system to examine the effects of electronic presence; instead, previous research traditionally utilizes computer-based monitoring (i.e., keystroke; Aiello & Kolb, 1995). Thus, the impetus of the present study was two-fold: 1) to determine the effects of EPM on sustained attention, and 2) to provide further evidence that video-based monitoring can be an effective form of EPM. To attain this goal, two experiments are described. The first experiment sought to explore the effects of video-based EPM on sustained attention (i.e., vigilance) performance. The second experiment sought to replicate and extend the results of the first experiment by exploring the effects of two individual forms of video-based EPM on vigilance task performance. Combined, the results of these two experiments provide further evidence for the effectiveness of different forms of video-based EPM and for the use of EPM to facilitate sustained attention.

3. Experiment 1

As previously discussed, EPM has rarely been examined in the context of sustained attention despite the growing body of research pertaining to the effects of social facilitation on vigilance task performance (i.e., Claypoole & Szalma, 2017, 2018a,b; Funke et al., 2016; Yu & Wu, 2015). Thus, the purpose for the present experiment was to determine whether typical social facilitation effects (i.e., improved performance) could be observed when utilizing electronic presence on a sustained attention (i.e., vigilance) task.

4. Method

4.1. Participants

Performance data from 106 participants (65 female) were collected. The average age for participants was 20.57 (SD = 3.39, $Range$ = 18–37). All participants were undergraduates recruited through a psychology experiment website at a large university in the southeastern United States. All participation was voluntary, though participants did receive course credit for completing the study. Importantly, all collected data were de-identified and all participant responses were private, and anonymous. Informed consent was obtained from each participant and this research complied with the

American Psychological Association Code of Ethics which was approved by the Institutional Review Board at the host university where the data were collected. At the conclusion of the study, all participants were debriefed and were provided the opportunity to ask any questions about the experiment.

4.2. Conditions

The present experiment was comprised of two conditions: *Control* and *Electronic Presence*. The *Control* condition contained no form of social presence throughout any part of the experiment (i.e., demographics survey; sustained attention task) and was used as a comparison group (Claypoole & Szalma, 2017). In this condition, each participant completed the entire experiment completely alone in an experimental room without the video camera or web-cam.

In the *Electronic Presence* condition there were two forms of electronic presence, a webcam and a video recorder. The webcam was placed on top of the computer screen and was used to "monitor the participant's performance and engagement while they completed the task", as explicitly stated to the participants. The video recorder was placed on a tri-pod, approximately 110 cm tall, one meter behind the participant at a 45-degree angle (Claypoole & Szalma, 2017; Putz, 1975) and was used to "record the participant's performance so that it could be evaluated later", as explicitly stated to the participants. These two forms of electronic presence were used in conjunction to elicit the feelings of evaluation and self-presentation described in the prominent theories of social facilitation (e.g., Baumeister, 1982; Cottrell, 1972). Both forms of electronic presence illuminated a light and presented a cue – either auditory (i.e., video recorder) or visual (i.e., webcam) – when they were engaged in monitoring the participant; these cues were utilized to increase the saliency of the electronic monitoring and to increase participants awareness of being monitored (Aiello & Douthitt, 2001). Fig. 1 provides a pictorial representation of the configuration of the electronic monitoring in the experimental room.

4.3. Experimental task

The experimental task was adapted from previous research on social facilitation and sustained attention (Claypoole & Szalma, 2018a; see also Warm et al., 1984). Participants were required to monitor a computer display of two-digit numbers. They were instructed to respond when a critical signal appeared on the computer screen. A critical signal was defined as any two-digit number that resulted in a difference of "0" or +/− "1". For example, "43", "77", and "01" were all critical signals whereas "73", "06", and "39" were not. Each stimulus was presented for 1000 ms and was followed by an interstimulus interval (ISI; a blank screen) that lasted 1500 ms. Participants were instructed to respond to critical signals by pressing the spacebar on a standard keyboard. Participants were able to respond at any time during the 1000 ms that the stimulus was on the screen or during the ISI. In the 24-minute task, there were five critical signals presented in each six-minute period on watch, for a total of 20 critical signals across the four periods. The timing of the presentations of the five critical signals was randomized during each period, but the selected times were held constant across participants.

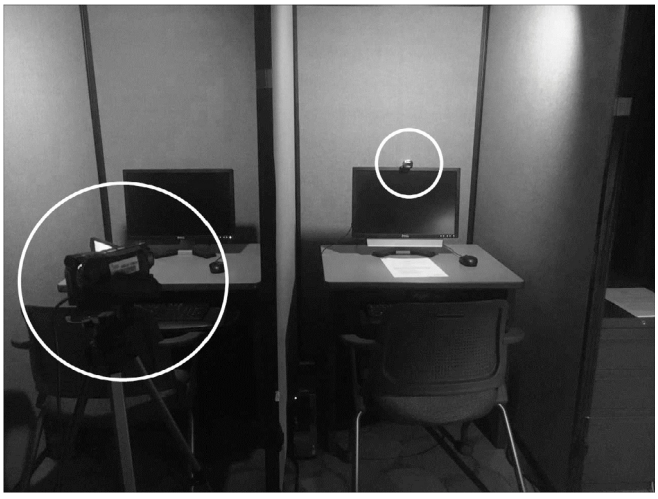

Fig. 1. Pictorial representation of the experimental set-up. Note the illumination on both the webcam (right) and the video recorder (left), outlined in white.

4.4. Procedure

The current procedure was adapted from previous research examining the effects of social presence on vigilance task performance (i.e., Claypoole & Szalma, 2017, 2018a,b). All participants registered for the experiment through the university-sponsored research participation website at the host university where the data were collected. When participants arrived to the research laboratory, they were asked to present their study confirmation code and to surrender any watches and cellular devices, consistent with previous research in sustained attention. Participants were randomly assigned to one of two experimental conditions; importantly, participants were not aware of which condition they were assigned.

In both experimental conditions, participants completed a brief demographics questionnaire prior to the sustained attention task and the electronic presence manipulations (if they were assigned to that condition). Following the completion of the demographics questionnaire, a research assistant reviewed the task instructions, presented example stimuli, and offered the opportunity to answer questions before exiting the room to allow the participants to complete a brief 3-minute practice session and the 24-minute sustained attention (i.e., vigilance) task. At the conclusion of the vigil, the research assistant re-entered the experimental room to fully debrief the participants about the nature of the experiment and to answer any final questions the participants may have had. The duration of the experiment lasted no longer than one hour.

Note that in the *Electronic Presence* condition additional instructions about the use of the electronic presence were provided. Specifically, participants were told that "the experiment employs electronic presence to monitor your performance. The webcam, located on the top of the computer screen, sends a live video feed into the office next door so that your performance and engagement can be evaluated while you complete the task. Additionally, the video recorder located behind you, is used to record your performance so that we may evaluate it later". Note that no participant took issue with being electronically monitored and none withdrew from the study. Importantly, the present experiment did not actually record or live stream participants during the experiment.

5. Results

Univariate Analyses of Variance (ANOVA) were computed for each dependent measure of interest, which included correct detections, false alarms, and response time. Performance was analyzed by a 2 (condition) by 4 (period) mixed ANOVA, with repeated measures on the second factor. There were 106 participants across both conditions: *Control* (53, 35 female); *Electronic Presence* (53, 30 female).

5.1. Correct detections

The proportion of correct detections significantly decreased across both conditions as a function of period on watch, $F(3, 312) = 39.869$, $p < .001$, $\eta 2p = .277$ (see Fig. 2), which is consistent with previous research on sustained attention (i.e., the vigilance decrement, Warm, Parasuraman, & Matthews, 2008). There was also a main effect of

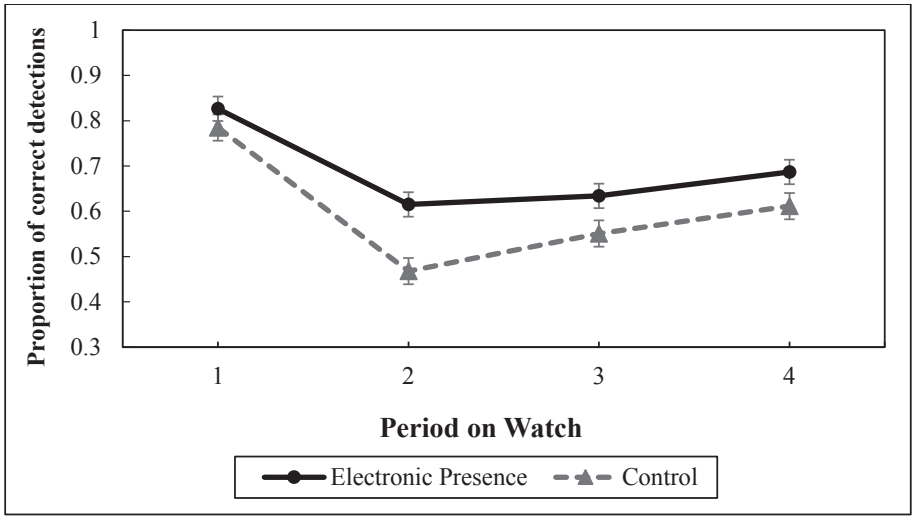

Fig. 2. The proportion of correct detections as a function of period on watch and experimental condition. *Note*. Error bars are standard errors.

Table 1
A comparison of the overall proportion of correct detections, overall proportion of false alarms, and overall median response time in milliseconds across Experiments One and Two.

	Experiment One (N = 106)				Experiment Two (N = 91)					
	Electronic Presence (N = 53)		Control (N = 53)		WCP (N = 30)		VRP (N = 30)		Control (N = 31)	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Correct Detections	.6906	.20	.6038	.21	.6300	.14	.6033	.16	.5274	.18
False Alarms	.0059	.01	.0201	.05	.0244	.06	.0185	.03	.0175	.04
Response Times	767.34	67.41	802.02	75.67	792.67	57.88	788.88	51.54	777.97	60.94

Note. VRP = Video-Recorder Presence; WCP = Webcam Presence.

condition for the overall proportion of correct detections, $F(1, 104) = 4.624$, $p = .034$, $\eta 2p = .034$ (see Table 1), such that participants who were monitored by the electronic presence detected significantly more critical signals ($M = 0.6906$, $SD = 0.20$) when compared to those who completed the task alone ($M = 0.6038$, $SD = 0.21$, $d = 0.42$). The interaction between condition and period on watch was not statistically significant ($p = .220$, $\eta 2p = .014$).

5.2. False alarms

The proportion of false alarms decreased significantly across both experimental conditions as a function of period on watch, $F(3, 312) = 5.445$, $p = .001$, $\eta^2p = .050$ (see Fig. 3), which is consistent with previous research on sustained attention (i.e., Warm et al., 2008) and previous iterations of this task (i.e., Claypoole & Szalma, 2018a). There was also a main effect of condition for the overall proportion of false alarms, $F(1, 104) = 4.932$, $p = .029$, $\eta^2p = .045$ (see Table 1), such that participants who were monitored by the electronic presence committed significantly fewer false alarms ($M = 0.0059$, $SD = 0.0082$) than those who completed the task alone ($M = 0.0201$, $SD = 0.0464$, $d = 0.43$). The interaction between condition and period on watch was not statistically significant ($p = .116$, $\eta 2p = .019$).

5.3. Response time

Median response time increased significantly across both experimental conditions as a function of period on watch, $F(3, 288) = 50.062$, $p < .01$, $\eta^2p = .343$ (see Fig. 4), which is consistent with previous research on sustained attention (i.e., the vigilance decrement, Warm et al., 2008), and previous iterations of this task (i.e., Claypoole & Szalma, 2018a). The results also indicated a significant difference between conditions for overall median response time, $F(1, 105) = 6.209$, $p = .014$, $\eta^2p = .056$ (see Table 1), such that participants who were monitored by the electronic presence were faster to respond to critical signals ($M = 767.34$, $SD = 67.41$) than those who completed the task alone ($M = 802.03$, $SD = 75.67$, $d = 0.48$). The interaction between condition and period on watch was not statistically significant ($p = .194$, $\eta 2p = .016$).

6. Experiment one discussion

Although recent research in the intersection of social facilitation and sustained attention has reported that social presence can improve detection performance in vigilance tasks (Claypoole & Szalma, 2017, 2018a,b; Funke et al., 2016; Yu & Wu, 2015), these empirical investigations have yet to extend the classification of "social presence" to electronic presence (or Electronic Performance Monitoring, EPM, but see Miyazaki, 2015; Putz, 1975). Thus, the purpose for the present experiment was to determine if traditional social facilitation effects could be observed when employing electronic presence in place of human social presence.

Consistent with previous research (i.e., Claypoole & Szalma, 2017; 2018a, b), these results suggest that social facilitation, and by extension EPM, can be employed to improve performance on sustained attention tasks that are cognitively demanding, yet boring (Scerbo, 2001). The results demonstrated robust effects, such that electronic presence was associated with increased correct detections, a reduction in errors of commission, and faster response times. Interestingly, the present experiment produced performance effects that were stronger than those previously observed in the literature. For example, Claypoole and Szalma (2017) reported that an evaluative presence reduced false alarms rates, but impaired response time and did not influence correct

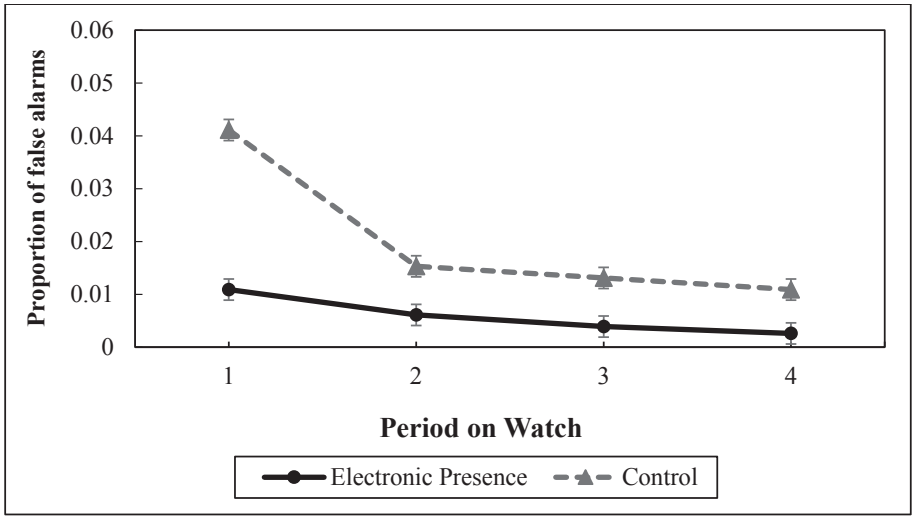

Fig. 3. The proportion of false alarms as a function of period on watch and experimental condition. *Note.* Error bars are standard errors.

detections. Conversely, another study reported that social facilitation (in this case, the presence of co-actors) only improved correct detection rates; co-actors did not affect false alarms or response times (Funke et al., 2016). The discrepancy between the present experiment and the previous research for the observed performance effects may be an artifact of the limited number of previous studies that have explored the effects of social facilitation on sustained attention. However, it is also likely that the type of social presence (i.e., evaluative, co-actor, EPM) used to facilitate performance in sustained attention tasks may produce distinct patterns of effects across dependent variables, though further research would be needed to support this claim. Importantly, although robust performance effects were observed for the overall dependent measures of interest, the vigilance decrement (i.e., a decline in performance over time) was not attenuated. Thus, although electronic presence led to more correct detections, fewer false alarms, and faster response times when compared to no social presence, the decrement was observed in both conditions.

The present experiment also demonstrated that video-based monitoring could be used as a method of electronic presence that yields results similar to those observed with other forms of EPM. As video-based EPM is a relatively less intrusive form of social presence (at least compared to visually distracting on-screen icons), this finding could help extend the usage of EPM from primarily clerical domains to domains that are either not computer-based (e.g., medical screenings) or are unable to use on-screen icons (e.g., flight path monitoring). However, the present study utilized two forms of EPM to ensure the saliency and awareness of the electronic presence (Aiello & Douthitt, 2001) – a web-cam that was described as currently evaluating performance and a video-recorder that was described as evaluating performance in the future. As there is virtually no prior research that has examined these two forms of social presence either simultaneously or independently, it may be the case that either *one* of the forms of EPM (i.e., webcam or video-recorder) produced the robust performance effects reported in the present study, *or*, that both forms of EPM are necessary to increase saliency and awareness, which in-turn led to the robust performance effects. Thus, further research is needed to determine whether these two forms of video-based EPM produce similar effects. Therefore, a second experiment was conducted to determine the extent to which webcam-based monitoring and video-recorder-based monitoring individually affect sustained attention performance.

7. Experiment 2

Experiment one established that electronic social presence can produce effects that are similar to traditional social presence, i.e., vigilance task performance was facilitated. However, the first experiment

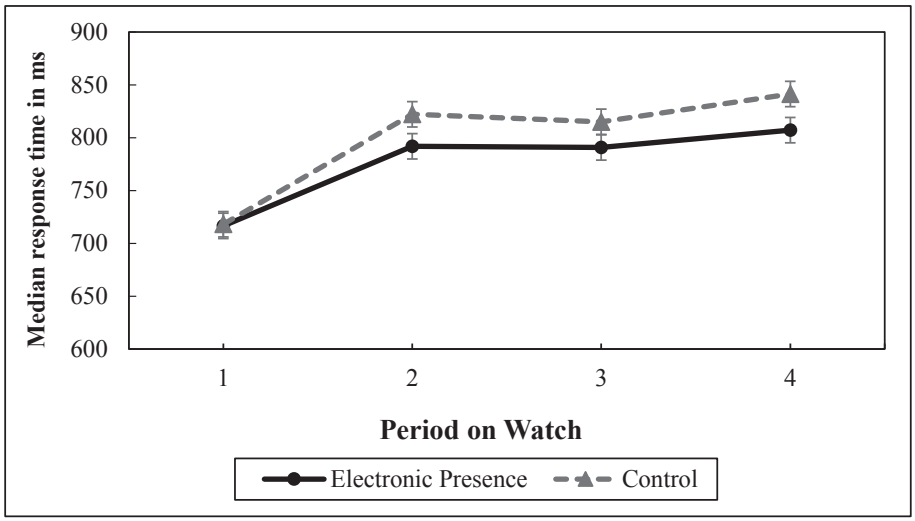

Fig. 4. Median response time in milliseconds as a function of period on watch and experimental condition. *Note.* Error bars are standard errors.

examined two forms of electronic presence simultaneously to assess the effects of EPM on sustained attention performance. From the first experiment, it is unclear whether both forms of video-based electronic presence facilitate performance or if the observed results were an artifact of increased saliency and awareness (i.e., Aiello & Douthitt, 2001). Thus, the purpose of the present experiment was to replicate the results reported in experiment one, and to extend these results by independently employing the forms of electronic presence previously outlined. By individually examining both of the implementations of electronic presence described in the first experiment, the present experiment will determine if several forms of video-based electronic presence can produce the previously observed results, or whether both forms of electronic presence must be used congruently to produce equivalent effects. The experimental task stimuli, measures, and procedure were identical to those of experiment one.

8. Method

8.1. Participants

In total, performance data from 91 participants (61 female) were collected. Average age for participants was 18.86 (*SD* = 3.55), with a range from 18 to 40 years. All participants were undergraduates recruited through a psychology experiment website at a large university in the southeastern United States. All participation was voluntary; though participants did receive course credit for completing the study. Identical to the first experiment, all collected data were de-identified and all participant responses were private and anonymous. Informed consent was obtained from each observer and this research complied with the American Psychological Association Code of Ethics which was approved by the Institutional Review Board at the host university where the data was collected. At the conclusion of the study, all participants were debriefed and were provided the opportunity to ask any questions about the experiment.

8.2. Conditions

The present experiment employed three conditions: *Control*, *Web-Cam Presence*, and *Video-Recorder Presence*. Identical to experiment one, the *Control* condition contained no form of social presence throughout any part of the experiment (i.e., demographics survey; sustained attention task) and was used as a comparison group (Claypoole & Szalma, 2017). In this condition, each participant completed the entire experiment completely alone in an experimental room.

Both the *Web-Cam Presence* and *Video-Recorder Presence* were used to examine the effects of two forms of video-based EPM. In the *Web-Cam Presence* condition, a webcam was placed on top of the computer screen and was used to “monitor the participant's performance and engagement while they completed the task”, as explicitly stated to the participants. Participants were told that the webcam sent a live feed into the office next door so that the experimenter could monitor their performance while they completed the task. In the *Video-Recorder Presence* condition, a video recorder was placed on a tri-pod, approximately 110 cm tall, one meter behind the participant at a 45-degree angle (Claypoole & Szalma, 2017) and was used to “record the participant's performance so that it could be evaluated later”, as explicitly stated to the participants. Note that the implementation of the *Web-Cam Presence*, and *Video-Recorder Presence* were identical to the *EPM* condition used in Experiment One, except that the two forms of EPM were used individually instead of contiguously.

Both forms of electronic presence illuminated a light and presented a cue – either auditory (i.e., video recorder) or visual (i.e., webcam) – when they were engaged in monitoring the participant; these cues were utilized to increase the saliency of the electronic monitoring and to increase participants awareness of being monitored (Aiello & Douthitt, 2001). Importantly, previous research has demonstrated that the placement of electronic presence relative to the participant (i.e., placing it in form vs. behind the participant) does not moderate performance effects (i.e., Putz, 1975). Thus, any performance differences found between the EPM conditions should not be attributed as an artifact of equipment placement.

9. Results

Univariate Analyses of Variance (ANOVAs) were computed for each dependent measure of interest (i.e., correct detections, false alarms, and response time). Performance was analyzed by a 3 (condition) by 4 (period) mixed ANOVA, with repeated measures on the second factor, followed by LSD pairwise comparisons where appropriate. There were 91 participants across all three conditions: *Control* (31, 20 female); *Video-Recorder Presence* (30, 20 female); and *Web-Cam Presence* (30, 21 female).

9.1. Correct detections

The proportion of correct detections significantly decreased across all three conditions as a function of period on watch, $F(3, 264) = 25.554$, $p < .001$, $\eta 2p = .225$ (see Fig. 5), a finding which is

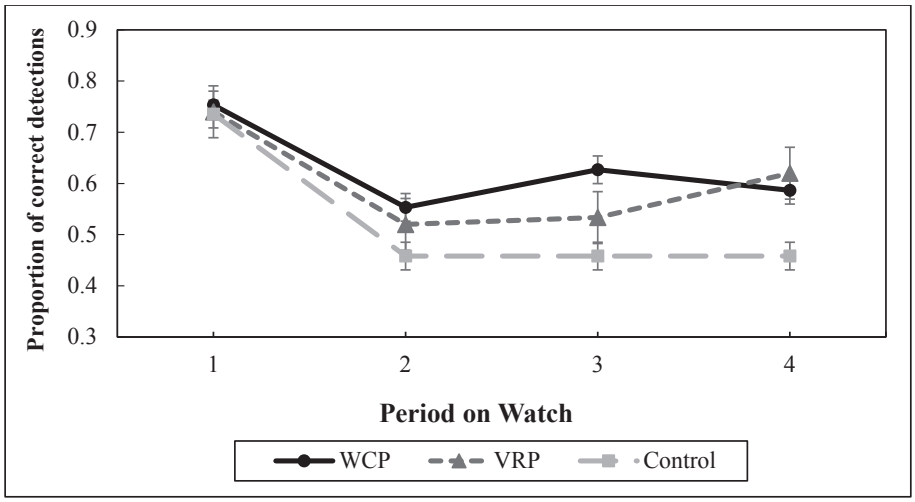

Fig. 5. The proportion of correct detections as a function of period on watch and experimental condition. *Note*. Error bars are standard errors. VRP = Video-Recorder Presence; WCP = Webcam Presence.

consistent with experiment one and the previous research on sustained attention (i.e., Warm et al., 2008). The interaction between condition and period on watch was not statistically significant ($p = .210$, $\eta 2p = .031$).

The results indicated that there was also a main effect of condition for the proportion of correct detections, $F(2, 88) = 3.280$, $p = .042$, $\eta 2p = .069$ (see Fig. 5b). Post-hoc analyses indicated that there was a significant difference between the *Web-Cam Presence* condition ($M = 0.6300$, $SD = 0.145$) and the *Control* Condition ($M = 0.5274$, $SD = 0.184$, $p = .016$, $d = 0.62$), and a trending difference between the *Video-Recorder Presence* condition ($M = 0.6033$, $SD = 0.155$) and the *Control* Condition ($p = .072$, $d = 0.44$). Interestingly, there were no significant differences between participants who were monitored by a webcam or a video-recorder, ($p = .527$, $d = 0.18$). As the reported effect sizes were not trivial, this suggests that both forms of EPM were able to improve correct detection performance, but importantly, there were no substantial differences in two implementations of electronic presence, which suggests that distinct forms of video-based EPM can produce similar effects.

9.2. False alarms

The proportion of false alarms decreased significantly across all three experimental conditions as a function of period on watch, $F(3, 264) = 7.099$, $p < .001$, $\eta^2p = .075$, which is consistent with the first experiment. The interaction between condition and period on watch was not statistically significant ($p = .385$, $\eta 2p = .024$), and the results indicated no significant differences across conditions in the overall proportion of false alarms, $F(2, 88) = 0.178$, $p = .838$, $\eta^2p = .004$. These results suggest that while false alarms declined as a function of period on watch, a common trend in the overarching vigilance literature (Warm et al., 2008), participants who were monitored by some form of electronic presence exhibited error rates similar to those who completed the task alone.

9.3. Response time

Median response time increased significantly across all three experimental conditions as a function of period on watch, $F(3, 234) = 32.725$, $p < .01$, $\eta^2p = .296$, which is consistent with experiment one and the previous research on sustained attention (i.e., Warm et al., 2008). The results indicated no significant differences across conditions in the median response time, $F(2, 78) = 0.975$, $p = .382$, $\eta^2p = .024$, suggesting that participants who were monitored by some form of electronic presence responded to critical signals at a similar speed as those who completed the task alone. The interaction between condition and period on watch was not statistically significant ($p = .213$, $\eta 2p = .035$). Table 2 provides a comparison of the performance results observed across both experiments.

10. Experiment two discussion

While the first experiment demonstrated that electronic presence could be used to facilitate vigilance performance, it left the question as to whether this finding was an artifact of using multiple forms of electronic presence. Thus, the purpose for the second experiment was twofold: 1) to replicate the observed results of the first experiment by demonstrating that electronic presence can facilitate sustained attention, and 2) to extend the results of the first experiment by examining the individual effects of distinct forms of video-based electronic presence on vigilance task performance.

The result of the present experiment partially replicated the results of experiment one. The electronic presence of both a webcam and a video-recorder were associated with the facilitation of detection performance in a cognitive vigilance task. However, only correct detections were increased as a result of the electronic presence, unlike the first experiment which demonstrated that electronic presence could also improve false alarm rates and response times. These findings suggest that two forms of electronic presence that are employed simultaneously may lead to more robust performance effects relative to the use of a singular form of electronic presence. Moreover, consistent with the first experiment and previous research on vigilance (i.e., Warm et al., 2008), traditional performance decrements were observed – correct detections declined and response times increased as a function of time. Thus, as in the first experiment, although electronic presence was unable to fully attenuate the vigilance decrement, correct detection rates were still improved relative to no social intervention, regardless of the type of video-based EPM.

These novel findings provide support to the postulation that electronic presence can produce similar performance effects relative to traditional social presence paradigms within the context of sustained attention. However, as the current research on the effects of social presence on vigilance task performance are limited at best, future work should seek to compare electronic presence and human social presence in sustained attention paradigms. This new avenue of research can provide evidence to determine if electronic presence could be used as a replacement in real-world vigilance tasks where physical human presence may be intrusive, such as military operations (McBride, Merullo, Johnson, Banderet, & Robinson, 2007).

11. General discussion

Electronic performance monitoring, or EPM, has been described as the use of technology to facilitate organizational work performance (Aiello & Kolb, 1995), which has become increasingly more common in a variety of occupational settings (American Management Association & EPolicy Institute, 2007). Interestingly, the previous research examining the effects of electronic presence have demonstrated that EPM can improve performance when tasks are relatively easy (e.g., data-entry, Aiello & Chomiak, 1992) or impair performance when tasks are relatively difficult (i.e., problem solving, Davidson & Henderson, 2000). These findings are consistent with the theoretical approaches of social facilitation (i.e., Bond & Titus, 1983; Cottrell, 1972; Zajonc, 1965), which have been argued to best explain the effects of EPM (Aiello & Douthitt, 2001).

Unfortunately, the majority of research examining EPM has focused on computer-based monitoring of clerical-type tasks, and has failed to extensively examine the effects of video-based monitoring of tasks that require sustained attention (e.g., x-ray screening, Tiwari et al., 2009). Therefore, the impetus of the present set of experiments was to

Table 2
A comparison of the performance effects associated with electronic presence (webcam and video-recorder) across both experimental conditions.

	Experiment One (N = 106)	Experiment Two (N = 91)
Correct Detections	When implemented simultaneously, two forms of electronic presence improved overall correct detections.	Each form of electronic presence individually improved overall correct detections, but there were no performance differences between the two forms of electronic presence.
False Alarms	When implemented simultaneously, two forms of electronic presence were associated with a reduction in overall false alarms.	Neither form of electronic presence individually affected overall false alarms.
Response Time	When implemented simultaneously, two forms of electronic presence were associated with faster response times.	Neither form of electronic presence individually affected overall response times.

determine the extent to which electronic presence could facilitate sustained attention and if the characterization of electronic presence could be extended to include types of video-based presence, such as webcams.

Across two experiments, video-based EPM resulted in improved detection performance overall. Importantly, all participants experienced a similar decline in detection performance over time (i.e., the decrement). Thus, these results suggest that participants who were monitored by video-based EPM achieved better detection performance overall relative to participates who completed the vigil alone, and that participants did not become insensitive to the EPM presence as performance did not suffer to a greater degree in later watch periods. In fact, there was a slight (but non-significant) uptick in correct detection performance in the second experiment for participants in the experimental conditions, which may suggest that these participants became more sensitive to the electronic presence over time. Practically, these results indicate that EPM is suitable for long-duration use, but future work should extend these results in a longitudinal design.

Experiment one, which utilized two forms of video-based electronic presence, was associated with the most robust effects on vigilance task performance. Specifically, correct detections, false alarms, and response times were facilitated. Experiment two, which *compared* the two forms of video-based electronic presence that were introduced in experiment one, only resulted in improved performance for correct detections, *not* for false alarms or response times. So, while improved performance was observed across both experiments, these effects were not equivalent; employing two forms of EPM simultaneously resulted in better overall performance than utilizing either form of EPM individually.

It is unclear, from the present results, why employing two forms of electronic presence led to better overall performance rather than utilizing either form of electronic presence individually. One possible explanation is that two forms of technology increased the saliency and awareness of the electronic presence (Aiello & Douthitt, 2001), which therefore resulted in better overall performance. However, another possible explanation resides in the perception of the evaluation and the moderating effects of individual differences. In experiment two, the two forms of social facilitation were described as two separate, unique functions. For instance, the webcam was explained to be used to monitor the participants' performance and engagement *while they completed the task*, while the video-recorder was explained to be used to record the participants' performance so it could be coded and *evaluated later*. Thus, this distinction between present evaluation and future evaluation may have led to different perceptions of the electronic presence and resulted in a moderating effect of individual differences. Put simply, it may be that individuals respond differently to the temporal properties of presence, such that the connotation of “future evaluation” affects different individuals to a higher (or lower) degree than the connotation of “present evaluation”, which then does not individually produce robust affects as compared to employing both types of temporal properties. While previous research has demonstrated that intermittent monitoring produces effects similar to those of continuous monitoring (i.e., Bergum & Lehr, 1963, Brewer, 1995; Griffith, 1993; Reither et al., 2012), the effects of the temporal properties of evaluation have not been examined, especially as an individual differences variable.

Additionally, it is also possible that the temporal properties of the evaluation interacted with other known individual differences factors, such as extraversion or intrinsic motivation (Kolb & Aiello, 1996; Uziel, 2006), to produce a moderating effect on social presence. Perhaps individuals higher in extraversion, for example, may be more concerned with a present-based evaluation, whereas individuals with higher self-esteem, are affected more by a future-based evaluation. However, this is pure speculation, and future research should investigate how individual differences moderate social facilitation effects.

11.1. Theoretical implications

As previously discussed, theoretical explanations of social facilitation are argued to encompass the effects of employing electronic presence (Aiello & Douthitt, 2001). Importantly, predominant theories of social facilitation, including the mere presence hypothesis (Zajonc, 1965) and evaluation apprehension (Cottrell, 1972), posit that the *emission of dominant responses* (otherwise commonly referred to as ‘performance’ in the literature) are facilitated by social presence on tasks that are easy or familiar. This theoretical proposition was evident in experiment two, which demonstrated that only correct detections were affected by the electronic presence. Conversely, the theories of social facilitation do not account for the reduction of errors (i.e., false alarms) or decreased response times, as these performance metrics are not classified as ‘dominant responses’. Thus, the predominant theories of social facilitation, and by extension EPM, do not explain the robust performance effects observed in the first experiment. Perhaps simultaneously employing two forms of electronic presence results in performance effects that are more robust than previous theories of social facilitation have been able to account for. Toward this point, it has been argued that the current theories of social facilitation should be expanded to include performance effects outside of the *emission of dominant responses* (Claypoole & Szalma, 2017, 2018a,b; Glaser, 1982). Based on the first experiment presented in this article, it is clear that ‘presence’ can also influence errors of commission and response times to target detections, which should be taken into consideration in future refinements of social facilitation theories.

12. Conclusion

Research examining the effects of electronic presence (or EPM) have largely failed to include applied organizational tasks, such as sustained attention (or vigilance). As sustained attention is an integral component of organizational sectors that require continuous high levels of performance, such as military surveillance (McBride et al., 2007), TSA airport baggage screenings (Tiwari et al., 2009), cockpit monitoring by pilots (Satchell, 1993), anesthesiology (Weinger & Englund, 1990), and electrocardiogram monitoring (Gill, 1996), current research would be remiss to not include an examination of EPM effects on such tasks. Thus, the present study reports the results of two experiment that each demonstrated the extent electronic presence could improve vigilance task performance. Both experiments demonstrated that distinct forms of electronic presence could facilitate performance, but employing two forms of EPM simultaneously lead to the most robust effects on overall performance. Moreover, the present study extended the characterization of ‘electronic presence’ to include video-based presence as opposed to the traditionally employed computer-based presence. This distinction may help improve the implementation of monitoring systems in organizational contexts where computer-based presence (i.e., computer icons) and human-based presence may be intrusive, such as in military operations (McBride et al., 2007), or impractical, such as in cockpit monitoring by pilots (Satchell, 1993).

Although the present study provides a significant contribution to the intersection of social presence and sustained attention, more work in needed to clarify the observed effects. For instance, based on the present results, it is unclear whether the robust effects in the first experiment were an artifact of saliency (i.e., Aiello & Douthitt, 2001) or a moderation of the temporal properties of the electronic presence. Thus, it would be prudent to conduct an analysis on the perception of the electronic presence to determine whether saliency, awareness, or the temporal properties of presence moderate the facilitation of performance. Similarly, future work should seek to extend the current paradigm to include an examination several implementations of electronic presence, including video-based, computer-based and robotic presence, to determine the extent to which performance effects are moderated by EPM type.

Most importantly, future work should extend the current laboratory-based results into organizational contexts to replicate these findings. It would also be prudent for these experiments to assess the potential workload and stress imposed onto the workers to determine if EPM is a viable option for industrial performance improvement, especially as it has been previously argued that EPM may reduce employee satisfaction and feelings of control in office environments (i.e., Douthitt & Aiello, 2001; Sewell, 1998; Stanton & Barnes-Farrell, 1996). The findings of these proposed experiments could lead to a cost-effective and easily implemented solution (i.e., Claypoole & Szalma, 2017) for improving the performance of high-risk sustained attention tasks, which could ultimately lead to fewer nuclear meltdowns (Reinerman-Jones, Matthews, & Mercado, 2016) and breaches of homeland security (Hancock & Hart, 2002; Meuter & Lacherez, 2016).

Author's note

A portion of the data presented in this manuscript were from an unpublished doctoral dissertation by the first author, under the supervision of the second author.

Declarations of interest

The authors have not declarations of interest to report.

References

Aiello, J. R., & Chomiak, A. (1992). *The effects of computer monitoring and distraction on task performance.* Unpublished manuscript.

Aiello, J. R., & Douthitt, E. A. (2001). Social facilitation from Triplett to electronic performance monitoring. *Group Dynamics: Theory, Research, and Practice, 5*(3), 163–180.

Aiello, J. R., & Kolb, K. J. (1995). Electronic performance monitoring and social context: Impact on productivity and stress. *Journal of Applied Psychology, 80*(3), 339–353.

Aiello, J. R., & Svec, C. M. (1993). Computer monitoring of work performance: Extending the social facilitation framework to electronic presence. *Journal of Applied Social Psychology, 23*(7), 537–548.

American Management Association, & EPolicy Institute (2007). *2007 electronic monitoring & surveillance survey.* Retrieved January 23, 2018, from: http://www.epolicyinstitute.com/2007-survey-results.

Baumeister, R. F. (1982). A self-presentational view of social phenomena. *Psychological Bulletin, 91*, 3–26.

Bergum, B. O., & Lehr, D. J. (1963). Effects of authoritarianism on vigilance performance. *Journal of Applied Psychology, 47*, 75–77.

Bond, C. F., & Titus, L. J. (1983). Social facilitation: A meta-analysis of 241 studies. *Psychological Bulletin, 94*(2), 265–292.

Bray, R. M., & Sugarman, R. (1980). Social facilitation among interacting groups: Evidence for the evaluation-apprehension hypothesis. *Personality and Social Psychology Bulletin, 6*(1), 137–142.

Brewer, N. (1995). The effects of monitoring individual and group performance on the distribution of effort across tasks. *Journal of Applied Social Psychology, 25*(9), 760–777.

Cahill, J., & Landsbergis, P. A. (1989). Electronic monitoring: Analysis of current practices and implications for occupational stress. *Meeting of the American public health association, Chicago*.

Chalykoff, J., & Kochan, T. A. (1989). Computer-aided monitoring: Its influence on employee job satisfaction and turnover. *Personnel Psychology, 42*(4), 807–834.

Claypoole, V. L., Schroeder, B. L., & Mishler, A. D. (2016). Keeping in touch: Tactile interface design for older users. *Ergonomics in Design, 24*(1), 18–24.

Claypoole, V. L., & Szalma, J. L. (2017). Examining social facilitation in vigilance: A hit and a miss. *Ergonomics, 60*(11), 1485–1499.

Claypoole, V. L., & Szalma, J. L. (2018a). Independent coactors may improve performance and lower workload: Viewing vigilance under social facilitation. *Human Factors,* 1–11.

Claypoole, V. L., & Szalma, J. L. (2018b). Facilitating sustained attention: is mere presence sufficient? *American Journal of Psychology, 131*(3), 417–428.

Cohen, J. L. (1980). Social facilitation. *Motivation and Emotion, 4*(1), 21–34.

Cohen, J. L., & Davis, J. H. (1973). Effects of audience status, evaluation, and time of action on performance with hidden-word problems. *Journal of Personality and Social Psychology, 27*(1), 74.

Cottrell, N. B. (1972). Social facilitation. In C. G. McClintock (Ed.). *Experimental social psychology* (pp. 185–236). New York: Holt, Rinehart, & Winston.

Cottrell, N. B., Rittle, R. H., & Wack, D. L. (1967). The presence of an audience and list type (competitional or noncompetitional) as joint determinants of performance in paired- associates learning. *Journal of Personality, 35*(3), 425–434.

Cottrell, N. B., Wack, D. L., Sekerak, G. J., & Rittle, R. H. (1968). Social facilitation of dominant responses by the presence of an audience and the mere presence of others. *Journal of Personality and Social Psychology, 9*(3), 245–250.

Davidson, R., & Henderson, R. (2000). Electronic performance monitoring: A laboratory investigation of the influence of monitoring and difficulty on task performance, mood state, and self-reported stress levels. *Journal of Applied Social Psychology, 30*(5), 906–920.

Davies, D. R., & Parasuraman, R. (1982). *The psychology of vigilance.* London, UK: Academic.

Douthitt, E. A., & Aiello, J. R. (2001). The role of participation and control in the effects of computer monitoring on fairness perceptions, task satisfaction, and performance. *Journal of Applied Psychology, 86*(5), 867.

Feinberg, J. M., & Aiello, J. R. (2006). Social facilitation: A test of competing theories. *Journal of Applied Social Psychology, 36*(5), 1087–1109.

Funke, G. J., Warm, J. S., Baldwin, C. L., Garcia, A., Funke, M. E., Dillard, M. B., et al. (2016). The independence and interdependence of coacting observers in regard to performance efficiency, workload, and stress in a vigilance task. *Human Factors, 58*(6), 915–926.

Gill, G. W. (1996). Vigilance in cytoscreening: Looking without seeing. *Advance for Medical Laboratory Professionals, 8*, 14–15.

Glaser, A. N. (1982). Drive theory and social facilitation: A critical reappraisal. *British Journal of Social Psychology, 21*, 265–282.

Grant, T., & Dajee, K. (2003). Types of task, types of audience, types of actor: Interactions between mere presence and personality type in a simple mathematical task. *Personality and Individual Differences, 35*(3), 633–639.

Griffith, T. L. (1993). Monitoring and performance: A comparison of computer and supervisor monitoring. *Journal of Applied Social Psychology, 23*(7), 549–572.

Hall, B., & Henningsen, D. D. (2008). Social facilitation and human–computer interaction. *Computers in Human Behavior, 24*(6), 2965–2971.

Hancock, P. A., & Hart, S. G. (2002). Defeating terrorism: What can human factors/ergonomics offer? *Ergonomics in Design, 10*(1), 6–16.

Hitchcock, E. M., Dember, W. N., Warm, J. S., Moroney, B. W., & See, J. E. (1999). Effects of cueing and knowledge of results on workload and boredom in sustained attention. *Human Factors, 41*(3), 365–372.

Huguet, P., Galvaing, M. P., Monteil, J. M., & Dumas, F. (1999). Social presence effects in the Stroop task: Further evidence for an attentional view of social facilitation. *Journal of Personality and Social Psychology, 77*(5), 1011–1025.

Kiran, A. H. (2012). Technological presence: Actuality and potentiality in subject constitution. *Human Studies, 35*(1), 77–93.

Kolb, K. J., & Aiello, J. R. (1996). The effects of electronic performance monitoring on stress: Locus of control as a moderator variable. *Computers in Human Behavior, 12*(3), 407–423.

Kolb, K. J., & Aiello, J. R. (1997). Computer-based performance monitoring and productivity in a multiple task environment. *Journal of Business and Psychology, 12*(2), 189–204.

Louie, J. F., & Mouloua, M. (2017). Executive attention as a predictor of distracted driving performance. *Proceedings of the human factors and ergonomics society annual meeting: Vol. 61*, (pp. 1436–1440). Sage CA: Los Angeles, CA: SAGE Publications No. 1.

Mackworth, N. H. (1948). The breakdown of vigilance during prolonged visual search. *Quarterly Journal of Experimental Psychology, 1*(1), 6–21.

Mallo, J., Nordstrom, C. R., Bartels, L. K., & Traxler, A. (2008). The effect of age and task difficulty. *Performance Improvement Quarterly, 20*(1), 49–63.

McBride, S. A., Merullo, D. J., Johnson, R. F., Banderet, L. F., & Robinson, R. T. (2007). Performance during a 3-hour simulated sentry duty task under varied work rates and secondary task demands. *Military Psychology, 19*, 103–117.

Meuter, R. F., & Lacherez, P. F. (2016). When and why threats go undetected: Impacts of event rate and shift length on threat detection accuracy during airport baggage screening. *Human Factors, 58*(2), 218–228.

Miller, F. G., Hurkman, M. F., Robinson, J. B., & Feinberg, R. A. (1979). Status and evaluation potential in the social facilitation and impairment of task performance. *Personality and Social Psychology Bulletin, 5*(3), 381–385.

Miyazaki, Y. (2015). Influence of being videotaped on the prevalence effect during visual search. *Frontiers in Psychology, 6*, 583.

Park, S., & Catrambone, R. (2007). Social facilitation effects of virtual humans. *Human Factors, 49*(6), 1054–1060.

Pigeau, R. A., Angus, R. G., O'Neill, P., & Mack, I. (1995). Vigilance latencies to aircraft detection among NORAD surveillance operators. *Human Factors, 37*(3), 622–634.

Putz, V. R. (1975). Effects of different modes of supervision on vigilance behaviour. *British Journal of Psychology, 66*, 157–160.

Rajecki, D. W., Ickes, W., Corcoran, C., & Lenerz, K. (1977). Social facilitation of human performance: Mere presence effects. *The Journal of Social Psychology, 102*(2), 297–310.

Reinerman-Jones, L., Matthews, G., & Mercado, J. E. (2016). Detection tasks in nuclear power plant operation: Vigilance decrement and physiological workload monitoring. *Safety Science, 88*, 97–107.

Reither, N., Hegel, F., Wrede, B., & Horstmann, G. (2012). Social facilitation with social robots? *7th ACM/IEEE international conference on human-robot interaction (HRI)*.

Rittle, R. H., & Bernard, N. (1976). Enhancement of response rate by the mere physical presence of the experimenter. *Personality and Social Psychology Bulletin, 3*(1), 127–130.

Satchell, P. M. (1993). *Cockpit monitoring and alerting systems.* Aldershot, Hants, England: Ashgate.

Scerbo, M. W. (2001). Stress, workload, and boredom in vigilance: A problem and an answer. In P. A. Hancock, & P. A. Desmond (Eds.). *Stress, workload, and fatigue* (pp. 267–278). Mahwah, NJ: Erlbaum.

Schmitt, B. H., Gilovich, T., Goore, N., & Joseph, L. (1986). Mere presence and social facilitation: One more time. *Journal of Experimental Social Psychology, 22*(3), 242–248.

See, J. E., Howe, S. R., Warm, J. S., & Dember, W. N. (1995). A meta-analysis of the

sensitivity decrement in vigilance. *Psychological Bulletin, 117*, 230–249.
Sewell, G. (1998). The discipline of teams: The control of team-based industrial work through electronic and peer surveillance. *Administrative Science Quarterly,* 397–428.
Shaver, P., & Liebling, B. A. (1976). Explorations in the drive theory of social facilitation. *The Journal of Social Psychology, 99*(2), 259–271.
Stanton, J. M., & Barnes-Farrell, J. L. (1996). Effects of electronic performance monitoring on personal control, task satisfaction, and task performance. *Journal of Applied Psychology, 81*(6), 738.
Tenner, E. (2004). *Our own devices. How technology remakes humanity.* New York: Vintage Books.
Tiwari, T., Singh, A. L., & Singh, I. L. (2009). Task demand and workload: Effects on vigilance performance and stress. *Journal of the Indian Academy of Applied Psychology, 35*(2), 265–275.
U.S. Congress, Office of Technology Assessment (1987). *The electronic supervisor: New technology, new tensions. (OTA-CIT-333).* Washington, DC: U.S. Government Printing Office.
Uziel, L. (2006). Individual differences in the social facilitation effect: A review and meta-analysis. *Journal of Research in Personality,* 579–601.
Warm, J. S., Howe, S. R., Fishbein, H. D., Dember, W. N., & Sprague, R. L. (1984). Cognitive demand and the vigilance decrement. *Trends in Ergonomics/Human Factors I,* 15–20.
Warm, J. S., Matthews, G., & Parasuraman, R. (2009). Cerebral hemodynamics and vigilance performance. *Military Psychology, 21*.
Warm, J. S., Parasuraman, R., & Matthews, G. (2008). Vigilance requires hard mental work and is stressful. *Human Factors, 50*, 433–441.
Weinger, M. B., & Englund, C. E. (1990). Ergonomics and human factors affecting anesthetic vigilance and monitoring performance in the operating room environment. *Anesthesiology, 73*, 995–1021.
Yu, R., & Wu, X. (2015). Working alone or in the presence of others: Exploring social facilitation in baggage X-ray security screening tasks. *Ergonomics, 58*(6), 857–865.
Zajonc, R. B. (1965). Social facilitation. *Science, 149*, 269–274.