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Examining social facilitation in vigilance: a hit and a miss

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ABSTRACT
Vigilance is the ability of an observer to maintain attention for extended periods of time; however, performance tends to decline with time on watch, a pattern referred to as the vigilance decrement. Previous research has focused on factors that attenuate the decrement; however, one factor rarely studied is the effect of social facilitation. The purpose for the present investigation was to determine how different types of social presence affected the performance, workload and stress of vigilance. It was hypothesised that the presence of a supervisory figure would increase overall performance, but may occur at the cost of increased workload and stress. Results indicated that the per cent of false alarm and response times decreased in the presence of a supervisory figure. Using social facilitation in vigilance tasks may thus have positive, as well as, negative effects depending on the dependent measure of interest and the role of the observer.

Practitioner Summary: Social facilitation has rarely been examined in the context of vigilance, even though it may improve performance. Vigilance task performance was examined under social presence. The results of the present study indicated that false alarms and response times decreased in the social presence of a supervisory figure, thus improving performance.

Vigilance is the capacity of an observer to maintain attention to a display or an environment over long, uninterrupted time periods and to respond to critical events when they occur (Mackworth 1948). Vigilance tasks are deceptively simple (Scerbo 1998), but previous research has established that detection ability declines with time on watch, a trend referred to as the vigilance decrement (Frankmann and Adams 1962; Warm 1984; See et al. 1995). Simply put, people are more likely to fail to detect important events or to make errors in response due to the prolonged nature of monitoring tasks. As described by Scerbo (2001), vigilance tasks are highly monotonous and usually presented in an uninteresting, 'homogenous' environment. Essentially, vigilance tasks are often cognitively demanding and yet they are also boring. This presents a significant challenge for operational settings that require observers to maintain high detection rates throughout a work shift. For example, TSA agents are more likely to miss targets the longer they are on watch without break (Tiwari, Singh, and Singh 2009), and in a recent TSA check, agents missed 95% of targets (CNN 2015). However, other organisational settings that utilise vigilance and benefit from the subsequent research include military surveillance (McBride et al. 2007), air traffic control (Proctor and Van Zandt 1994), cockpit monitoring by pilots (Satchell 1993), naval navigation (Mackworth 1948), transportation (Dorrian et al. 2007), anaesthesiology (Weinger and Englund 1990) and electrocardiogram monitoring (Gill 1996).

The vigilance decrement is the most pervasive finding across vigilance research (Fraulini et al. 2017). Many factors have been associated with the vigilance decrement. For example, task difficulty, time pressure (eg high event rate), arousal/alertness and task load have each been found to affect the magnitude of the performance decrement (Parasuraman, Warm, and Dember 1987; Warm, Parasuraman, and Matthews 2008; Szalma 2009, 2011; Tiwari, Singh, and Singh 2009). Performance decrements in vigilance are often accompanied by high levels of perceived workload and stress (Hart 2006). One widely used instrument for measuring perceived workload is the NASA-Task Load Index (NASA-TLX; Hart and Staveland 1988; Hart 2006). The NASA-TLX provides an index of overall (global) workload, as well as, ratings on six specific sources of workload that reflect perceptions of task demands (mental, physical, temporal) and perception of the participant regarding their own response to those demands (performance, effort and frustration; Hart and Staveland 1988). It has been established that vigilance tasks are generally associated with high global workload load scores, with the mental demand and frustration scales of the TLX being...
the primary contributors to workload in vigilance (Warm, Dember, and Hancock 1996).

There are also many studies indicating that vigilance is stressful, based on evidence from both physiological and self-report measures. In recent research, self-reports of stress in vigilance have been measured using the Dundee Stress State Questionnaire (DSSQ; Matthews et al. 2002, 2013). The DSSQ is comprised of 11 scales that reflect the cognitive, affective and motivational/energetic dimensions of stress (Matthews et al. 1999, 2002, 2013). These scales comprise three broad secondary factors: task engagement, distress and worry. Task engagement reflects the cognitive and motivational components of stress, and it is associated with the core relational theme of commitment of effort; distress is a measure of the cognitive and affective aspects of stress and it indicates the core relational theme of overload of cognitive capacity; worry reflects the cognitive dimension, and it is associated with the core relational theme of item of self-evaluation (Matthews et al. 2002, 2013). Several vigilance experiments have revealed a consistent pattern of stress response, such that pre–post task engagement declines and distress increases (Szalma et al. 2004). In addition, observer task engagement correlates with better performance on a demanding vigilance task (Helton, Matthews, and Warm 2009), which is consistent with the contention that engagement may be an indicator for mental resource availability (Reinerman et al. 2006; Matthews et al. 2011). It was recently argued that compulsion to engage in a vigilance activity might influence performance and stress more than previously believed (Hancock 2013). The decline in task engagement observed across multiple studies suggests that motivation declines during the vigil (Szalma et al. 2004). In addition, given that task engagement can predict vigilance performance (eg Dember et al. 1984; Dember, Galinsky, and Warm 1992; Helton, Matthews, and Warm 2009), the presence of other people may be one way to offset the pre–post vigil decline in task engagement and to improve performance. Furthermore, a modern issue of concern associated with vigil performance is being able to effectively improve performance; organisations look for cost effective solutions that are easily implemented. While the social presence of another person has demonstrated the potential to improve performance, organisations may find it potentially easy to implement and relatively cost-effective. Of course, any economic benefit largely depends on what organisations deem to be ‘cost-effective’ (ie the cost associated with performance failures).

Social facilitation

The paradigm of social facilitation accounts for the influence of social presence on task performance (Aiello and Douthitt 2001). Social facilitation effects occur when the presence of others leads to improved performance on simple or well-learned tasks but also leads to impaired performance on complex or unfamiliar tasks (Cottrell 1972; Bond and Titus 1983). This effect was first observed over a century ago when Triplett (1898) discovered that cyclists pedalled faster when they were racing against another person (Uziel 2007). Since its inception, this paradigm has extended into many domains of psychology (for a review see: Geen and Gange 1977; Bond and Titus 1983). Research on social facilitation is diverse with respect to the tasks investigated, which include video game play (Bowman et al. 2013), competitive motor tasks (Snyder, Anderson-Hanley, and Arciero 2012) and cognitive operational tasks (Huguet et al. 1999).

The most commonly accepted theory on social facilitation is Zajonc’s Drive Theory. Zajonc (1965) argued that arousal increases in the presence of other individuals (mere presence), and that high arousal increases the emission of dominant responses. If the correct responses are dominant, then social presence improves performance; but performance will be impaired if the correct responses are non-dominant (recessive), such as is typically the case for more complex tasks. However, it has been argued that the mere presence of others is insufficient to improve task performance, and as such, the presence of others must elicit a cognitive state of evaluation apprehension. This state of evaluation leads to an improvement in task performance (Cottrell 1972). Essentially, Cottrell argued that an evaluative context rather than a mere social presence of another person is necessary for the strengthening of dominant responses that affect performance. While these two theories are the most dominant in the literature, other theories have also been postulated to account for the performance effects found in social facilitation (for a review see: Aiello and Douthitt 2001).

Social facilitation and vigilance task performance

There are a limited number of studies that have investigated social facilitation and vigilance, but previous research has shown that the presence and behaviour of an experimenter can influence performance of attentionally demanding tasks (Sipowicz, Ware, and Baker 1962; Bergum and Lehr 1963; Ware, Kowal, and Baker 1964). For instance, use of a democratic (expansive and permissive) experimenter was associated with higher levels of performance when compared to participants who experienced an autocratic experimenter (Ware, Kowal, and Baker 1964). In earlier research, Fraser (1953) found that the mere presence of the experimenter improved the task performance in a visual search task. Bergum and Lehr (1963) extended this manipulation to a vigilance task and found that when
the presence of an authority figure was aperiodic and unpredictable, performance (ie percentage of correct detections) was better than when compared to participants who performed the vigil alone. Putz (1975) demonstrated that when compared to a condition with no supervision, participants performed significantly better under experimenter observation on a Mackworth-type vigilance task. More recently, Yu and Wu (2015) reported that on a simple target-present baggage screening vigilance task, the mere presence of the experimenter was associated with faster response times compared to a condition in which participants were not monitored. However, on a complex target-present baggage screening vigilance task, the mere presence of the experimenter was associated with slower response times compared to a condition in which participants were not monitored, consistent with typical social facilitation effects.

These studies are not without limitations, which include specific social presence relationships, confounding operationalisations and varying indices of performance. Fraser (1953) and Bergum and Lehr (1963) each used military personnel as participants, which may not be representative of individuals in the civilian workforce. Further, because military personnel were used as participants, their commanding officers were also used as the authoritative figures. This would likely result in a very different relationship between the authority figure and the participant than one might find in typical civilian and operational settings.

Although the results of Yu and Wu’s (2015) experiment indicated social facilitation, they operationalised ‘mere presence’ as the experimenter directly observing the participant as they performed the task, which could have evaluation tendencies leading to an evaluation apprehension approach instead of a mere presence approach as the authors report. Putz (1975) operationalised his authority figure as the experimenter directly observing the participant while they performed the task. The inconsistencies in the authority figure and ‘mere presence’ operationalisations complicate comparisons across studies or the generalisation of results to the multiple work contexts that require vigilance.

In addition to problems in operational definitions, there is a large discrepancy across studies in the type of performance affected by social presence. Bergum and Lehr (1963) measured the mean percentage of correct detections, while Putz (1975) measured the percentage of signals missed and Yu and Wu (2015) measured the response time needed to make a correct detection. Although technically percentage of correct detections and percentage of signals missed are essentially the same, it is interesting that no analyses of signal detection theory were utilised to determine shifts in response bias or sensitivity. The differences between the types of performance measured also causes difficulties in generalisations to more applied settings (ie actual organisational use). Furthermore, none of these studies reported that social presence attenuated the vigilance decrement. Even when the presence of a supervisor increased task performance when compared to those who completed the task alone (Bergum and Lehr 1963), there will still a significant decrement in performance over time.

The present study

The present study sought to extend the knowledge of social presence on vigilance performance, and examined how the presence of a person in a supervisory role affects vigilance. While the term ‘supervisor’ may be a subjective construct, Amsler, Findley, and Ingram (2013) provide a clearly defined list of supervisory roles and how to implement them. According to Amsler, Findley, and Ingram (2013), a supervisor has certain key objectives: (i) to ensure the task is performed as required, (ii) to motivate subordinates to work at maximum capacity and (iii) to provide supervision. These objectives can each be manipulated in a laboratory setting. Amsler, Findley, and Ingram (2013) also recommend supervisor-monitoring techniques for supervision of performance: Direct observation, inspection of work in progress and completed work and checklists. Again, these techniques can be implemented in a laboratory setting.

The present study is primarily concerned with how individuals respond to the presence of others who are in an authoritative role. The purpose of this experiment is to replicate and extend previous results (eg Bergum and Lehr 1963; Putz 1975) on the effects of supervisory presence on vigilance. Note that most of these experiments were conducted over 50 years ago. Social constructs are continuously changing, and a social construct that was measured several decades ago may not have the same effects in the current population (Cronbach 1975). In addition, previous vigilance studies involving social presence measured performance but neglected the evaluation of perceived workload and stress. The present study measures these variables to determine whether the observed performance benefits of social presence occur at the cognitive and energetic costs of higher workload and stress. Moreover, we include multiple indices of performance (ie proportion of hit, false alarms, signal detection measures and response time) so that the results may be compared across other studies. In essence, the purpose of this study was to re-examine social facilitation effects of vigilance.

It was hypothesised that relative to the control condition in which no observer was present, participants who were under some type of observation would achieve higher performance (ie more signals detected, fewer false
alarms and/or faster response times). It was also hypothesised that participants, who were under some form of observation, would experience higher perceived workload and stress when compared to those assigned to the control condition. In line with Cottrell’s (1972) theory of evaluation apprehension, it was expected that individuals who were monitored by a supervisor would have superior performance when compared to those in the mere presence of an observer. Again, it was expected that this would occur in conjunction with higher perceived workload and stress.

**Method**

**Participants**

In total, performance data from 164 participants (119 female) were collected. The minimum number of needed participants was determined by power analyses conducted via G*Power 3.1.9.2 (Faul et al. 2007). Based on the parameters (ie power = 0.80), the minimum number of needed participants equalled 102. Participants were undergraduates recruited through the SONA Psychology Experiment Website at a large university in the south-eastern Unites States. The proportion of gender was representative of the overall gender proportion at the university where the data were collected. All participation was on a voluntary basis; however, participants did receive extra credit for their college courses for completing the study. Mean age for participants was 19.56 (SD = 3.04), with a range from 18 to 41 years. Participants were assigned at random to one of three experimental conditions. Random assignment was determined using a random number generator. The random number generator assigned each condition a number. Then these numbers were randomly selected to determine the sequence of assignment of participants to the experimental condition, with the constraint that there be an equal number of conditions present. The participants were then assigned in the randomised order.

**Design**

There were three experimental conditions in this study: **Supervisor Present, Observer Present and No Observer Present (Control)**. In all three conditions, the participants were introduced to the assistant and the supervisor in the same manner. The only difference between conditions was in how the supervisor and the assistant interacted with the participants.

In the first condition, the initial researcher (a 19–21-year-old Caucasian female), who assumed the role of an assistant, introduced the participant to the supervisor, who was a 19–21-year-old Caucasian male and also one of the researchers on the project. To ensure that the supervisor was perceived as legitimate, a specialised script was performed for each participant that emphasised the supervisor having a position of authority. In addition, the supervisor also wore professional business attire (ie dress pants, button-up collared shirt and tie) and carried a clipboard to appear as if he were taking notes and completing a checklist about the participant per the Amsler, Findley, and Ingram (2013) recommendations. The participants were also explicitly told that the experimenter was their supervisor for the study and would be monitoring their performance throughout the task. The supervisor then sat 1 metre behind the participant at an approximately 45-degree angle and directly observed and monitored the participant’s performance using the aforementioned clipboard while the participant completed the vigilance task (similar to the experimental procedures of Putz 1975). While the supervisor did display monitoring behaviour and was evaluative throughout the vigil, the supervisor also assumed a passive role in that he did not actively interfere with the participant’s behaviour nor did he provide the participant with feedback.

In the second condition, the initial researcher, again acting as an assistant, introduced the male researcher as the supervisor. In this condition, the supervisor was introduced in the same manner as in the first condition. However, the supervisor was not present during the experiment. Instead, the initial researcher (ie the assistant) acted as an observer and remained in the room while the participant completed the vigilance task (similar to the experimental procedures of Kidd and Christy 1961). This observer acted in a passive manner (ie did not monitor, evaluate or communicate with the participant during the vigil), and was merely present in the room. Therefore, in this condition there was no direct monitoring of the participant as there was in the supervisor condition. The observer condition served to control for the effects of the mere presence of an observer during the vigil.

In the third condition, the initial researcher introduced the participant to the supervisor; however, neither the initial researcher; nor the supervisor remained present during the completion of the vigilance task (Kidd and Christy 1961; Bergum and Lehr 1963; Putz 1975). This condition served as a control, as there was no social presence during vigil completion.

**Stimuli**

The stimuli used in the present experiment are based on those used by Szalma (2011). Participants were shown examples to familiarise them with the stimuli to be presented during the task. In the vigil, there were two types of stimuli: a critical signal (Figure 1a) and a neutral event (Figure 1b). A critical signal was defined as any stimulus...
NASA-TLX was used, in which participants first provided ratings on a scale of 0–100 on each of the six subscales and then completed a paired-comparison procedure to determine the relative importance of the subscales as contributions to the individual’s experience of workload. These weights were used to compute global workload; a weighted average of the six subscales.

**Dundee Stress State Questionnaire**
Perceived stress was measured using the DSSQ (Matthews et al. 2002, 2013). The DSSQ is comprised of 11 scales that reflect the cognitive, affective and motivational/energetic dimensions of stress (Matthews et al. 1999, 2002, 2013). These 11 scales comprise 3 broad secondary factors: task engagement, distress and worry. The pre-task version was administered prior to the vigil, and the post-test version was completed after the vigil.

**State Trait Anxiety Index**
The State-Trait Anxiety Inventory (STAI; Spielberger 1989) is a psychological inventory designed to measure both stable trait anxiety, as well as, transient state anxiety. The STAI is comprised of 40 items, and participants respond to each item using a four-point Likert-type rating scale. Higher scores indicate higher levels of state or trait anxiety.

**Attitudes Towards Supervisors Inventory**
This inventory was developed by the researchers to measure participants’ perceptions of the supervisor, as well as their attitudes and feelings about being monitored during the experiment. Questions included items such as ‘I felt the supervisor was monitoring me while I completed the task’.

**Procedure**
Upon arrival to the laboratory, participants were asked by the researchers to show their student identification and to remove any timepieces and cellular devices. Participants were assigned at random to one of three conditions, each of which included a script for the researchers to follow. In all of the conditions, participants completed three questionnaires (pre-task DSSQ, Trait Anxiety STAI, and demographics questionnaires) prior to the supervisor/observer manipulation. The order of presentation of questionnaires before the vigil was as follows: Demographics, pre-task DSSQ and Trait STAI. After the questionnaires were completed, the supervisor/observer manipulation was implemented. Example stimuli were presented and a five-minute block of practice trials was completed to familiarise participants with the task. The 24-min vigilance task began immediately after the practice block.

After the vigilance task was concluded, the participant completed post-task questionnaires to assess perceived...
workload, stress, attitudes towards the supervisor, state-anxiety and self-reported views of task. The order of presentation of questionnaires after the vigil was as follows: Attitudes towards supervisor, post-task DSSQ, State STAI and the NASA-TLX.

Results

Univariate analyses of variance were computed for each dependent measure, followed by pairwise comparisons where appropriate. There were 164 participants across each of the three conditions, Supervisor Present, Observer Present and No Observer Present (Control), with 54 (44 female), 56 (40 female) and 54 (35 female) participants in each condition, respectively.

Descriptive statistics

In sum, 55% of the participants in the Supervisor Present condition indicated that they felt that the supervisor was actively monitoring them throughout the experiment, while 45% did not feel like they were being actively monitored. Likewise, 55% of participants in the Observer Present condition indicated that they did not feel as if the observer was monitoring them throughout the vigil; this is evidence that there was little feeling of evaluation apprehension in the Observer Present condition. Interestingly, 45% of those in the control group felt as if they were being monitored in some way, although there were no observers present in that condition.

Note that participants were only classified as feeling as though they were being monitored (Supervisor condition) if they selected ‘Strongly Agree’ (5) on a five-point Likert scale when asked to select their level of agreement to the following statement: ‘I felt as if the supervisor was watching me while I performed the task’. Likewise, participants were only classified as feeling as though they were not being monitored (for the Observer and Control conditions) if they selected ‘Strongly Disagree’ (1) when asked to select their level of agreement to the following statement: ‘I felt as if the assistant [the word “assistant” was changed to “someone” for the control condition] was watching me while I performed the task’. Although these criteria are somewhat strict, it provides the allowance of a more rigorous manipulation check.

Performance indices

Performance was measured via the proportion of hits, the proportion of false alarms, and response time to correct detections. In addition, signal detection measures of sensitivity and response bias were also computed. As expected, performance changes over time on watch were observed in terms of proportion of signals detected, proportion of false alarms and response times. The proportion of signals detected decreased significantly across all three conditions as a function of period on watch, $F(3, 483) = 3.95, p = 0.008, \eta^2_p = 0.024$. In addition, the proportion of false alarms also decreased significantly across all three conditions as a function of period on watch, $F(3, 483) = 8.55, p < 0.001, \eta^2_p = 0.050$. Median response time increased significantly across all three conditions as a function of period on watch, $F(3, 477) = 5.726, p = 0.001, \eta^2_p = 0.035$. However, the results indicated no statistically significant difference among conditions in the proportion of signals detected [$F(2, 161) = 0.100, p = 0.904, \eta^2_p = 0.001$], the proportion of false alarms emitted [$F(2, 161) = 0.255, p = 0.775, \eta^2_p = 0.003$] or for response times [$F(2, 161) = 0.154, p = 0.857, \eta^2_p = 0.002$].

The proportion of correct detection and false alarms were used to compute non-parametric indices of sensitivity ($A^1$) and response bias ($\beta$) (Macmillan and Creelman 2005). Sensitivity did not change significantly as a function of period on watch, $F(3, 483) = 0.053, p = 0.984, \eta^2_p < 0.001$, or across the three conditions, $F(2, 161) = 0.257, p = 0.773, \eta^2_p = 0.003$. Thus, participants in the Supervisor condition were not significantly more sensitive than those in either the Observer or Control conditions. There was a significant increase in response bias as a function of period on watch across all three conditions $F(3, 483) = 19.995, p < 0.001, \eta^2_p = 0.110$, indicating that conservativism increased with period on watch. However, there were no significant differences between conditions for response bias, $F(2, 161) = 0.321, p = 0.726, \eta^2_p = 0.004$.

Perceived workload, stress and anxiety

The results indicated that the Supervisor condition was associated with the highest level of global workload, although it was not statistically significant from the other two conditions. In addition, there were no significant differences between conditions on any of the six subscales. However, the results indicated that the scores on the Temporal Demand subscale approached significance between conditions, $F(2, 160) = 1.853, p = 0.163, \eta^2_p = 0.023$, with post hoc analyses indicating that Temporal Demand was higher in the Supervisor condition when compared to both the Observer and Control conditions ($p = 0.116, d = 0.32$ and $p = 0.086, d = 0.31$, respectively), although these results are not significant, effect sizes are not trivial.

The DSSQ assesses levels of task engagement, distress and worry. A statistically significant effect of condition was observed for task engagement $F(2, 159) = 3.329, p = 0.038, \eta^2_p = 0.040$. Participants in the Supervisor condition reported higher levels of pre–post task engagement than those in the Control condition ($p = 0.024, d = 0.44$).
Likewise, participants in the Observer condition reported higher levels of pre–post task engagement than those in the Control condition ($p = 0.030, d = 0.42$). However, there was no significant difference between the Supervisor and Observer conditions ($p = 0.921, d = 0.02$). There were no significant differences between conditions in distress or worry, although across all three conditions there were significant differences in the pre–post vigil change scores of distress, $t(161) = 12.812, p < 0.001$ and worry $t(161) = -3.674, p < 0.001$. This indicates that although there were no statistically significant differences in stress as a function of the experimental condition, distress increased and worry decreased as a function of the task itself for all three groups, which is consistent with previous vigilance research (Warm, Parasuraman, and Matthews 2008). In addition to the ‘big three’ components of the DSSQ (ie task engagement, distress and worry), the 11 individual subscales that comprise the three components were also analysed. The results indicated no statistically significant differences across conditions on any of the 11 subscales, $p > 0.055$ in each case.

The STAI measures both trait and state anxiety separately. There was no significant difference across conditions in trait anxiety, as expected. Participants in the Supervisor condition reported significantly higher levels of post-vigil state anxiety than those in the Observer condition ($p = 0.027, d = 0.34$) and those in the Observer condition reported significantly lower levels of state anxiety than those in the Control condition ($p = 0.046, d = -0.29$). There was not a significant difference between the Supervisor and Control conditions, and there was a small effect size ($p = 0.753, d = 0.20$). Overall, the average state anxiety across conditions was $35.42$ (SE = 0.914), which indicates a moderate level of state anxiety (Julian 2011).

**Attitudes towards supervisors and observers**

Participants were asked to rate how much the supervisor and assistant (the observer) resembled typical supervisors and assistants they had encountered in the past, and 72% indicated that the supervisors were similar to past experiences and 87% reported that the assistants were similar to past experiences. Interestingly, most participants in the Supervisor Present condition and Observer Present condition indicated that their performance was not affected in either a negative or a positive way by either having someone monitor them or a person being in the room (38 and 45%, respectively). Of participants in the Supervisor Present condition, 38% reported that they found it difficult to focus on the task while the supervisor was watching them and 43% reported that it made them feel uncomfortable. Conversely, 87% of participants in the Observer Present condition reported that they were unaffected by the presence of the observer in terms of difficulty focusing and feelings of discomfort.

**Discussion of present results**

The results indicated that, consistent with traditional vigilance research, a performance decrement was observed; the proportion of signals detected and false alarms both significantly decreased over time. False alarms also declined over time, suggesting an increase in conservatism. However, there were no significant differences on any of the performance measures as a function of the experimental condition, suggesting that the presence of another person during the vigil does not influence performance. This is in direct contrast to the major theoretical stances (Zajonc 1965; Cottrell 1972), to which we are not the first to report null results. In fact, past literature suggests that the effects of social facilitation are subject to the ‘file drawer problem’ (Bond and Titus 1983). Moreover, Manstead and Semin (1980) conducted a series of five studies where the typical performance effects from social facilitation were not found, and Glaser (1982) reports as many as 61 studies that failed to observe social facilitation effects.

However, the indicators of perceived workload were similar to those of previous vigilance research, such that global workload is high and mental demand and frustration were among the strongest contributors of workload. Perhaps the most compelling evidence of social facilitation was found for task engagement. Those in either social presence conditions reported higher levels of task engagement than those who performed the task alone, but there was no significant difference between the two social presence conditions. This indicates that a mere presence of an observer is sufficient to elicit higher levels of task engagement. Furthermore, pre-post scores of worry and distress indicated that distress increased and worry decreased as a function of the task itself for all three groups, which is consistent with typical findings in vigilance experiments (Warm, Parasuraman, and Matthews 2008).

As expected, the results indicated that there was no significant difference among conditions in trait anxiety, indicating that the groups were statistically equivalent on the measure. However, there was a significant difference in post-vigil state anxiety such that participants being monitored by a supervisor or in the mere presence of an observer were more anxious than those that completed the task alone. Again, it was found that there was no significant difference between the two social presence conditions, indicating that the mere presence of an observer may be sufficient to induce anxiety.

Overall, our hypotheses were supported in terms of perceived workload and stress, but the results indicated that performance was not affected by the presence of...
another person. Social presence did affect workload, task engagement and state anxiety. One possible reason our performance hypotheses were not supported may have been because of variation across participants in the effectiveness of the social manipulation. To address this issue, we analysed a subset of the sample that included only those participants for whom the manipulation was successful. The second sample only included participants who selected ‘Strongly Agree’ (Supervisor condition) or ‘Strongly Disagree’ (Observer and Control conditions) on a five-point Likert-type scale that assessed if the participants felt like they were being monitored throughout the experiment. For example, if a participant was in the Control condition and they selected either ‘somewhat disagree’ (2) or ‘neither agree or disagree’ (3) when asked if they felt like they were being monitored throughout the experiment, they were then classified as feeling some sort of observation and therefore not included in the second analysis.

Results for subset of sample

In all three conditions, Supervisor Present, Observer Present and No Observer Present (Control), there were a total of 89 participants with 29 (24 female), 30 (25 female) and 30 (19 female) participants in each condition, respectively. Average age for participants was 19.54 (SD = 3.45), with a range from 18 to 41 years.

Performance indices

The proportion of signals detected did not significantly decrease across all three conditions as a function of period on watch, $F(3, 258) = 1.898, p = 0.130$, indicating the absence of a performance decrement. The results indicated no statistically significant difference among conditions in the proportion of signals detected ($p > 0.1$ in each case; the means and standard errors can be found in Table 1).

Proportion of false alarms decreased significantly across all three conditions as a function of period on watch, $F(3, 258) = 11.677, p < 0.001$ (see Figure 2). There was also a significant difference across conditions in the proportion of false alarms, $F(2, 88) = 4.247, p = 0.017$. Post hoc analyses indicated that those in the Supervisor condition and Observer condition were significantly slower than those in the Control condition ($p = 0.008, d = 0.66$ and $p = 0.027, d = 0.53$, respectively). Again, there were no significant differences in the median response times between those in the Supervisor condition and Observer condition ($p = 0.619, d = 0.17$).

The proportion of correct detection and false alarms were used to compute non-parametric indices of sensitivity ($A’$) and response bias ($B’$) (see et al. 1995). Sensitivity did not change across all three conditions as a function of period on watch, as illustrated in Figure 3, $F(3, 258) = 1.499, p = 0.215$. However, there was a significant difference across conditions in sensitivity, $F(2, 88) = 8.203, p = 0.001$. Post hoc analyses indicated that those in the Supervisor condition and Observer condition were significantly more sensitive than those in the Control condition ($p < 0.001, d = 0.42$ and $p = 0.004, d = 0.22$, respectively). Again, there were no significant differences in the sensitivity scores across conditions.

Table 1. Means and standard errors of proportion of signals detected across conditions ($N = 89$).

<table>
<thead>
<tr>
<th>Condition</th>
<th>Period 1 $M$ (SE)</th>
<th>Period 2 $M$ (SE)</th>
<th>Period 3 $M$ (SE)</th>
<th>Period 4 $M$ (SE)</th>
<th>Overall $M$ (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supervisor ($N = 29$)</td>
<td>0.7011 (0.028)</td>
<td>0.6322 (0.041)</td>
<td>0.6523 (0.033)</td>
<td>0.6523 (0.033)</td>
<td>0.6595 (0.027)</td>
</tr>
<tr>
<td>Observer ($N = 30$)</td>
<td>0.6750 (0.042)</td>
<td>0.6250 (0.037)</td>
<td>0.6222 (0.036)</td>
<td>0.6167 (0.042)</td>
<td>0.6347 (0.031)</td>
</tr>
<tr>
<td>Control ($N = 30$)</td>
<td>0.6417 (0.038)</td>
<td>0.6222 (0.037)</td>
<td>0.6250 (0.0366)</td>
<td>0.6361 (0.043)</td>
<td>0.6313 (0.030)</td>
</tr>
<tr>
<td>Total ($N = 89$)</td>
<td>0.6723 (0.021)</td>
<td>0.6264 (0.022)</td>
<td>0.6330 (0.020)</td>
<td>0.6348 (0.023)</td>
<td>0.6416 (0.017)</td>
</tr>
</tbody>
</table>

Figure 2. Proportion of false alarm rates by period on watch across conditions.
between those in the Supervisor condition and Observer condition ($p = 0.370, d = 0.31$).

There was a significant increase in conservatism as a function of period on watch across all three conditions, which is illustrated in Figure 4, $F(3, 258) = 12.862, p < 0.001$. There were also significant differences in response bias across conditions, $F(2, 88) = 16.654, p < 0.001$. Post hoc analyses indicated that participants in the Supervisor condition and Observer condition were significantly more conservative than those in the Control condition ($p < 0.001, d = 1.18$ in each case). Again, there were no significant differences in response bias between those in the Supervisor condition and Observer condition ($p = 0.863, d = 0.06$).

**Perceived workload, stress and anxiety**

Participants in the Supervisor condition reported the highest levels of global workload, although it was not statistically significant between conditions (see Table 3 for means and SEs). There was a statistically significant difference across conditions for the subscale of temporal demand $F(2, 86) = 3.736, p = 0.029$. Post hoc analyses indicated that participants in the Supervisor condition reported significantly higher levels of temporal demand than those in the Observer and Control conditions ($p = 0.040, d = 0.56$ and $p = 0.012, d = 0.61$). However, those in the Observer condition were not significantly different from participants assigned to the Control condition ($p = 0.595, d = 0.10$). There were no significant differences between conditions on the other workload subscales ($p > 0.1$ in each case).

Another significant difference across conditions was observed for the subscale of score of worry ($87) = −1.882, p < 0.001$. This indicates that although there were no statistically significant differences in stress as a function of the experimental condition, distress increased, while task engagement and worry decreased as a function of the task itself for all three groups, which is consistent with typical vigilance experiments (Warm, Parasuraman, and Matthews 2008). In addition to the ‘big three’ components of the DSSQ, the 11 individual subscales were also analysed. There were no statistically significant differences across conditions on any of the 11 subscales, $p > 0.055$ in each case.

The means and standard errors for both state and trait anxiety can be found in Table 4. As expected, there was no significant difference across conditions in trait anxiety. However, there was a statistically significant difference across conditions for state anxiety, $F(2, 86) = 4.660, p = 0.012$. Post hoc analyses indicated that those in the Observer condition had significantly lower levels of state anxiety than those in the Supervisor ($p = 0.029, d = 0.61$) and Control conditions ($p = 0.004, d = 0.77$). However, there was no significant difference between those in the Supervisor and Control conditions ($p = 0.507, d = 0.16$). Overall, the average state anxiety across conditions was
Table 3. Means and standard errors of NASA TLX across conditions (N = 89).

<table>
<thead>
<tr>
<th></th>
<th>Global Workload</th>
<th>Mental Demand</th>
<th>Physical Demand</th>
<th>Temporal Demand</th>
<th>Performance</th>
<th>Effort</th>
<th>Frustration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SE</td>
<td>M</td>
<td>SE</td>
<td>M</td>
<td>SE</td>
<td>M</td>
</tr>
<tr>
<td>Supervisor (N = 29)</td>
<td>66.36</td>
<td>3.32</td>
<td>72.24</td>
<td>4.77</td>
<td>19.31</td>
<td>3.46</td>
<td>66.21</td>
</tr>
<tr>
<td>Observer (N = 30)</td>
<td>64.77</td>
<td>3.32</td>
<td>76.00</td>
<td>4.22</td>
<td>17.33</td>
<td>2.82</td>
<td>53.33</td>
</tr>
<tr>
<td>Control (N = 30)</td>
<td>62.06</td>
<td>2.61</td>
<td>67.00</td>
<td>5.07</td>
<td>16.33</td>
<td>2.87</td>
<td>51.00</td>
</tr>
<tr>
<td>Total (N = 89)</td>
<td>64.37</td>
<td>3.08</td>
<td>71.74</td>
<td>2.71</td>
<td>17.64</td>
<td>1.75</td>
<td>56.74</td>
</tr>
</tbody>
</table>

Table 4. Means and standard errors of trait and state anxiety across conditions (N = 89).

<table>
<thead>
<tr>
<th></th>
<th>Trait anxiety</th>
<th>State anxiety</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SE</td>
</tr>
<tr>
<td>Supervisor (N = 29)</td>
<td>36.79</td>
<td>2.20</td>
</tr>
<tr>
<td>Observer (N = 30)</td>
<td>31.57</td>
<td>1.70</td>
</tr>
<tr>
<td>Control (N = 30)</td>
<td>35.67</td>
<td>2.08</td>
</tr>
<tr>
<td>Total (N = 89)</td>
<td>34.65</td>
<td>1.67</td>
</tr>
</tbody>
</table>

41.98 (SE = 1.07), which indicates a moderate-to-high level of state anxiety (Julian 2011).

Discussion of results for subset of the sample

Performance effects were observed only when the data were filtered to include those most affected by the manipulation. These results underscore the importance of including such manipulation checks as so many studies do not (see Bond and Titus 1983) and social variables can vary substantially in their effectiveness. More importantly, the data suggest that social facilitation has its strongest effects on errors of commission and response time indices of performance, but it did not affect the percentage of correct detections. This is an important distinction because the literature oftentimes fails to evaluate multiple measures of performance; instead a general ‘performance was affected’ approach is taken and the differences across types of performance are not discussed.

The proportion of signals detected was not affected by the social presence of another individual, and in addition, this subset did not yield the traditional vigilance decrement. The proportion of false alarms was affected such that participants who were in the social presence of another committed fewer errors of commission. Interestingly, there was no difference between the two social presence conditions, a result more supportive of Zajonc’s (1965) hypothesis than Cottrell’s (1972) theory of evaluation apprehension. For this measure of performance, the traditional social facilitation effects were observed. Similarly, response time was also affected by social presence, such that when in said social presence, participants were slower to respond to critical signals. Again, there were no differences between the two social presence conditions, further supporting Zajonc’s (1965) hypothesis that the mere presence of another person is sufficient to effect performance. However, the results directly conflict with previous experiments that have indicated that the social presence of another person causes participants to perform the task faster when compared to being alone (Yu and Wu 2015).

Previous research has suggested that if the presence of others is truly arousing, then some amount of stress will be experienced (Shaver and Liebling 1976). In our measures of perceived workload, stress and anxiety, this was not the case. Although participants in some form of monitoring social presence reported higher levels of workload than those who completed the task alone, the results were not significant. Furthermore, there were no differences among the three conditions on any measure of perceived stress. Interestingly, the most compelling results came in the form of self-reported anxiety. Those who performed the task alone had the highest levels of state anxiety, perhaps due to the unfamiliarity with the task, and being in a strange room alone. Moreover, those who were in the mere presence of an observer reported the lowest levels of state anxiety suggesting that having the mere presence of another person helps to lower the anxiety related to completing a task, but only to the extent that the presence is not evaluative as in the Supervisor condition (which had higher levels of state anxiety). This is supported by the finding that 38% of participants in the Supervisor condition reported that they found it difficult to focus on the task, while the supervisor was watching them and 43% reported that it made them feel uncomfortable, while 87% of participants in the Observer condition reported that they were unaffected by the presence of the observer in terms of difficulty focusing and feelings of discomfort. These findings taken together suggest that being evaluated is accompanied with anxiety and negative emotions.
General discussion

In the present study, two analyses were performed to determine the effect social facilitation had on a vigilance task. In the first analysis, the results did not conform to traditional social facilitation effects; indicating that the social presence of another individual did not improve performance. Overall, the results indicated that the proportion of signals detected was not affected by the presence of another individual, whether they be in the role of a supervisor or a non-evaluative observer. However, this could have been caused by a limitation of the task used in this study. The results indicated that there was not a traditional vigilance detection decrement associated with the task, meaning that a floor effect was possible. This possibility is supported by the low overall detection rates as the highest percentage of proportion of signals detected across any condition and period was 0.7011, which is extremely low compared to previous research using this task (Szalma 2011). Typical vigilance tasks have a starting proportion of signals detected in the range of 0.80–0.90 (Szalma 2011), which suggests a floor effect in our study. Furthermore, the study in which the stimuli were adapted from (Szalma 2011) had previously found traditional vigilance decrements, which indicates that something in the present sample was remiss (ie a floor effect). In addition, errors of commission (ie false alarms) were also not improved by the social presence of another person. The results from this first analysis indicated that social facilitation is not a mechanism in which performance on a vigilance task can be reliably improved.

However, social manipulations are oftentimes sensitive. For this reason, we included a manipulation check to ensure our social variables performed as desired. In the second analysis, only the participants for whom the manipulation was successful was included. When this subset was analysed, certain performance measures were affected by social presence. The results indicated that the strongest social facilitation effects were found for errors of commission and response time indices. Overall, the results tend to support Zajonc’s (1965) mere presence hypothesis. There were no significant differences on the measures of performance between the two social presence conditions, indicating that the mere presence of another person is sufficient to facilitate performance.

A novel component of the present investigation was the use of signal detection measures. Although there is no previous work to compare the effects of social presence on signal detection measures of vigilance tasks, the results indicated that the social presence of another person causes participants to be more sensitive and conservative in their responses. The shift is conservatism is unsurprising; previous research utilising a visual search task found that participants tend to be more conservative when in the social presence of another individual (Wolfe et al. 2007; Miyazaki 2015), to which it has also been found that the presence of another person causes criterion shifting in these tasks. Future work should replicate and extend upon this finding in the context of vigilance.

Subjective measures of workload, stress, and anxiety were also measured. Similar to traditional vigilance tasks, global workload was high and mental demand and frustration were among the strongest contributors of workload. However, there was no statistically significant differences among conditions for workload. It may be that any workload induced by the presence of another person was small relative to the level of workload induced by the task itself. In other words, social presence may not add to the workload induced by the task itself, especially since vigilance tasks are typically associated with high levels of workload (Hart 2006).

In terms of stress, task engagement was higher in the two social presence conditions than the control condition for the full analysis. Moreover, post-vigil state anxiety was higher in the two social presence conditions when compared to the control condition, such that participants being monitored by a supervisor or in the mere presence of an observer were more anxious than those that completed the task alone. Again, it was found that there was no significant difference between the two social presence conditions, indicating that the mere presence of an observer may be sufficient to induce anxiety. In the subset analysis, workload and stress were not significantly different among the experimental conditions. However, anxiety was affected. The results suggest that when compared to participants who completed the task alone, being in the mere presence of another person can lower anxiety when completing a task. However, when the social context is evaluative, anxiety is still fairly high, likely due to the negative emotions associated with being evaluated.

Overall, our hypotheses were partially supported. In the analysis of all participants, performance was not facilitated, but the social presence of another person did cause an increase in workload, task engagement and anxiety. In the subset analysis, performance was only facilitated in terms of errors of commission, indicating that participants are less likely to make a false alarm when in the presence of others. In addition, workload and stress were not affected by the social presence of another person, and anxiety was reduced when completing the task in the mere presence of another individual. This could be potentially beneficial when making a false alarm is costly and employee health is important such as in the TSA or medical radiology. Although arguably a miss is costlier than a false alarm, hits (and therefore misses) were not affected by the social
presence of another individual. If this protocol were implemented in organisations, it would have the potential to reduce false alarms without the cost of employee health.

The results of the present experiment could have further implications to organisational domains. As previously mentioned, several organisational settings utilise vigilance and will potentially benefit from the subsequent research. Organisational settings such as military surveillance (McBride et al. 2007), air traffic control (Proctor and Van Zandt 1994), cockpit monitoring by pilots (Satchell 1993), naval navigation (Mackworth 1948) and baggage screening (ie TSA agents, Tiwari, Singh, and Singh 2009) could all easily implement social monitoring into their daily tasks in order to improve performance. The social presence of others is a relatively easy and cheap method for organisations to implement in order to improve task performance, and in some cases, national security. Social presence on vigilance should be further explored and applied to organisational domains.

Vigilance and social facilitation are largely separate research literatures. Although the unitary arousal construct (Hebb 1955) has been employed in both research domains, the energetic resource perspective in vigilance (Parasuraman, Warm, and Dember 1987) has not yet been extended to social facilitation. Such theoretical integration is beyond the scope of the present work, but the cognitive resource model may be a fruitful approach to further developing social facilitation theory. The arousal induced by social presence may affect resource availability (eg increased arousal leading to greater resource availability), the allocation of these resources or a combination of both mechanisms. It may be that when performance impairment occurs, particularly in the context of complex tasks demanding large amounts of processing capacity, it is due to allocating processing resources to attending the social presence and thereby reducing the cognitive capacity available for allocation to the task (cf. Baron 1986). Future empirical effort should include investigation of the relations between arousal and the availability and allocation of processing resources to the task and the social presence.

Social facilitation has several avenues through which it can be implemented. The presence of the observer could be continuous, as in the present research, intermittent (Bergum and Lehr 1963) or through electronic means (electronic performance monitoring, Aiello and Douthitt 2001). Furthermore, the relationship (ie positive or negative, familiar or unfamiliar, peer or supervisor) between the observer and the observed has shown to potentially influence the extent of social facilitation effects (Ware, Kowal, and Baker 1964; Shaver and Liebling 1976; Claypoole, Neigel, and Szalma 2016). Moreover, the type of social presence (ie merely present, evaluative, co-acting) has also demonstrated varying effects on performance such that in certain situations a merely present observer is sufficient to induce social facilitation, while in other situations an evaluative observer is necessary to produce these effects (Bond and Titus 1983). Although these variable have not been studied simultaneously, the present research provides further evidence that the type of monitoring (ie mere presence vs. evaluative), as well as, the social role (ie peer vs. supervisor) of the observer can influence performance. Future work should explore these variables more thoroughly and a taxonomic framework of resulting performance effects should be constructed. This extension would work towards identifying how the use of social facilitation interacts with organisational constructs.

Limitations

As in most research, there were several limitations in the present experiment. The use of students, a small subset of the sample for further analysis, perceptually simple stimuli and the need to carefully the social facilitation manipulation experimentally all limit the generalisability of the results to operational settings. While it is not uncommon to use college students as the main source of participants for psychological research, there is evidence that college students approach experimental tasks differently than their organisational counterparts (Peterson 2001). However, the present results suggest that even in college students, social facilitation may improve performance on a vigilance task. Future work should examine the effects of social facilitation on vigilance in an organisational environment.

In the present experiment, the supervisor constantly sat 1 metre behind the participant. This was a necessary procedure for experimental control, albeit unrealistic for organisational contexts. In a natural organisational setting, supervisors tend to periodically monitor employees throughout a shift. Therefore, the experimental procedures found in the present experiment do not reflect a natural organisational setting and thus may not generalise to such. However, previous research has indicated that when a supervisor intermittently monitors their subject, performance is improved (Bergum and Lehr 1963). Future work should extend both results to compare continuous and intermittent monitoring.

Additionally, the stimuli utilised in the present experiment was highly impoverished and not reflection of stimuli found in operational settings. While this common, and a limitation of vigilance research in general, future work should explore the effects of social facilitation on vigilance performance using real-world stimuli in order to achieve higher external validity.

Although there are several limitations that may reduce the generalisability of the present work, the results indicate that social facilitation may improve vigilance performance. Therefore, it is suggested that future research on
these topics work to incorporate realistic designs in order to enhance external validity.

Conclusion

The present study sought to examine how the presence of a person in a supervisory role affected performance on a vigilance task. Performance in terms of the per cent of correct signals detected did not significantly differ across conditions, but errors of commission (proportion of false alarms) were significantly lower for participants in the Supervisor condition. In addition, those who were monitored responded significantly more slowly to critical signals relative to those who were alone. Future work should explore the effects of supervisory presence as a function of task difficulty. The higher response time for participants in the Supervisor condition confirmed the expectation that such presence affects the efficiency of vigilance. The smaller effect of observer presence suggests that presence of another person, per se, may not be sufficient to substantially affect performance, which is consistent with Cottrell’s (1972) evaluation apprehension approach to social facilitation.

In sum, this experiment has implications for the competing theories of social facilitation, the research surrounding it, and future applications. Future studies show include manipulation checks to ensure social manipulations are effective. In doing so, social experiments can become more generalisable and have wider implications. When the current data-set was filtered, performance effects were much more prominent. Based on our re-analysis, it is recommended that future studies include these manipulation checks to ensure the social variables are accurate. Future investigations should also explore the factors that may account for the difference in results obtained in this study to prior research. In particular, the social role of the observer and supervisor should be investigated more extensively (eg passive vs. active observers). The combined results from the quantitative and qualitative data support the notion that the presence of an observer during a task affects performance. Results of the present investigation suggest that the supervisor methodology implemented in this study may be a useful approach to evaluating the effect of social context on vigilance.

Future work should include several indices of performance in order to obtain a more complete picture of the effects of social facilitation. Furthermore, any studies utilising a vigilance task should include signal detection measures in order to more fully evaluate social facilitation effects on human performance. Moreover, we suggest that a taxonomy of social facilitation be developed to guide future investigations of social facilitation of performance.

Disclosure statement

No potential conflict of interest was reported by the authors.

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