Research Article

IJUSEng – 2019, Vol. 7, No. 1, 12-23
http://dx.doi.org/10.14323/ijuseng.2019.2

# Influence of Ambient Light and Feedback on Motivation to Carry Out a Task: Implications for Operation of Unmanned Aircraft

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***Abstract***: Smith S. and Spiridon E. (2019). Influence of ambient light and feedback on motivation to carry out a task: Implications for operation of unmanned aircraft. *International Journal of Unmanned Systems Engineering*. ***7***(1): 12-23. Extensive aerial surveillance using unmanned aerial vehicles require persistent motivation to monitor areas under surveillance, track people or vehicles, and carry out multiple checklists. Environmental factors and behavioural triggers can attenuate or enhance the approach motivation. The aim of this study was to test whether ambient lighting in the ground control station of an unmanned aerial vehicle and task feedback can incite motivation changes. Thirty participants were randomly allocated to a light (red, blue, or control) condition and a feedback (negative or positive) condition to test the effects of light and feedback on motivation during a 20-minute study. Self-report measures of mood state and motivation were taken while the participant completed two rounds of a visual search task before and after the ambient light and feedback interventions. Positive motivation increased in the blue light condition and decreased in the red and the control group relative to the baseline. No other significant effects were found, however trends in the data suggest that blue light raises approach motivation, and red light decreases approach motivation. The findings suggest that ambient interventions could be a useful tool to ensure a positive motivation is maintained for the operation of unmanned vehicles.

***Keywords:*** Ambient light, Blue light, Feedback, Mood state, Motivation, Red light.

## I. Introduction

In the aviation field, the misuse of checklists was found to be a major contributing factor to many crashes (Rantz, Dickinson, Sinclair, & Van Houten, 2009). Whether the task is apprised as monotonous or the pilot 's cognitive workload is stretched by multitasking (Herbst & Klöckner, 2014), there is a high risk that motivation to perform the task is dropping (Fairclough & Ewing, 2017). Maintaining a positive motivation to approach and perform the task might be modulated by environmental factors. Previous studies (e.g., Spiridon & Fairclough, 2017) indicated that blue light is an efficient ambient intervention to reduce subjective negative feelings, but no links have been investigated in relation to the motivation. Positive motivation has also been found to be heighten by constant positive feedback (Rantz et al., 2009), but interactions with the ambient light have not been investigated. Many pilots in the armed forces already fly attack and surveillance unmanned aerial vehicles (UAV) from confined ground control stations with minimal exposure to natural light and ambient blue light might have behavioural benefits on its own (e.g., go over a checklist regularly) by

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maintaining a high motivation, or in combination with feedback of performance. Hence, the current study examined whether ambient interventions and positive feedback could increase an approach motivation to carry out a set task. The results could be generalised to motivation triggers to use checklists in unmanned aviation.

*Light and Motivation*

Research on the way in which ambient lighting influences motivation has found some mixed findings (Knez, 2001; Mehta & Zhu, 2009; Wang et al., 2014). Red light is associated with failure or danger and leads to avoidance motivation (Mehta & Zhu, 2009). However, research also finds that people will attribute blue colours to fearful expressions which would suggest that in blue light there would be some avoidance motivation (Dael et al., 2016). Contrary to findings by Dael and colleagues (2016) and by Mehta and Zhu (2009) research found that blue light will induce approach motivation in tasks while learnt associations with blood and warnings cause red light to induce avoidance motivation (Wang et al., 2014). As blue light induces approach motivation it causes an individual to have the desire to face a task and perform best on this while red inspires the feelings to run away of withdraw from a task (Wang et al., 2014). The presence of the colour or even the word red can cause anxious responses appearing as an avoidance motivation (Elliot et al., 2007). In an attempt to replicate Mehta and Zhu's (2009) findings in an exact replication of their anagram study with triple the number of participants, research by Steele (2014) failed to find significant effects of colour priming on approach or avoidance motivation.

Red light has a positive effect on tasks that require local attention style of processing (Mehta and Zhu, 2009). Exposure to red light increases performance on cognitive tasks and increases focus on detail oriented tasks (Mehta and Zhu, 2009). This increased focus may be due to strong effects of the colour or word red and its ability to cause a narrowing of attention (Maier, Elliot, & Lichtenfeld, 2008). Blue light has a significant effect on alertness and performance on both cognitive and creative tasks (Ekstrom & Beaven, 2014; Plitnick, et al., 2010). Blue light has been found to reduce the number of attentional lapses that occur during task participation leading to higher levels of focus and increased mental effort on a task (Holzman, 2010). Contrary to this, Knez (2001) states blue light impairs short term memory and attention on cognitive tasks. In support of research suggesting light influences motivation, research by Dzulkifi & Mustafar (2013) states that the presence of any colour at all will raise attention levels. This highlights the fact that any environment with non-white lighting will increase attention and alertness (Dzulkifi & Mustafar, 2013). In response to this raise in attention a person's reaction time increases, this will cause them to give a faster response time on a timed task (Dzulkifi & Mustafar, 2013).

*Feedback and Motivation*

Feedback can act as an external motivator, or be perceived as a threat to the self, encouraging withdrawal from a task to protect self-esteem (Cianci et al., 2010). Research by Vellerand and colleagues (1988) and Tang and Baldwin (2001) discovered that verbal performance feedback on an interesting task would direct an individual's intrinsic motivation, specifically positive verbal feedback would raise intrinsic motivation in both males and females. When presented with negative feedback, there is a prospect of task failure inciting an individual to either disengage from a task or aim to work harder to aim to succeed, while this occurs a change in motivation can present as an increase or decrease in motivation (Fairclough & Roberts, 2011; Tang & Baldwin, 2001). Burgers and colleagues (2015) found that negative feedback decreased feelings of competence in game players but encouraged prolonged game play, while positive feedback satisfied feelings of competency boosting intrinsic motivation. Negative feedback in general will increase avoidance behaviour and reduce motivation to continue (Krenn et al., 2013). Feedback types either descriptive, comparative, or evaluative were also found to have differing results in changes in motivation and task engagement, with evaluative feedback increasing task continuation while comparative feedback decreased motivation to continue (Burgers, Eden, van Engelenburg, & Buningh, 2015). Some research suggests that higher motivation encourages an individual to be more responsive to feedback that is given in any form, as well as influence how they will use it to continue with the task (DePasque & Tricomi, 2015).

This research aims to understand further how feedback and ambient lighting in the environment will motivate an individual to pursue a task. Key research on how red and blue colours influence motivation tend to agree and suggest red leads to avoidance while blue leads to approach motivation (Mehta & Zhu, 2009). However, when attempting to replicate the research carried out by Mehta and Zhu (2009), Steele (2014) failed to find corresponding results bringing into question the replicability of the results. To address this discrepancy, further research needs to be explored into the area of light and colour and its subsequent influence on motivation valence. Research on feedback is often conflicting or shows only smaller, minor effects particularly in terms of motivation (Krenn, Würth, & Hergovich, 2013). Varying methods are used to test motivation changes in people either through self-report (Matthews et al., 2002) or by timing how long a person is willing to do a task (Tang & Baldwin, 2001). This present research aimed to address this by seeking to find a further, stronger effect of feedback on motivation using the self-report method of measuring motivation to get tangible scores for participant's feelings.

From research by Holzman (2010) and by Mehta & Zhu (2009) it is expected that red light will a negative effect on motivation while blue light will increase task motivation. Negative feedback will incite a change in motivation, the direction of change is disputed in the literature however (Burgers et al., 2013; Krenn et al., 2013; Fairclough & Roberts, 2011; Tang & Baldwin, 2001; Vellarand et al., 1988). In response to the interaction between light and feedback the combination of red light and negative feedback will reduce approach motivation and focus of attention.

## II. Methods

### Participants

University students were recruited through a poster campaign and opportunity sampling. In total there were 30 participants with an age range of 18-52 years, (M = 22.86 years). In total, there were 8 males and 22 females. Participants were pre-screened for heart conditions and colour blindness and state levels of anger. Through random selection 10 participants received red light exposure, 10 participants received blue light exposure, and 10 participants were in the control group receiving no light exposure (Table 1). A group of 15 participants received positive feedback on task performance while 15 participants received negative feedback on task performance. All participants provided informed written consent. Ethical approval was reviewed and approved by the institution.

**Table 1. Means and SD participant STAXI Trait in all experimental conditions**

| | Red Light | Blue light | Control | Positive feedback | Negative feedback |
|---|---|---|---|---|---|
| **No. of Participants** | 10 | 10 | 10 | 10 | 10 |
| **Mean STAXI** | 18.90 | 17.70 | 16.30 | 17.20 | 18.07 |
| **SD** | 6.12 | 4.00 | 2.00 | 3.57 | 5.12 |

### Study Design

A mixed groups design was utilised to investigate the effects of ambient lighting and feedback on negative emotional affect, attention, and motivation. The independent variables were ambient light and feedback given. The dependent variables were state anger level, attention, heart rate and motivation. Participants anger levels were measured with the STAXI-2 test (Spielberger, 1999) and through measures of heart rate. Motivation was measured using the motivation subset of questions from the Dundee Stress State Questionnaire (Matthews et al., 2002). Attention scores were given based on the error rate and reaction time on a visual search task. The formal design of the present study is presented in Table 1. It was predicted that mean anger levels would be higher in the negative feedback group and red-light group. Mean motivation was expected to be higher in the blue light condition and the negative feedback condition. It was further expected that attention would be higher in the red-light condition with feedback having no effect on attention.

**Materials**

*Light exposure*

Participants were randomly selected to receive exposure to red, blue, or no light exposure while sat in a darkened room. Ambient red light and blue light exposure were administered using unbranded 240V LED tape light placed on the desk around the computer the participant was sat at to complete the task. The light tapes were 6 m long with 60 LED lights per metre with a space of 16.7 mm between LEDs. A maximum of 225 lx was measured for both the blue light and red light in the room. Research on ambient light exposure completed by Plitnick et al. (2010) used lights of 10 lx and 40 lx. Other research, however, suggests that approximately 195 lx is required to incite changes in an individual (Varkevisser, Raymann & Keyson, 2011). This suggests that the lighting used should be strong enough to have witnessed significant changes. The total time exposed to ambient lighting did not exceed 25 mins for all participants, research suggests this ambient lighting exposure is harmless to an individual and safe to use for research purposes (Varkevisser et al., 2011).

*Negative Affect*

To obtain a measure of both state and trait anger, participants were asked to fill out the State anger scale (Spielberger, 1999). The questionnaire is made up of fifteen items measured on a Likert scale from 1 to 4 (1 = not at all, 5 = very much so). The response is formed into three subscales which are: a) feelings of anger (*S-Ang/F*), (b) feel like expressing anger verbally (*S-Ang/V*), and (c) feeling like expressing anger physically (*S-Ang/P*). Evidence of predictive validity of the STAXI-2 in the measurement of anger has been provided in several pieces of research (Spielberger & Reheiser, 2010; Deschênes, Dugas, Fracalanza, & Koerner, 2012). The internal consistency for all scales and subscales was reliable with Cronbach's alpha values ranging from .76 for the 4-item T-Anger/R subscale to greater than .84 (Spielberger, 1999; Spielberger and Reheiser, 2004). Responses for the STAXI state questionnaire in this instance yielded Chronbach's alpha scores of .79 for trait anger and .95 for state anger.

*Motivation*

Motivation was measured with the Dundee Stress State Questionnaire (DSSQ) (Matthews et al., 2002). The 8-item questionnaire is formed into two subscales, which are positive and negative motivation. Internal consistency of all scales and subscales was found to be reliable with Cronbach's alpha values ranging from .05 for the positive motivation subscales to greater than .74 for negative motivation.

*Task*

To obtain a score of attention, participants completed a practice trail and full round of a visual search task available online (www.swarthmore.edu); Fig. 1. The sequences of searching consisted of either 4, 8, 12, 16, 20, 24, or 28 distractors present on the screen while a participant was looking to locate the letter "Q" (the target) among letter "O" (the distractor). For the practice trial round there were 28 sequences of visual searching and 140 sequences for the actual task round. The use of visual search tasks as a measure of attention have been used and discussed in several pieces of literature (Verghese, 2001; Yantis & Jonides, 1984). Task error and response time were recorded to indicate task performance and attention as research suggests light exposure would influence response time (Chellappa et al., 2011).

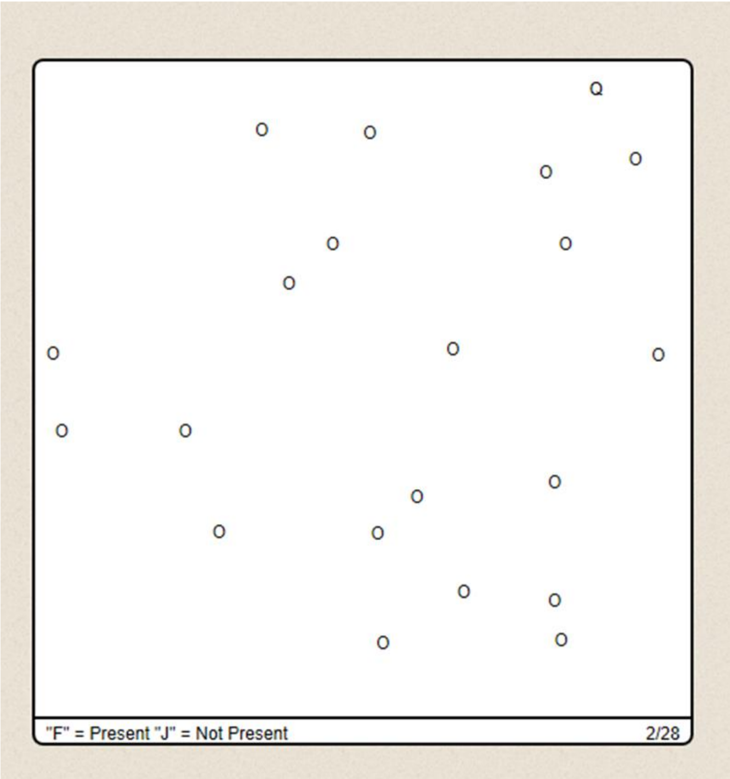


**Fig. 1. Visual search task**

**Procedure**

Participants were pre-screened for colour blindness, heart conditions, other medical conditions, medication, and trait levels of anger were taken. Self-report measures were tested between positive and negative feedback, between light conditions, and across all experimental stages (baseline, trial and task). The participants then took a seat in front of a computer in a darkened room. Participants completed a STAXI-II to assess a present state level of anger. Before completing a trial round of a visual search task on the computer, the relevant light for the condition the participant was assigned to was turned on. This light remained on throughout the rest of the study, approximately 10 minutes. Participants were instructed to complete the trial round of a visual search task as quickly and accurately as possible. Upon completing the trial, the participant filled out STAXI-II and motivation questionnaires while the researcher looked over and saved results from the trial. False feedback either positive or negative depending on the condition participant was assigned to was then handed to the participant. They were then instructed to take a minute to read over the feedback before being given a further STAXI-II questionnaire to assess any change in mood state after feedback. They then moved on to a second round of the visual search task. After task completion, a final STAXI-II and motivation questionnaire were given before the participant was handed a debrief. Deception of the false feedback was revealed, and the participant was given opportunities to ask any questions before leaving. The whole procedure lasted between 10 and 25 minutes with some participants responding slower than others on both self-report and visual search tasks.

## III. Results

*Self-report measures*

State levels of negative affect was examined in terms of a 3 (Light: red vs. blue vs. control) x 2 (Feedback valence: positive vs. negative) x 4 (STAXI measure: pre-trial vs. post-trial vs. post-feedback vs. post-task) mixed ANOVA. It was expected that negative affect would be higher in the red-light condition, and in the negative feedback condition, and in the post-feedback and post-task responses.

There was no significant main effect of light, $F(2, 24) = 1.13$, $p > .05$, $\eta_p^2 = .08$, negative affect was higher in the control group ($M = 16.35$, SD = .40) relative to the red light condition ($M = 15.55$, SD = .40) and blue light condition ($M = 15.68$, SD = .40).

There was no significant effect of light across experimental stages, $F(6, 72) = 0.47$, $p > 0.05$, $\eta_p^2 = .04$, however negative affect scores raised for red ($M = 15.2$, SD = .83, $M = 16.10$. *SD = .52)* and blue light conditions ($M = 15.40$, SD = .83, $M = 16.20$, SD = .52) while in the control group scores lowered slightly ($M = 16.80$, SD = .83, $M = 16.60$, SD = .52) from first to last measure, respectively. No significant effect of feedback was found, $F(1,24) = .22$, $p > .05$, $\eta_p^2 = .01$. Means were slightly higher as expected in the negative feedback condition ($M = 15.97$, SD = .32) than positive feedback ($M = 15.75$, SD = .32). Additionally, no significant effect was found of feedback across experimental stages $F(3, 84) = 2.43$, $p > .05$, $\eta_p^2 = .08$. STAXI scores rose for the negative feedback ($M = 15.47$, SD = .67, $M = 16.67$, SD = .40) while lowering for positive feedback conditions ($M = 16.13$, SD = .67, $M = 15.93$, SD = .40) from the first measure to the last, respectively. There was also a non-significant interaction between Light and Feedback, $F(2,24) = .06$, p > .05, $\eta_p^2 = .01$. Means and SD are listed in Table 2.

**Table 2. Means and SDs of STAXI scores in red, blue and control across experimental stages.**

| Light | Feedback | Experimental stage | Mean | SD |
|---|---|---|---|---|
| Red | Positive | 1 | 15.20 | .45 |
| | | 2 | 15.60 | .89 |
| | | 3 | 15.20 | .45 |
| | | 4 | 15.60 | .89 |
| | Negative | 1 | 15.20 | .45 |
| | | 2 | 15.40 | .89 |
| | | 3 | 15.60 | 1.34 |
| | | 4 | 16.60 | 1.67 |
| Blue | Positive | 1 | 15.40 | .55 |
| | | 2 | 15.60 | .89 |
| | | 3 | 15.20 | .45 |
| | | 4 | 15.80 | 1.30 |
| | Negative | 1 | 15.40 | .89 |
| | | 2 | 15.00 | .00 |
| | | 3 | 16.40 | 2.61 |
| | | 4 | 16.60 | 1.67 |

Positive motivation was examined in terms of a 3 (Light: red vs. blue vs. control) x 2 (Feedback valence: positive vs. negative) x 2 (Motivation measure: post-trial vs. post task) mixed ANOVA. It was expected that positive motivation would be higher in the blue-light condition and would increase over the progression of the study, and in the positive feedback condition in the post-task responses positive motivation would also be higher.

There was no significant main effect of light, $F(2, 24) = .08$, $p > .05$, $\eta_p^2 = .01$ positive motivation was higher in the control group (*M* = 7.10, SD = .78) than red light (*M* = 6.65, SD = .78) and blue light (*M* = 6.85, SD = .78). There was a significant effect of light across experimental stages, $F(2,24) = 3.85$, $p < 0.05$, $\eta_p^2 = .24$, positive motivation scores raised in the blue light group (*M* = 6.60, SD = .66, *M =7.10, SD* = .96*)* and lowered for red light (*M* = 6.80, SD = .66, *M* = 6.50, SD = .96) and the control group (*M* = 7.80, SD = .66, *M* = 6.40, SD = .96) from first to second measure, respectively. No significant effect of feedback was found, $F(1,24) = .54$, $p > .05$, $\eta_p^2 = .02$ means were slightly higher in the negative feedback condition (*M* = 7.20, SD = .64) than positive feedback (*M* = 6.53, SD = .64). Additionally, no significant effect was found of feedback across experimental stages $F(1,24) = 3.61$, $p > .05$, $\eta_p^2 = .13$, positive motivation scores rose for the negative feedback (*M* = 7.13, SD = .54, *M* = 7.27, SD = .78) while lowering for positive feedback conditions (*M* = 7.00, SD = .54, *M* = 6.07, SD = .78) from the first measure to the second measure, respectively. There was also a non-significant interaction between Light and Feedback, $F(2,24) = .03$, p > .05, $\eta_p^2 = .00$. Means and SD are listed in Table 3.

**Table 3. Means and SDs of positive motivation scores in red, blue and control, as well as positive and negative feedback across experimental stages.**

| Light | Feedback | Experimental stage | Mean | SD |
|---|---|---|---|---|
| Red | Positive | 1 | 6.80 | 2.17 |
| | | 2 | 5.80 | 2.39 |
| | Negative | 1 | 6.80 | 2.77 |
| | | 2 | 7.20 | 3.56 |
| Blue | Positive | 1 | 7.00 | 1.87 |
| | | 2 | 5.80 | 3.27 |
| | Negative | 1 | 6.20 | 1.79 |
| | | 2 | 8.40 | 3.36 |
| Control | Positive | 1 | 7.20 | 2.17 |
| | | 2 | 6.60 | 2.97 |
| | Negative | 1 | 8.40 | 1.52 |
| | | 2 | 6.20 | 2.39 |

A 3 (Light: red vs. blue vs. control) x 2 (Feedback valence: positive vs. negative) x 2 (Motivation measure: post-trial vs. post task) mixed ANOVA was utilized to examine negative motivation. It was expected that negative motivation would be higher in the red-light condition, and positive feedback condition in the post-task responses.

There was no significant main effect of light, $F(2, 24) = 2.15$, $p > .05$, $\eta_p^2 = .15$ negative motivation was higher in the blue light group (*M* = 14.15, SD = .68) than red light (*M* = 14.10, SD = .68) and control (*M* = 12.40, SD = .68). No significant effect of light was seen across experimental stages, $F(2,24) = .43$, $p > 0.05$, $\eta_p^2 = .04$, negative motivation scores lowered in the blue light group (*M* = 15.10, SD = .71, *M* = 13.20, SD = .81), red light (*M* = 14.80, SD = .71, *M* = 13.40, SD = .81), and the control group (*M* = 12.90, SD = .71, *M* = 11.90, SD = .81) from first to second measure, respectively. No significant effect of feedback was found, $F(1,24) = 1.32$, $p > .05$, $\eta_p^2 = .05$ means were slightly lower in the negative feedback condition (*M* = 13.10, SD = .55) than positive feedback (*M* = 14.00, SD = .55). Additionally, no significant effect was found of feedback across experimental stages $F(1,24) = 3.14$, $p > .05$, $\eta_p^2 = .12$, negative motivation scores rose for the negative feedback (*M* = 13.47, SD = .58, *M* = 12.73, SD = .66) and positive feedback conditions (*M* = 15.07, SD = .58, *M* = 12.93, SD = .66) from the first measure to the second measure, respectively. There was also a non-significant interaction between Light and Feedback, $F(2,24) = .45$, p > .05, $\eta_p^2 = .04$. Means and SDs are listed in Table 4.

**Table 4. Means and SD of negative motivation scores in red, blue and control and positive and negative feedback across experimental stages.**

| Light | Feedback | Experimental stage | Mean | SD |
|---|---|---|---|---|
| Red | Positive | 1 | 15.60 | .89 |
| | | 2 | 13.40 | 3.21 |
| | Negative | 1 | 14.00 | 2.45 |
| | | 2 | 13.40 | 2.88 |
| Blue | Positive | 1 | 15.40 | 1.34 |
| | | 2 | 12.40 | 3.05 |
| | Negative | 1 | 14.80 | 1.09 |
| | | 2 | 14.00 | .07 |
| Control | Positive | 1 | 14.20 | 1.30 |
| | | 2 | 13.00 | .70 |
| | Negative | 1 | 11.60 | 4.34 |
| | | 2 | 10.80 | 2.39 |

## IV. Discussion

Environmental visual cues are important in human mood, cognitions and behaviours. Ambient lighting, of both red and blue colour, have been shown to incite changes in individual mood, motivation, attention and heart rate (Dzulkifi & Mustafar, 2013; Elliot & Maier, 2007; Plitnick et al., 2010, Santesso et al., 2012). Task feedback additionally has been shown to cause changes to mood, motivation, attention and heart rate (Cianci et al., 2010; Fairclough & Roberts, 2011; Hattie & Timperley, 2007). For optimal performance in learning and achievement contexts an awareness of how both these factors influence a person is highly important. The present study aimed to address gaps and discrepancies in the literature as well as combine the use of multiple independent variables discussed in other research. This was achieved by investigating the effects that both ambient lighting (red and blue) and task feedback (positive and negative) had on a person's mood, motivation, attention, and heart rate.

*Light and Motivation*

A significant effect of light on positive motivation was found across experimental stages. In the blue light condition, positive motivation raised while it lowered in both the red ambient light and control groups. Means were higher in the blue light condition than the red light or control group. It can be inferred that ambient lighting does influence positive motivation and the presence of blue light is associated with higher positive motivation. However, negative motivation was not affected by the ambient light.

Overall these findings agree with Wang and colleagues (2014) that states blue light will induce approach motivation. Over the progression of the study means of positive motivation were seen to decrease in both the red light and the control condition suggesting that the participant was becoming more avoidant of the task and desire to continue with the task lowered. This supports research that red will induce anxious and avoidance responses (Elliot et al., 2007). However, negative motivation scores were not found to be affected by light conditions which may indicate that subjective appraisal of negative motivation might be underrated to avoid negative feelings or could be attributed to individual differences to light perception. Pervious research found that blue light tends to invoke also avoidance motivation (Dael et al., 2016); although this study found such trend in the data, the results remained inconclusive related to the negative motivation imposing the need for a further expansion of the research in this topic.

*Feedback and Motivation*

No significant effect of feedback on positive motivation was found. Positive motivation was higher in the negative feedback condition than positive feedback condition. No significant effect of feedback was found across experimental stages either. Positive motivation did raise in response to negative feedback while lowering in the positive feedback condition. Changes in means found suggest that negative feedback increases approach motivation that causes an individual to become more motivated to continue with the task.

Negative motivation was not significantly changed by feedback given to participants. Means were lower in the negative feedback condition than the positive feedback condition. Over experimental stages, negative motivation did not significantly change. Negative motivation means rose for both feedback conditions. Positive feedback increased negative motivation suggesting a disengagement from the task after receiving the feedback.

Negative feedback was seen to cause higher positive motivation which increased through experimental stages while negative motivation was lower in the negative feedback and rose with task progression. Findings do support prior research that suggested negative feedback would cause an increase in motivation as both positive and negative motivation increased showing an overall increase in motivation (Burgers et al., 2015; Fairclough & Roberts, 2011; Tang & Baldwin, 2001).

Positive feedback was seen to have higher negative (avoidance) motivation as well as a lowered positive (approach) motivation this is conflicting to research that suggested that positive feedback would increase intrinsic motivation (Tang & Baldwin, 2001; Vellerand et al., 1988). These findings are of little importance as overall they were not seen to be significant, therefore any changes will have been mild and more likely due to extraneous variables than feedback manipulation.

*Limitations of the study*

Most research on ambient light interventions exposed participants to 30 minutes or more of whichever form or colour of light that was chosen (Drummond & Quah, 2001; Gabel et al., 2017; Yuda et al., 2017). While based on the design of this research participants received a maximum of 15 minutes of ambient light exposure. It is possible that the time of exposure was not enough to cause any significant effects or changes in the participants, particularly those that completed the task in faster time periods. Additionally, as the participants were instructed to complete computer tasks as quickly and accurately as possible this led to inequality in overall time of light exposure which would be an extraneous variable affecting result's significance.

An imbalance in the numbers of each gender of participant may be problematic as gender differences in susceptibility to feedback are present. Research by Tan and Pang (2012) suggest that females may be more likely to avoid stressors and engage in emotionally focussed coping strategies in response to stress such as negative task feedback. Alternatively, males were found to be more likely to adopt both cognitive and behavioural avoidance strategies when faced with failure such as in negative feedback (Brougham, Zail, Mendoza, & Miller, 2009).

Hattie and Timperley (2007) suggest that feedback has more of an influence on an individual when they are additionally given details on how to improve. This may suggest why the feedback given in this research had not revealed a significant effect as the participants were not presented with information on how to improve. In addition, research suggests that the most effective forms of feedback are those given through video, audio, or computer assisted mediums which were not used in the present study and could have potentially assisted in the lack of significant effects of feedback (Hattie & Timperley, 2007).

*Practical Applications*

In the aviation contexts the use of feedback on task performance can encourage an individual to become more motivated to continue with a task, and if used in combination with a blue-light intervention an overall highest level of approach motivation could be achieved. The presence of blue light could provide the optimal performance situation for an UAV pilot of payload operator and will lead to higher motivation to do a task even it is routinely unchallenging (e.g., performing regularly checklists). Although the GCS architecture is highly processor-oriented, the GCS requires pilots to maneuver the UAVs and a payload operator to monitor the computer systems, gather intelligence, and forward intelligence from the UAV to other end users (Natarajan, 2001). By ensuring motivational self-control of GCS operators, we would be developing a two way interactive platform where the user controls the UAV while another computer controls the user's motivational state to ensure optimum performance.

*Future Directions*

Future research should consider limitations in the present study in terms of design and adjust to improve these. As trends in the data do appear to head in the direction of the hypotheses it could be worthwhile to re-examine the effects that the combination of ambient lighting and feedback have on mood state, motivation, and psychophysiological effects. There is evidence for the fact that blue light and feedback can influence positive affect, a future study could explore a comparison between positive and negative affect in response to ambient lighting and feedback valence. A deeper exploration of the interaction specifically between blue light and positive feedback should be completed as the present study's findings suggest the combination of the two will lead to highest levels of motivation, attention, and affective state.

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