Inducing Neutral Affective States in HCI Experiment Participants

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Abstract

Affective state impact human performance and can become an uncontrolled confounding factor during evaluation of interactive systems. We compare two calming interventions designed to bring users neutral affective states. A within-subject experiment, including stress-inducing activities alongside the calming interventions, showed that while both interventions lower significantly arousal, no significant effect was observed on the valence aspect, and the selected method for use in subsequent experiments as a calming intervention was ultimately based on design considerations.

CCS Concepts

• **Human-centered computing** → **Human computer interaction (HCI)**; **User studies**; **Interaction design**.

Keywords

Affective State, Valence, Arousal, User Studies

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1 Introduction and Motivation

In HCI experimental contexts, multimedia stimuli or directed activities can be used to induce affective states, to research user performance under such conditions. Well known stimulus examples are image datasets such as IAPS [7] and OASIS [5], audio datasets such as AAD [8] or DEAM [1], and affectively loaded phrases [4]. Prior work has further shown that colours can influence perceived affective states across different media contexts [9]. After stimulus exposure, affective state is frequently measured in terms of Valence and Arousal (VA), using validated instruments such as the Affective Slider, a digital self-assessment scale designed to capture valence and arousal in an intuitive and language-independent manner [2].

HCI experiments typically employ between-subject designs [3], which require fewer participants to achieve adequate power. In such experiments, establishing and restoring participants to a neutral affective baseline is important when sequential stimuli conditions are used, as residual affective states may influence subsequent measurements. Unfortunately, extant literature lacks methodological investigations on techniques to achieve this goal. Engineering interactive systems also includes the methodologies and infrastructures used for their evaluation [6]. In this context, our study aims to address this gap by comparing two calming visual interventions and evaluating their effectiveness in restoring affective neutrality.

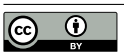
2 Experiment Setup

We implemented two calming interventions to return participants to a neutral affective state in terms of VA using a mobile app. Participants completed the study unsupervised in their home environment. We define the neutral affective state as 0.5 on a normalized 0-1 scale in both VA dimensions. The first intervention consisted of a slideshow of 10 images selected from the OASIS dataset [5], with VA ratings within the 0.4-0.6 range on a normalized 0-1 scale. The second intervention consisted of a sequence of changing colours, selected based on prior literature [9] to promote calmness and relaxation. Colours were displayed consecutively, transitioning smoothly from one to another. Both interventions lasted one minute.

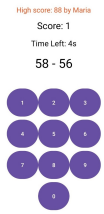
The study followed a counterbalanced within-subjects experimental design, in which each participant experienced both calming interventions. At the beginning of the experiment (Stage 1), participants reported their affective state using the Affective Slider [2]. Participants were then exposed to a stress-inducing activity (Stage 2), consisting of two time-constrained rounds of arithmetic operations performed. After completing the activity participants again reported their affective state. Following, participants were exposed to one of the calming interventions (Stage 3). Their affective state was subsequently measured to evaluate the effect of the intervention. The stress-inducing activity was then repeated (Stage 4), followed by an affective state assessment and the second calming intervention (Stage 5) and a final affective state evaluation. A total of 29 participants (15 female; ages 21 to 57, $\bar{x} = 30.23$, $\sigma = 7.41$) were recruited via convenience sampling. 15 participants were Master's holders, 3 had a University's degree and 11 a High-school diploma.

3 Results

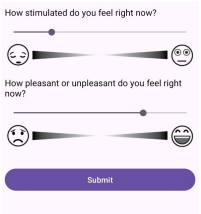
Repeated-measures ANOVAs were conducted separately for each cohort to examine whether arousal and valence differed across the five stages of the experiment. In Cohort 1, where users experienced the colour transition first, the analysis revealed that arousal level differed across stages ($F(4, 60) = 14.20, p < 0.001, \eta_n^2 = 0.44$). A moderate change in valence across changes was also identified ($F(4, 60) = 3.42, p = 0.033$). Bonferroni-corrected pairwise comparisons revealed only one significant difference, where valence after



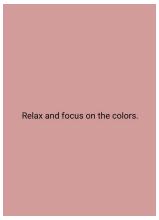
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(a) Stress-inducing activity



(b) Affective Slider

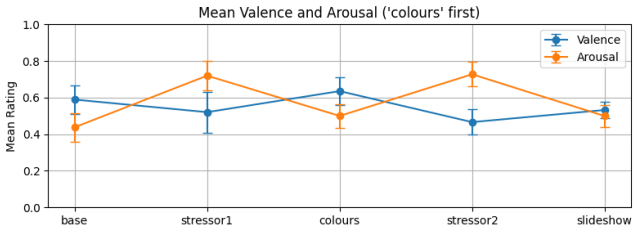


(c) Colours transition

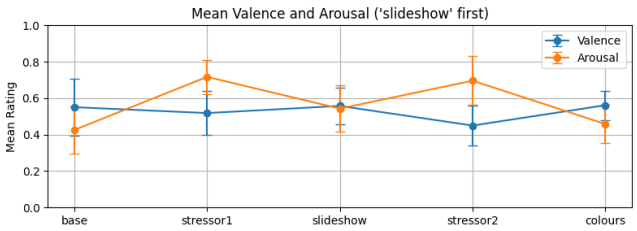


(d) Slideshow

Figure 1: Snippets of the application used for the study.



(a) Valence and arousal results, colours as first intervention



(b) Valence and arousal results, slideshow as first intervention

Figure 2: Affective responses after experiment stages.

the colours intervention differed significantly from valence after the second stressor ($p = 0.021$), while all the other differences where no significant. In Cohort 2, arousal also varied significantly across stages ($F(4, 48) = 6.10, p = 0.004, \eta_n^2 = 0.24$). Valence remained relatively stable across stages without statistically significant changes.

To verify the effectiveness of the stressor, we compared baseline measurements with the measurements taken immediately after the first stressor activity. Since both cohorts started the same way we include all participants in this analysis. Arousal increased significantly ($t(28) = 5.40, p < 0.001$) from $\bar{x} = 0.43(\sigma = 0.20)$ to $\bar{x} = 0.72(\sigma = 0.16)$ after the activity, well over the 0.6 threshold considered as a "neutral" state. Valence decreased slightly from $\bar{x} = 0.57(\sigma = 0.22)$ to $\bar{x} = 0.52(\sigma = 0.22)$, but the difference was not significant ($t(28) = -1.06, p = 0.298$). A mixed ANOVA was conducted to examine whether arousal differed between the first and second stressor activities and whether this depended on intervention order. The analysis revealed no significant main effect of intervention order ($F(1, 27) = 0.13, p = 0.717$), no significant effect of stressor stage ($F(1, 27) = 0.01, p = 0.915$) and no significant interaction between stage and order ($F(1, 27) = 0.09, p = 0.771$), indicating that the stressor activity brought participants to similar arousal levels regardless of intervention order.

Arousal decreased significantly following both interventions (colours (C): $\bar{x} = 0.71 \rightarrow 0.48, t(28) = 5.94, p < 0.001$; slideshow (S): $\bar{x} = 0.72 \rightarrow 0.52, t(28) = 5.31, p < 0.001$). Valence increased significantly only after the colours intervention (C: $t(28) = -2.52, p = 0.014$; S: $t(28) = -1.85, p = 0.075$). Post-intervention arousal did not differ from the neutral midpoint (0.5) for either condition (C: $t(28) = -0.62, p = 0.539$; S: $t(28) = 0.57, p = 0.572$). Valence was significantly above neutral only following the colours intervention (C: $t(28) = 3.63, p = 0.001$; S: $t(28) = 1.72, p = 0.097$). Finally, no significant differences were found between the effects of the colours and slideshow interventions for either arousal ($t(28) = 0.66, p = 0.517$) or valence ($t(28) = 1.48, p = 0.150$).

4 Discussion

The aim of this study was to compare two calming interventions designed to return users to a neutral affective state. The results indicate that the stress-inducing activity successfully increased participants' arousal levels, leaving valence unaffected, an outcome consistent with time-constrained cognitive tasks, which often increase tension without necessarily altering affective valence. Both calming interventions were effective in reducing arousal levels following the stress task, suggesting that both visual stimuli can effectively facilitate short-term affective regulation after a stress-inducing activity. In contrast, neither intervention significantly shifted participants' valence closer to neutrality when examining pre–post changes. However, post-intervention analyses revealed an important difference between the two approaches. While the slideshow intervention maintained valence levels that were not significantly different from neutrality, the color-based intervention shifted valence slightly toward the positive end of the scale. Although this shift was relatively small, it indicates that the color intervention may introduce a mild positive affective bias. Given that the objective of the subsequent experiment is affective stabilization rather than valence enhancement, the slideshow intervention was selected on conceptual alignment with the subsequent experimental design, despite the lack of statistical superiority between conditions. This study is limited by participant recruitment and affective state self-reporting which may affect generalizability. Further research could explore additional calming interventions with different populations and stressors.

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