The Relationship Between Mood and the Intentionality and Content of Mind Wandering

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Abstract

The present study assessed the relationship between mood, mind wandering (MW), and task performance, with special consideration of the neural correlates of MW as measured through electroencephalography (EEG) analysis. Participants (n=50) underwent a mood induction with either a positive or negative film clip and then participated in a repetitive task, which allowed researchers to examine the relationship between participant mood, MW, and task performance. Participant mood was measured at several time points during the study using the Positive and Negative Affect Schedule (PANAS), and participant self-reports on MW status during the task were collected through probes and a retrospective questionnaire. Participants’ self-reported MW status was analyzed in conjunction with mood, task performance, and EEG measures. Findings suggest that mood is directly related to task performance and EEG measures of attention, but that it is not influenced by spontaneous, deliberate, or overall MW. Furthermore, both higher overall MW as well as poorer participant mood negatively affected task performance, even though, contrary to expectations, there was no significant relationship between overall MW and mood. Findings discussed also include complex individual differences in the relationship between mood, task performance, and deliberate and spontaneous MW.
The Influence of the Intentionality and Content of Mind Wandering on Mood

Introduction

Defined as internally directed thought, mind wandering (MW) refers to thoughts that are unrelated to the external environment or to the task at hand. MW can include reminiscing about a past event, imagining possible future interactions, or even thinking about what you will eat for dinner. MW can occur either deliberately or spontaneously, both of which have different implications for executive functioning and sensory processing. Since so much of our time is spent MW, it is important to understand the impact that it has on our cognition and other neurological processes.

MW is related to the phenomenon of perceptual decoupling. According to Schooler et al. (2011), perceptual decoupling refers to the disengagement of attention from perception. MW is thought to interfere with an individual’s ability to process sensory information, leading to decreased detection of external stimuli. Therefore, MW increases the occurrence of perceptual decoupling.

Due to the nature of MW as an internal process, it is difficult to characterize reliably and empirically. Research on MW typically uses self-report measures and neuroimaging studies to understand how MW occurs and how it affects our thoughts and feelings. Contradictions exist in the literature regarding the effect of MW on individuals; therefore, it is essential that this research is expanded upon and that methods are developed to study MW that will allow researchers to make confident and valid conclusions.

The Neural Correlates of Mind Wandering

One way in which MW is studied is through its neural correlates. EEG is a useful way to study MW as it is relatively inexpensive, non-invasive, and accurate in terms of time resolution.
EEG uses a cap with electrodes to measure and record the electrical activity of the scalp, which provides a macroscopic picture of neural activity in the brain. Through past research, MW has been shown to correspond with increased alpha wave activity in EEG recordings (Compton et al., 2019). In addition to increased alpha activity, MW has also been associated with reduced P300 waves on EEG recordings (Barron et al., 2011). The P300 wave is a spike that occurs when an individual is presented with a target stimulus (“P300” 2020). Thus, a reduction in this signal indicates that less attention is being paid to the external stimulus, which provides evidence for the phenomenon of perceptual decoupling.

While EEG data is certainly valuable in the study of MW, it does not provide detailed information about the location of different structures and brain regions involved in MW. To obtain information about brain systems involved in MW, scientists use functional magnetic resonance imaging (fMRI). During fMRI scans, regions of the brain that are activated during given activities light up due to changes in blood flow, which allows scientists to identify which brain structures are involved in the given activity. Christoff et al. (2016) drew upon fMRI research to identify the default mode network (DMN) as a significant system in the neural control of MW. The DMN contains many different brain structures, including the posterior parietal cingulate, the medial prefrontal cortex (medial PFC), and the medial temporal lobes (Schooler et al., 2011). A second network identified in relation to MW is the frontoparietal control network (FPCN), which is associated with executive attention. According to this study, spontaneous MW is associated with increased activation in the DMN and decreased activation in the FPCN (Christoff et al., 2016). This provides evidence for the perceptual decoupling hypothesis by indicating that, when a person experiences spontaneous thought, their cognitive resources are being directed away from executive attention and toward internal thought.
processes. The use of multiple approaches to study the neural correlates of MW (both through EEG and fMRI) is valuable since each can reveal different aspects of how MW is represented in the brain and how this is related to cognition and other observable effects.

**Deliberate Versus Spontaneous Mind Wandering**

While early research regarded MW as a uniform state and predominantly compared MW with on-task thought, distinctions have since been made between different types of MW. One main distinction is between deliberate and spontaneous MW. Deliberate, or intentional, MW occurs when an individual purposefully switches their attention from an external stimulus or task to an internally directed train of thought. This form of MW is associated with more executive control. Deliberate MW is also negatively associated with stress and anxiety, suggesting that it might be protective against these forms of affective dysfunction (Seli et al., 2019).

In contrast, spontaneous, or unintentional, MW is associated with a failure of executive control. This form of MW occurs when an individual does not plan or intend to redirect their attention towards internal thoughts, but it happens anyway. Spontaneous MW is associated with more disordered behavior such as increased attention deficit hyperactivity disorder (ADHD) (Seli et al., 2015) and obsessive-compulsive disorder (OCD) (Seli et al., 2016) symptomatology. Additionally, spontaneous MW is associated with increased depression, anxiety, and stress (Seli et al., 2019), and is positively correlated with self-rumination (Vannucci & Chiorri, 2018).

These two types of MW are also represented by different neural patterns. Specifically, EEG signals from MW may differ depending on the intentionality of the MW episode. Martel et al. (2019) determined that deliberate MW is associated with increased alpha power and cortical phase-locking, whereas spontaneous MW is associated with reductions of sensory responses. Additionally, connectivity in certain areas of the brain differ between spontaneous and deliberate
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MW. Deliberate MW is associated with increased connectivity between the frontoparietal network (FPN) and the DMN, while spontaneous MW is associated with cortical thinning in areas adjacent to the FPN and the DMN (Golchert et al., 2017). This pattern of neural connectivity makes sense since deliberate MW is associated with more executive control than spontaneous MW, because deliberate MW would require more connectivity in the frontal cortex of the brain.

The intentionality of MW is independent of meta-awareness. Intentionality refers to whether an individual deliberately or spontaneously mind wanders, while meta-awareness refers to whether an individual is aware that they are MW (Seli et al., 2017). Though both factors may play a role in how MW affects us, for the purposes of this paper we will focus on the influence of intentionality rather than of meta-awareness on the effects of MW.

Mind Wandering and Mood

Since we spend so much time MW, it is beneficial to understand how it affects our mood so that we can recognize any detrimental effects and learn to harness MW in a productive way. Several studies have explored the relationship between MW and mood; however, the conclusions from these studies are mixed. For instance, several studies have determined that MW is associated with negative affect. One survey conducted by Killingsworth and Gilbert (2010) utilized experience sampling to determine that people who were MW reported feeling less happy than those who were not MW, indicating that MW is associated with a more negative mood. Another study determined that MW was positively correlated with depression and negatively correlated with mindfulness, indicating that MW is more predictive of negative affect (Deng et al., 2012).
In contrast, other studies suggest that MW may be associated with improvements in mood. One study conducted by Kruger et al. (2020) suggests that deliberate MW may be used by gamblers to escape negative emotions. In this study, gamblers were periodically probed while playing a slot machine and while completing an auditory vigilance task to assess whether they were on task, deliberately MW, or spontaneously MW. The slot machine task was shown to produce greater positive affect, while the vigilance task was shown to produce greater negative affect. Researchers found that gamblers who engaged in more severe problem gambling were more likely to deliberately mind wander during the vigilance task, suggesting that deliberate MW may be a way to cope with negative affect.

Additionally, the causal relationship between MW and affect has not been established with confidence. Some articles suggest that MW precedes negative affect, while others suggest that negative affect is a precursor to more frequent MW. For example, one study found that people who were sad or in a negative mood were more likely to MW; however, MW itself was not predictive of a later negative mood (Poerio et al., 2013). A second study conducted by Smallwood et al. (2009) also supports the conclusion that negative affect leads to MW. In this study, researchers induced positive, neutral, or negative affect in participants and found that the negative mood induction led to increased MW. Other studies, however, have made different conclusions. Mason et al. (2013) analyzed results from two different studies and concluded that there is likely a bidirectional relationship between MW and affect, in which both factors influence each other. While existing research suggests a relationship between negative affect and MW, the direction of this relationship is yet to be fully understood.

Several studies have also explored the potential of the content of an individual’s MW to influence their mood. One study suggests that MW itself does not influence mood, but that the
content of MW positively correlates with later mood (Poerio et al., 2013), while another study found that MW surrounding interesting and useful thoughts predicts a more positive mood (Franklin et al., 2013). A study by Weltz et al. (2017) suggests that MW with positive content is more likely to be associated with less negative affect. Studies have also explored the temporal orientation of the content of MW, finding that MW content that is focused on the past is associated with a negative mood, while MW content that is focused on the future is associated with a more positive mood (Ruby et al., 2013). While there is existing literature on the relationship between MW and mood, contradictory findings from different studies indicate that there is still much to learn and discover about this relatively novel topic of research.

**The Present Study**

Results from existing studies are mixed on the relationship between MW and affect, as well as whether other factors, such as the content of MW, mediate this relationship. Additionally, there is not a consensus on the directionality of the causal relationship between MW and affect; therefore, it is unknown whether MW precedes an affective state, whether an affective state precedes MW, or whether there is a bidirectional relationship between these two variables. Furthermore, many studies associating MW and affect fail to make a distinction between whether the MW is deliberate or spontaneous. Therefore, there is a relative lack of research on how the type of MW may influence the affective state of an individual.

The present study attempts to better characterize the relationship between the intentionality of MW, the content of MW, and mood. Through mood induction of participants, we can study how affective state influences the type of MW that occurs. Additionally, we explore how the type and content of MW affects future mood and we use EEG to study the neural correlates of different types of MW and affect. The proposed study expands on existing literature
by exploring the association between the type of MW (either spontaneous or deliberate) and affective state. Additionally, our results provide novel evidence about the neural correlates of the relationship between type of MW and affect, given that the use of EEG is a relatively new approach to studying this relationship.

This study was designed to test two main predictions involving the relationship between MW and affect. First, we hypothesized that induced negative mood in participants would lead to increased spontaneous MW. Additionally, induced negative mood would lead to the effects most associated with MW; these effects include poorer performance on the Sustained Attention to Response Task (SART), poorer mood following MW, as well as reduced P300 response to external stimuli. Other studies have empirically shown aspects of these relationships. For instance, Smallwood et al. (2009) demonstrated that negative mood induction was associated with more lapses and less engagement of attention, while Barron et al. (2011) found that participants showed reduced P300 amplitude when MW. Therefore, one goal in testing this hypothesis is to confirm past findings on MW and to add to the existing literature on this topic. Additionally, the present study integrates the findings from these two earlier studies to test a novel hypothesis that negative mood may lead to neural evidence of perceptual decoupling (as observed by the P300 response). Furthermore, this hypothesis expands on past findings by specifying that spontaneous MW, rather than MW in general, is associated with these adverse effects.

For the second main hypothesis, we predicted that MW may be used by some individuals deliberately to escape or regulate negative emotion. Due to deliberate MW requiring more executive control than spontaneous MW, we also predicted that, when compared to spontaneous MW, individuals who deliberately MW would show less of a reduction in the P300 response and
would perform better on the SART. Additionally, participants would have a more significant mood improvement after deliberate MW than after spontaneously MW.

Finally, we predicted that the content of MW would have an influence on mood; thus, any findings would be moderated by individual differences in the content of MW. Specifically, we predicted that individuals who MW about more positive topics would report more significant improvement in mood when compared to individuals who MW about negative topics. This is suggestive of a possible therapeutic application of MW, where individuals may utilize executive control to deliberately MW about positive topics to regulate emotion.

Methods

Participants

We recruited 50 participants through word of mouth and electronic postings. Participants included 41 females and 9 males. These participants were Haverford College and Bryn Mawr College undergraduate students who were enrolled for the Spring 2022 semester. Participants were randomly selected to undergo either a positive or negative mood induction, participant mood was assessed, and then participants performed a repetitive task.

One participant was excluded from EEG data analysis due to recording failure at the Pz site. A second participant was excluded from all data analyses due to technology issues resulting in an inability to complete the task. Therefore, 49 participants were included for analysis of performance and self-report data and 48 participants were included for EEG analysis.

Procedure

In this study, we first assessed participant mood using the Positive and Negative Affect Schedule (PANAS). We then showed the participant either a positive or negative film clip to induce either a positive or a negative mood. Participants then answered the PANAS again, which
assessed their mood post-film to ensure that the manipulation was successful. Participants then engaged in a repetitive task known as the SART. During this task, participants were given periodic probes in which they were asked about their MW status. After the task was complete, participants answered the PANAS again. Participants were also asked more detailed questions in a retrospective questionnaire about their MW experience. This questionnaire assessed the type of MW that participants engaged in (spontaneous or deliberate) as well the content of the MW.

*Positive and Negative Affect Schedule (PANAS)*

The PANAS scale includes 20 different moods and asks participants to indicate how strongly they feel each of them. The answers that participants provide range on a scale from 1 to 5, with 1 being “very slightly or not at all” and 5 being “extremely.” To see the full PANAS that was used, refer to Appendix A. Two additional questions were added after the PANAS that asked participants to rate how happy and sad they felt on a scale from 1 to 5. Participant mood was assessed prior to mood induction (T1), after mood induction (T2), and after the SART (T3). T1 and T2 PANAS scores were intended to be used as a manipulation check to determine whether the mood induction worked, as well as to assess participant mood prior to completing the task. The T3 PANAS score was intended to assess participant affect after the task.

*Mood Induction Film Clips*

For the mood induction, participants were randomly selected to undergo either a positive or negative condition. Each participant was shown a video clip of approximately three minutes in length. A pilot study was conducted prior to the main experiment to ensure that the film clips that were selected produced the desired effect on mood. The negative film clip was from the movie *A Dog’s Purpose* and was 3:02 minutes in length. This clip was from the end of the movie when the dog passed away. The positive film clip was called *The Present*, which is an animated short
film made by Jacob Frey, and 3:18 minutes in length. This clip showed a boy receiving a puppy as a present and then going outside to play with the puppy.

*Sustained Attention to Response Task (SART)*

The repetitive task that participants performed was the SART. This task was performed electronically. During this task, single digits were presented to participants on a screen. Participants were asked to press a button every time that they saw the target number “3,” but not to press the button if they saw any other number. Each set of this task contained 128 occurrences of non-target stimuli and 10 occurrences of target stimuli. Each number was presented for two seconds, and there was 500 ms between numbers. Participants were given three sets, for a total of 384 occurrences of non-target stimuli and 30 occurrences of target stimuli.

*Probes*

Prior to the SART, participants were given instruction about what MW is, as well as about the difference between deliberate and spontaneous MW. For the exact definitions provided to participants prior to the SART, refer to Appendix B. During the SART, participants were given periodic probes which allowed them to indicate their MW status. Four probes were placed per set of the SART, which resulted in 12 probes over the duration of the experiment (since participants were required to complete three sets). For the probes, participants were first asked if they were deliberately MW, spontaneously MW, or on task. If the participant was MW, they were then asked if their thoughts were positive or negative. Participants rated the valence of their MW thoughts on a Likert scale from 1-7, with 1 being very negative and 7 being very positive.

*Retrospective Questionnaire*

After completing the SART, participants were asked to complete a retrospective questionnaire. This questionnaire asked participants to report the valence of their MW, the
frequency of their MW, and the spontaneity or deliberateness of their MW. The content of MW was assessed by giving participants the prompt, “Describe what you were thinking about during the task.” Participants were given space to answer this question in an open-ended format. The valence of MW was assessed by asking participants, “When you were MW, did the content of your thoughts tend to be negative or positive?” Participants answered this question on a sliding scale, with negative on one end and positive on the other. The frequency of MW was assessed by asking participants, “What percentage of time during the task do you think you were MW?” Participants answered this question on a sliding scale of 0% to 100%. Finally, the spontaneity and deliberateness of MW was assessed using the question, “When you were MW, how often were you deliberately MW versus spontaneously MW?” Participants answered this question on a sliding scale with deliberate on one end and spontaneous on the other.

**EEG Recording and Processing**

EEG was used to measure neural activity in participants while completing the task. Each participant was equipped with a Quik-caps fabric cap prior to performing the task, which had embedded Ag/AgCl electrodes at different measurement sites across the scalp to measure participant neural activity throughout the duration of the study. Additionally, electrodes were placed around the eyes to measure participant blinks and eye movement artifacts. EEG data was recorded continuously by the NuAMPS amplifier at 1000 HZ sampling rate.

Several steps were taken to process the EEG data. First, gross artifacts were manually rejected from participant files. Data were then re-referenced to the average of A1 and A2 (except for participant 109, where just A2 was used due to A1 recording complications). Channels were then corrected for blink artifacts using Scan’s regression-based blink reduction algorithm. The file was then separated into epochs. Each epoch contained an event marker and was 1200 ms in
length. The epoch began 200 ms prior to the stimulus onset and ended 1000 ms after the stimulus onset. For each trial type (target and non-target stimuli), the epochs were averaged. This produced two average waveforms for each participant (one target and one non-target). The P300 amplitude was taken for the P3, Pz, and P4 sites of each participant. The P300 amplitude was measured as the mean voltage between 500-700 ms after stimulus onset. These amplitudes were then used for further statistical analyses. A grand average was developed for each of the three sites (P3, Pz, P4), with the waveform average of all target and non-target trials.

**Results**

Several statistical tests were performed to determine the relationship between participant mood, the type and amount of MW, and participant SART performance. For a comprehensive list of significant findings and marginal trends from these analyses, refer to Appendix C. A significance level of $p < 0.05$ was used to determine a significant finding, and a significance level of $0.05 < p < 0.1$ was used to determine a marginal trend.

*Film Influence on Mood*

Four 2 (film type: positive or negative) x 3 (time point: T1, T2, T3) mixed factorial ANOVAs were conducted to determine if the film clips affected mood as expected. The 2x3 mixed factorial ANOVAs tested the participants’ negative affect, positive affect, happy, and sad ratings prior to the mood induction (T1), following the mood induction (T2), and after the SART (T3). Estimated marginal means plots were then developed for each dependent variable to visualize the participants’ moods at various time points (See Figure 1).

A 2x3 mixed factorial ANOVA was conducted to analyze the relationship between positive affect and time point for the two film conditions. There was a main effect of time, $F(2, 94) = 38.85, p < 0.001$, indicating that participant’s positive affect changed significantly
depending on the time. There was a main effect of the film group as well, $F(2, 94) = 7.47, p < 0.001$, indicating that participants’ positive affect changed significantly depending on the film clip that they received. There was also a significant interaction effect between film group and time, $F(1, 47) = 10.6, p = 0.002$, indicating that the effect of film clip on positive affect differed between time points. The estimated marginal means plot for this test (Figure 1) indicates that the film groups differed most at T2 (immediately after the film clip). We ran a Tukey’s HSD Post Hoc Test and found a significant difference in positive affect between the two film groups at T2, $p < 0.001$. There was not a significant difference between the two film groups at T1 or T3 ($p = 0.353$ and $p = 0.380$, respectively). This confirms that the trend observed in the estimated marginal means plot is significant.

A 2x3 mixed factorial ANOVA was conducted to analyze the relationship between negative affect and time point for the two film conditions. There was a main effect of time, $F(2, 94) = 5.66, p < 0.005$, indicating that participant’s negative affect changed significantly depending on the time. There was also a main effect of the film group, $F(2, 94) = 15.35, p < 0.001$, indicating that participants’ negative affect changed significantly depending on the film clip that they received. There was a significant interaction effect between film group and time as well, $F(1, 47) = 5.23, p < 0.027$, indicating that the effect of film clip on negative affect differed between time points. The estimated marginal means plot for this test (Figure 1) indicates that the film groups differed most at T2 (immediately after the film clip). We ran a Tukey’s HSD Post Hoc Test and found a significant difference in negative affect between the two film groups at T2, $p = 0.002$. There was not a significant difference between the two film groups at T1 or T3 ($p = 1.000$ and $p = 0.835$, respectively). This confirms that the trend observed in the estimated marginal means plot is significant.
A 2x3 mixed factorial ANOVA was conducted to analyze the relationship between happiness and time point for the two film conditions. There was a main effect of time, $F(2, 90) = 14.5, p < .001$, indicating that participant’s happiness changed significantly depending on the time. There was a main effect of the film group as well, $F(2, 90) = 17.8, p < .001$, indicating that participants’ happiness changed significantly depending on the film clip that they received. There was also a significant interaction effect between film group and time, $F(1, 45) = 27.7, p < .001$, indicating that the effect of film clip on happiness differed between time points. The estimated marginal means plot for this test (Figure 1) indicates that the film groups differed most at T2 (immediately after the film clip). We ran a Tukey’s HSD Post Hoc Test and found a significant difference in happiness between the two film groups at T2, $p < 0.001$. There was not a significant difference between the two film groups at T1 or T3 ($p = 0.705$ and $p = 0.106$, respectively). This confirms that the trend observed in the estimated marginal means plot is significant.

A 2x3 mixed factorial ANOVA was conducted to analyze the relationship between sadness and time point for the two film conditions. There was a main effect of time, $F(2, 94) = 26.3, p < 0.001$, indicating that participant’s sadness changed significantly depending on the time. There was also a main effect of the film group, $F(2, 94) = 14.8, p < 0.001$, indicating that participants’ sadness changed significantly depending on the film clip that they received. There was a significant interaction effect between film group and time as well, $F(1, 47) = 9.32, p = 0.004$, indicating that the effect of film clip on sadness differed between time points. The estimated marginal means plot for this test (Figure 1) indicates that the film groups differed most at T2 (immediately after the film clip). We ran a Tukey’s HSD Post Hoc Test and found a significant difference in sadness between the two film groups at T2, $p < 0.001$. There was not a
significant difference between the two film groups at T1 or T3 ($p = 1.000$ and $p = 0.551$, respectively). This confirms that the trend observed in the estimated marginal means plot is significant.

All four mood measures tested (positive affect, negative affect, happiness, and sadness) revealed significant main effects of time and film group, as well as significant interaction effects between film group and time. Furthermore, after running Tukey’s HSD Post Hoc tests, we found that there was a significant difference in mood between film groups at T2 for each mood measure, but not at T1 or T3. This indicates that the mood manipulation is successful at T2, but that the effectiveness of this manipulation wanes over time.

*Film Influence on MW*

We next conducted independent samples t-tests to determine the influence of the film group on MW. MW was measured in two ways. First, MW was measured with probe responses, which participants completed during the SART. Additionally, MW was measured with retrospective questions that participants completed following the SART. For probe responses, there were no significant differences between film groups for on-task responses, total MW, deliberate versus spontaneous MW, or MW valence (See Table 1 for means and standard deviations). For retrospective responses, there were no significant differences between film groups for overall MW, deliberate versus spontaneous MW, negative MW, or positive MW (See Table 1). There was a marginal trend for film clip on overall MW, $t(47) = 2.002, p = 0.051$, indicating that participants in the negative film group report higher levels of overall MW than participants in the positive film group; however, this did not quite reach significance.

*Film Influence on SART Performance*
An independent sample t-test was conducted to determine whether the film clip had an influence on the SART performance. There was a significant difference between film groups for non-target accuracy, $t(47) = -2.094, p = 0.042$. This indicates that participants in the negative film group pressed a non-target significantly more than participants in the positive film group. There was also a marginal trend between film groups and target accuracy, $t(47) = -1.686, p = 0.098$, indicating participants in the positive film group accurately selected the target more frequently than participants in the negative film group (positive film group: 99.3% correct, negative film group: 96.8% correct); however, this finding failed to reach significance. There was no significant difference between film groups for reaction time (See Table 1 for means and standard deviations).

*Film Influence on P300 Response*

A grand average waveform was generated from the P300 amplitude values among participants in response to target and non-target stimuli at each of the three electrode sites selected for analysis (P3, Pz, P4) (See Figure 2). The parietal sites were selected since the P300 peak tends to be most pronounced in the parietal area. A 2 (negative film clip, positive film clip) x 2 (non-target, target) x 3 (P3, Pz, P4 electrode site) mixed factorial ANOVA was conducted to determine whether the film clip had an influence on P300 response for targets and non-targets. There was a main effect of trial type (non-target vs target) on P300 response, $F(1,46) = 112.753, p <.001$. This indicates that P300 response was higher for targets than non-targets; this result was consistent with expectations that more attention would be allocated to targets than to non-targets. Additionally, there was a significant two-way interaction between trial type and film clip on P300 response, $F(1, 46) = 73.142, p = 0.025$, indicating that participants in the positive film group had a stronger interaction between the targets and the non-targets than participants in the
negative film group (See Figure 3). A Tukey’s HSD post hoc test was run to further characterize this relationship, and it was found that there was not a significant difference between film groups for non-targets \( (p = 0.998) \) or for targets \( (p = 0.124) \). Therefore, though participants in the positive film group showed a greater change in P300 response than participants in the negative film group, the P300 response to targets for participants in the positive film group was not significantly higher than the P300 response to targets for participants in the negative film group.

Additionally, there was a significant two-way interaction between trial type and site \( (\text{P3, Pz, and P4}) \) on P300 response, \( F(2, 92) = 3.673, p = 0.002 \), indicating that the Pz electrode site showed a more pronounced P300 response than the P3 or P4 electrode sites (See Figure 4). There was no main effect of site on P300 response, nor was there a significant two-way interaction between site and film clip on P300 response. Furthermore, there was no three-way interaction between trial type, site, and film clip on P300 response. Lastly, there was a marginal trend in the between subjects effect for film clip, \( F(1,46) = 3.19, p = 0.081 \), indicating that there was an overall marginal difference between the two film groups in P300 amplitude with a higher overall mean for the positive film group.

**Individual Differences**

A correlation matrix was run to assess the relationship between mood prior to the SART and the type and amount of MW that the participants experienced during the SART. Separate analyses were conducted for the positive film group and negative film group since the mood manipulation that participants underwent differed between groups. In the negative film group, there was no significant correlation between the participant mood at T2 (prior to the SART) and the occurrence of overall MW or the occurrence of deliberate versus spontaneous MW. In the positive film group, participants with higher positive affect at T2 were more likely to deliberately
MW versus spontaneously MW during the SART. This finding was significant for both retrospective reports of deliberate MW, $r = 0.433$, $p = 0.034$, as well as for probe-caught deliberate MW during the task, $r = 0.487$, $p = 0.018$. Furthermore, participants with a higher negative affect at T2 were likely to report more overall MW during the SART, $r = 0.490$, $p = 0.015$.

A second correlation matrix was run to examine the relationship between the type and amount of MW during the SART and the change in mood of the participants over the course of the SART. In the negative film group, there was no significant correlation between the amount or type of MW during the SART and mood change in the participants during the task. Similarly, there was no significant correlation in the positive film group between the type and amount of MW and the mood change in participants during the task.

A third correlation matrix was run to determine the relationship between the amount and type of MW that participants engaged in and their performance on the SART and P300 responses. There was a marginal trend between reaction time and deliberate MW, where participants who had more deliberate than spontaneous MW during the task (measured through retrospective reporting) had slower reaction times, $r = 0.252$, $p = 0.087$. Additionally, there was a marginal trend indicating that higher non-target accuracy was associated with more spontaneous versus deliberate MW; this trend was present both for retrospective measures of deliberate MW, $r = -0.268$, $p = 0.069$, as well as for probe-caught measures of deliberate MW, $r = -0.275$, $p = 0.056$.

Overall MW was also assessed in relation to SART performance. There was a significant negative correlation between retrospective reports of overall MW and accuracy identifying targets, $r = -0.314$, $p = 0.028$, as well as accuracy identifying non-targets, $r = -0.327$, $p = 0.022$. 
Furthermore, there was a marginal trend between retrospective reports of overall MW and reaction time to targets, $r = 0.265, p = 0.066$, suggesting that participants who were MW more took longer to react to targets. Together, this data indicates that greater overall MW is associated with poorer performance in recognizing targets and non-targets in the SART. There was no significant relationship between P300 response and the type of MW, amount of MW, or SART performance measures.

**Discussion**

The goals of this study were to explore the relationship between mood and different forms of MW, with special attention paid to neural correlates of MW. Several hypotheses were made in relation to these goals. First, we hypothesized that induced negative mood would lead to increased spontaneous MW, poorer SART performance, poorer mood after the SART, and a reduced P300 response, which taken together are indicative of perceptual decoupling. Additionally, we hypothesized that deliberate MW would be associated with better performance on the SART, better mood after the SART, and less of a reduction in the P300 response. Furthermore, we predicted that individual differences in MW would moderate the effect on mood.

*Film Influence on Mood*

We found that the mood induction was successful for all four mood measures (positive affect, negative affect, happiness, and sadness). For positive affect, the biggest discrepancy was seen at T2, with participants in the negative film group showing a much larger drop in positive affect when compared to the positive film group. For negative affect, the biggest discrepancy was seen at T2 as well, with the negative film group showing a significant increase in negative affect when compared to the positive film group. This pattern continues for happiness, where
participants in the negative film group show a much larger drop in happiness than participants in the positive film group at T2. Furthermore, participants in the negative film group show a much larger spike in sadness at T2 than participants in the positive film group.

For each test, the differences between film groups were found to be significant at T2, immediately after the participants watched the film clip. At T3, these differences between film groups were not significant, suggesting that the effects of the mood induction waned over time. Given that there was a significant interaction between mood measures and time point for all four variables tested, as well as the fact that the estimated marginal means plots depict the relationships between time, film group, and mood to be as expected in all cases, it was concluded that the mood manipulation worked as intended.

Film Influence on MW

When analyzing the probe responses, we found no significant differences between film groups for on-task, overall MW, deliberate versus spontaneous MW, or MW valence reports. This is contrary to expectations. It was expected that the participants in the negative film group would respond with less on-task responses, more total MW, more spontaneous than deliberate MW, and more negative MW valence. Instead, there was no statistically significant difference between film groups for the probe responses.

When analyzing the retrospective responses, results also indicated that there were no significant differences between film groups for overall MW, deliberate versus spontaneous MW, negative MW, or positive MW. This is also contrary to expectations. It was expected that participants in the negative film condition would report more overall MW, more spontaneous MW, more negative MW, and less positive MW. There was a marginal trend of more overall MW
in the negative film group than in the positive film group ($p = 0.051$), which is consistent with expectations; however, this failed to reach significance.

Overall, these results were not as expected. These results contradict previous findings, such as findings from Deng et al. (2012) and Killingsworth and Gilbert (2010), that indicate that negative affect is associated with increased MW. It is possible that the probes in the present study were too frequent and drew participant attention back to the task often enough to inhibit MW. It is also possible that participants were not transparent in their self-reports of MW because they were concerned that not being on-task would reflect poorly on them.

Film Influence on SART Performance

The influence of the film on SART performance was analyzed, with the expectation that participants in the negative film group would perform worse on the SART (longer reaction times, less target and non-target accuracy) than participants in the positive film group. It was found that participants in the negative film group had less non-target accuracy than participants in the positive film group. Additionally, a marginal trend was observed between film group and target accuracy, where the participants in the positive film group had more target accuracy than participants in the negative film group. These results are consistent with expectations that participants would perform better on the task if they were in a better mood. Lastly, there was no significant difference between film groups for reaction time to targets. This is contrary to expectations, as it was hypothesized that participants in the negative film group would have longer reaction times than participants in the positive film group. Overall, there is some evidence that participants in the negative film group performed worse on the SART than participants in the positive film group, but these results are not as strong as had been expected;
while participants in the negative film group did perform worse on some measures of SART performance, there was not a significant difference between film groups for other measures.

*Film Influence on P300 Response*

The influence of the film on P300 response was analyzed to determine the impact of participant mood on perceptual decoupling. A lower P300 response suggests perceptual decoupling because it indicates that there is less attention being paid to surroundings. It was expected that P300 responses would be higher for targets than for non-targets, and that participants in the negative film group would have lower P300 responses to target stimuli than participants in the positive film group.

It was found that there was a main effect of trial type (non-target vs target) on P300 amplitude, with targets yielding a higher P300 amplitude than non-targets. This is consistent with the expectation that the target stimulus would attract more attention than the non-target stimulus. Additionally, there was a significant two-way interaction between trial type and film clip on P300 amplitude (see Figure 3). Further analysis of this interaction revealed that participants in the positive film group had a larger difference between target and non-target P300 response than participants in the negative film group. This is a novel finding which is consistent with expectations. Furthermore, this finding provides evidence for perceptual decoupling; participants in the negative film group may be paying less attention to their surroundings, leading to a smaller change in P300 response.

Overall, there were several significant findings from the analyses of the film manipulation, but also some unexpected results. First, it was found that the mood manipulation worked; the negative film group had a poorer mood at T2 than the positive film group. Contrary to expectations, there were no significant findings that indicated that there was a difference in
film group for being on-task, overall MW, deliberate versus spontaneous MW, or MW valence during the task; however, there was some evidence that participants in the positive group performed better on the SART than participants in the negative film group, and that participants in the positive film group had a larger difference in P300 response to targets versus non-targets than participants in the negative film group did. Together, the results from the film manipulation suggest that mood does have the expected effect on task performance and P300 response, but that MW is not involved in this relationship.

Individual Differences

One of the goals in analyzing individual differences was to characterize the relationship between mood and subsequent MW. It was hypothesized that a poorer mood prior to the SART would be associated with more spontaneous MW and more overall MW during the SART. To study this relationship, the correlation between mood at T2 and the type and amount of MW during the SART was assessed. In the negative film group, there was no significant relationship between mood at T2 and the type and amount of MW during the SART. This contrasted with the expectation that participants in the negative film group with more negative affect at T2 would be more likely to report higher levels of spontaneous versus deliberate MW, as well as more overall MW. In the positive film group, the participants with more positive affect were more likely to deliberately MW as opposed to spontaneously MW, and participants with higher negative affect were more likely to MW overall. This is consistent with the hypothesis that positive affect is associated with deliberate MW and that negative affect is associated with more overall MW.

Given that no other significant connections between mood and MW were found, it is interesting that there were significant findings for the positive film group for the correlation between mood at T2 and MW. It is possible that, since the positive film clip had both happy and
sad components, and the mood change for participants in the positive film group was not as drastic as the mood change for participants in the negative film group at T2, the positive film clip may have been more susceptible to different interpretations and individual differences than the negative film clip was. Alternatively, it is also possible that this was a spurious finding.

To characterize the relationship between MW and participant mood further, the correlation between the type and amount of MW during the SART and the mood change in participants during the SART was assessed. It was hypothesized that more MW, and specifically more spontaneous MW, would be associated with a more negative change in affect, while more deliberate MW may be associated with a positive change in affect. Contrary to expectations, there were no significant findings for the positive film group nor the negative film group. This also contradicts findings published by Deng et al. (2012), which suggested that more MW is predictive of negative affect. Deng et al. (2012) also used the SART task when studying MW. In their study, the SART consisted of 16 blocks, with 15 to 45 numbers appearing in each block. Participants answered one probe at the end of each block. It is possible that an individual would need to MW for a certain length of time before it caused a measurable change in mood, and the probes during the SART in the present study interrupted the participants frequently enough that this threshold was not reached.

The relationship between the amount and type of MW, performance on the SART, and P300 responses was also assessed. It was hypothesized that deliberate MW would be associated with better performance on the SART and higher P300 scores, while spontaneous MW would be associated with poorer performance on the SART and lower P300 scores. Additionally, more overall MW would be associated with poorer performance on the SART and lower P300 scores than less overall MW would be. There was a marginal trend indicating that deliberate MW was
associated with longer reaction times. Additional marginal trends that were found suggested that
more spontaneous MW was associated with higher target and non-target accuracy. These
findings are contrary to the hypothesis that deliberate MW would be associated with shorter
reaction times and better performance since it is considered to be indicative of adaptive
attentional control and enhanced executive functioning. It is possible that participants who were
deliberately MW had more of their attention directed away from the task than participants who
were spontaneously MW, resulting in more effort to redirect attention to the task when a target
came on the screen.

Additionally, more overall MW was associated with less accuracy in identifying both
targets and non-targets. Furthermore, there was a marginal trend between more overall MW and
longer reaction time to targets. These findings suggest that more overall MW is related to poorer
performance on the SART, which is consistent with the initial hypothesis that MW would have a
detrimental effect on performance.

P300 levels were not significantly associated with the amount or type of MW, nor with
SART performance. This is not consistent with expectations that spontaneous MW and poorer
SART performance would be positively correlated with lower P300 scores. This is also contrary
to previous studies, such as the study conducted by Martel et al. (2019) which suggested that
spontaneous MW was more closely associated with sensory response reduction, or the study by
Barron et al. (2011) that suggested that participants showed a reduced P300 amplitude when
MW. These findings do not support the perceptual decoupling hypothesis, since the participants’
attention to the environment did not differ depending on whether they were MW or not.

*Takeaways*
The relationship between mood and MW is not as cut-and-dry as expected. While some findings were significant and consistent with the initial hypotheses, other findings contradicted initial expectations, while still others were not significant at all.

From the results, it does not appear that there is a significant correlation between participant mood and deliberate versus spontaneous MW, as we had initially hypothesized that there would be. The one exception to this conclusion was that, if a participant was in the positive film group, they were more likely to deliberately MW if they had a higher positive affect at T2, and they were likely to MW more overall if they had a higher negative affect at T2. This finding was not found within the negative film group. There was also no significant evidence to support the hypothesis that deliberate, spontaneous, or overall MW would be associated with subsequent mood in either film group. This conflicts with previous studies, such as those conducted by Mason et al. (2013) and Smallwood et al. (2009), which suggest that there is a direct relationship between MW and affect.

Since there were not many differences between spontaneous versus deliberate MW found during analysis of these results, it is important to explore why this might be the case. Previous research on different forms of MW revealed marked differences, such as increased incidence of disordered behavior (Seli et al., 2015) as well as increased depression and anxiety (Seli et al., 2019) associated with spontaneous MW, compared to the use of deliberate MW to cope with negative affect (Kruger et al., 2020). Since several studies have explored the distinction between these two forms of MW with significant results, it is possible that differences in our study methods led to this discrepancy. One possibility is that participants were not clear on the distinction between deliberate versus spontaneous MW (See Appendix B for the exact definitions given to participants).
Deliberate versus spontaneous MW also did not appear to play a mediating role in the relationship between P300 response and SART performance. Therefore, if a lower P300 response and poorer SART performance is indicative of perceptual decoupling, it is possible that perceptual decoupling is not related to the extent to which a person is deliberately or spontaneously MW, but rather the person’s mood independent of these forms of MW. This supports the novel hypothesis that negative mood leads to neural evidence of perceptual decoupling. It is also possible that an unidentified factor, other than MW, may play a mediating role in the relationship between mood and P300 response. Since the use of EEG measures is a novel approach to answering these questions, further research is necessary to determine if, and how, mood and P300 response are related, as well as the implications that this has on the concept of perceptual decoupling.

**Strengths and Limitations**

This study had several strengths and limitations. One aim of this study was to support and add to current literature on the relationship between MW and mood. Due to a wide base of conflicting research on this topic, this study provides additional contributions to the literature. Importantly, this study also extends on current research to look at novel questions surrounding how this relationship can be studied through EEG measurements. This study appears to be the first study to compare the effect of film manipulation and mood on P300 response. This addition allows us to make inferences on perceptual decoupling as a possible consequence of mood.

One limitation of this study is that the sample of participants may not be representative of the general population. Undergraduate students at two selective liberal arts schools may have different attention spans and methods of coping with negative affect than members of the general
population. Therefore, it would be interesting to conduct this study with a broader sample and determine if, and how, the results differ.

Furthermore, this study relied on self-report measures to assess deliberate, spontaneous, and overall MW. It is possible that the responses provided by participants were not entirely representative of their actual MW experience; perhaps participants did not want to indicate if they were MW because they thought that it would reflect poorly if they were not on-task. Additionally, periodic probes throughout the task may have interrupted the natural progression of MW and drawn participant attention back to the task too frequently; it is possible that short, interrupted segments of MW would not cause the same effect on mood as a longer, uninterrupted period of MW (which is what typically occurs outside of a research setting).

Future Directions for Research

Due to time constraints, we were unable to include in our analysis how individual differences in the content of MW was related to participant mood, MW, and SART performance. It would be worthwhile to analyze the open-ended responses that participants gave at the end of the study and determine whether there were patterns between the content of thoughts and study outcomes. This information could be used to expand on past studies, such as the study by Poerio et al. (2013) which suggested that the content of MW, rather than MW in general, positively correlated with later mood. From the open-ended responses, it is possible that common themes, such as relationships, the past, or homework, could be identified that have stronger correlations with MW and SART performance than participant mood does. If this is the case, it would suggest that certain topics are more closely associated with MW and perceptual decoupling than other topics are.
Additionally, analysis of individual differences in this study revealed that there was a difference between the positive and negative film groups with respect to the amount and type of MW that occurred in relation to mood. The discrepancy between these groups suggests that there is some difference between the two clips used for the mood induction that impacts MW. This opens the door to future research in order to better understand what component of the clips causes this. One possible explanation is that the film clip that was used for the positive film condition had both happy and sad components, and the positive film group had less of a change in mood than participants in the negative film group (Figure 1). Furthermore, some aspects of the positive clip may have been more susceptible to individual interpretation; for instance, both the dog and the boy in the clip had physical disabilities. This may have impacted participants in a way that was different than anticipated. In the future, a film clip could be chosen that is not as open to individual differences and interpretations, and special attention would be paid to whether there is still a discrepancy between positive and negative film groups.

In summary, the relationship between mood, MW, and task performance is not as clear as anticipated. Analysis of results from the film manipulation suggest that better mood leads to better task performance and stronger P300 response but does not impact MW. Furthermore, individual differences in mood on measures of MW, task performance, and P300 response were mixed. In the positive film group, findings for the relationship between MW and mood were consistent with expectations; however, in the negative film group, findings were not as anticipated. Given that the results from this study were mixed, and that some results contradicted previous findings in the literature, further research and analysis is warranted in order to explicitly and confidently determine the relationship between MW, mood, and task performance.
References


https://doi.org/10.1016/j.paid.2017.09.022

https://doi.org/10.1007/s12671-017-0778-y
Figures

Figure 1. The interaction between film group and time for four different mood measures.

These plots depict participant mood prior to the film (T1), after the film (T2), and after completion of the SART (T3). There were significant two-way interactions between time point and mood for all four mood measures, including (a) positive affect, (b) negative affect, (c) happiness, and (d) sadness. In each plot, it is clear that mood was the most affected at T2, immediately after the mood induction. The trends in each of these plots show the expected relationship between film clip and mood, indicating that the mood manipulation was effective. The error bars at each data point represent the confidence intervals.
Figure 2. Grand average of P300 amplitude by trial type at parietal electrode sites. These plots depict the grand average P300 amplitudes, or the average among all participants, in response to targets. These amplitudes were measured at the parietal electrode sites (a) P3, (b) Pz, and (c) P4. The time frame ranges from 200 ms prior to the onset of the stimulus to 1 second following the onset of the stimulus. In all three plots, the P300 peak occurred at approximately 550 ms following the onset of the stimulus. In each plot, the blue line represents P300 response to non-targets, while the red line represents P300 response to targets. It is clear from these plots that P300 response was higher for targets than non-targets at each parietal site measured.
Figure 3. Significant two-way interaction between trial type and film clip on P300 amplitude. According to the 2x2x3 mixed factorial ANOVA assessing the influence of various factors on P300 amplitude, there was a significant two-way interaction between trial type and film clip, $F(1, 46) = 73.142, p = 0.025$. From this plot, it appears that participants in the positive film group had a greater change in P300 response between targets and non-targets than members of the negative film group. The error bars at each data point represent the confidence intervals.
Figure 4. Significant two-way interaction between trial type and site on P300 amplitude.

According to the 2x2x3 mixed factorial ANOVA assessing the influence of various factors on P300 amplitude, there was a significant two-way interaction between trial type and electrode site, $F(2, 92) = 3.673, p = 0.002$. From this plot, it appears that the influence of trial type on P300 amplitude is greatest at the Pz site when compared to the P3 and P4 sites. The error bars at each data point represent the confidence intervals.
## Tables

**Table 1. Mean (SD) scores for negative and positive film groups.**

<table>
<thead>
<tr>
<th></th>
<th>Negative Film [M(SD)]</th>
<th>Positive Film [M(SD)]</th>
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<tbody>
<tr>
<td>Retro Overall MW *</td>
<td>57.2 (25.6)</td>
<td>41.7 (28.7)</td>
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<tr>
<td>Retro MWD</td>
<td>28.8 (23.9)</td>
<td>24.2 (22.2)</td>
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<tr>
<td>Retro MW Negative</td>
<td>36.0 (28.1)</td>
<td>28.3 (25.1)</td>
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<tr>
<td>Retro MW Positive</td>
<td>46.0 (30.1)</td>
<td>52.1 (29.3)</td>
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<tr>
<td>Probe Count On Task</td>
<td>4.840 (3.3)</td>
<td>5.875 (2.98)</td>
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<tr>
<td>Probe Proportion MWD</td>
<td>0.273 (0.25)</td>
<td>0.234 (0.27)</td>
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<tr>
<td>Probe Count Total MW</td>
<td>7.160 (3.3)</td>
<td>6.125 (2.98)</td>
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<td>Probe Count MW Valence</td>
<td>3.963 (0.80)</td>
<td>4.237 (0.81)</td>
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<tr>
<td>SART Accuracy non-target</td>
<td>0.998 (0.0037)</td>
<td>1.00 (0.0)</td>
</tr>
<tr>
<td>SART Accuracy Target *</td>
<td>0.968 (0.07)</td>
<td>0.993 (0.020)</td>
</tr>
<tr>
<td>SART Reaction Time Target</td>
<td>561.575 (107.8)</td>
<td>550.689 (102.2)</td>
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**p < 0.05**

* 0.05 < p < 0.1
Appendices

Appendix A

Positive and Negative Affect Schedule (PANAS) to Measure Participant Mood

<table>
<thead>
<tr>
<th>PANAS 1</th>
<th>Interested</th>
<th>Very slightly or not at all</th>
<th>A little</th>
<th>Moderately</th>
<th>Quite a bit</th>
<th>Extremely</th>
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<th>Distressed</th>
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<th>A little</th>
<th>Moderately</th>
<th>Quite a bit</th>
<th>Extremely</th>
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<th>A little</th>
<th>Moderately</th>
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<th>PANAS 4</th>
<th>Upset</th>
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<th>A little</th>
<th>Moderately</th>
<th>Quite a bit</th>
<th>Extremely</th>
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<tr>
<th>PANAS 5</th>
<th>Strong</th>
<th>Very slightly or not at all</th>
<th>A little</th>
<th>Moderately</th>
<th>Quite a bit</th>
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<th>PANAS 6</th>
<th>Guilty</th>
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<th>A little</th>
<th>Moderately</th>
<th>Quite a bit</th>
<th>Extremely</th>
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<th>Scared</th>
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<th>A little</th>
<th>Moderately</th>
<th>Quite a bit</th>
<th>Extremely</th>
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<th>PANAS 8</th>
<th>Hostile</th>
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<th>Moderately</th>
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<th>A little</th>
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<th>A little</th>
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<th>Quite a bit</th>
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<th>Moderately</th>
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<th>A little</th>
<th>Moderately</th>
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<th>A little</th>
<th>Moderately</th>
<th>Quite a bit</th>
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<th>A little</th>
<th>Moderately</th>
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<th>A little</th>
<th>Moderately</th>
<th>Quite a bit</th>
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<th>Jittery</th>
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<th>A little</th>
<th>Moderately</th>
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Appendix B

Definitions of Deliberate Versus Spontaneous MW Given to Participants Prior to SART

Immediately after the second PANAS (at T2), participants were shown a series of five slides explaining the distinction between deliberate versus spontaneous MW (see below):

Slide 1:

Every now and then during the task, a screen will appear that asks if you are on-task or mind-wandering.

By “on task” we mean that your thoughts are fully focused on the task itself (watching for the number 3).

By “mind-wandering,” we mean that your thoughts have wandered away from the task and you are thinking about something else, like plans later in the day or something that happened yesterday. As long as you are thinking about something else, choose the mind-wandering option rather than saying you are “on task.”

Press any key to continue with more instructions….

Slide 2:

You will also be asked if your mind-wandering is deliberate or spontaneous.

By “deliberate,” we mean an intentional shift to inward thoughts. An example of deliberate mind-wandering is when an individual is in history class and they begin to intentionally move their attention to something more productive like what they are going to make for dinner that night or how they are going to do their math homework.

Press any key for more instructions

Slide 3:
Another example of deliberate mind-wandering is when you're on a long car ride and you have nothing to do, so you purposely start planning what you are going to do at your destination.

Press any key for more instructions

**Slide 4:**

By “spontaneous” mind-wandering, we mean an unintentional shift to internal thoughts. An example of spontaneous mind-wandering is when an individual is in history class and they begin to think about what to make for dinner despite their best efforts to concentrate on what the professor is saying.

Press any key to continue

**Slide 5:**

Another example of spontaneous mind-wandering is when you’re on a long car ride and you have nothing to do, and your mind starts to drift towards thoughts of your last vacation.

Press any key for more instructions
Appendix C

Significant Findings From Various Statistical Analyses

*Findings with an asterisk indicate that the finding was a marginal trend, 0.05 < \( p \) < 0.1, while findings with no asterisk were statistically significant, \( p \) < 0.05

Film Influence on Mood

- Main effect of time point on positive affect, \( F(2, 94) = 38.85, p < 0.001 \)
- Main effect of film group on positive affect, \( F(2, 94) = 7.47, p < 0.001 \)
- Interaction between film group and time on positive affect, \( F(1, 47) = 10.6, p = 0.002 \)
- Significant difference in positive affect between film groups at T2, \( p < 0.001 \)
- Main effect of time point on negative affect, \( F(2, 94) = 5.66, p < 0.005 \)
- Main effect of film group on negative affect, \( F(2, 94) = 15.35, p < 0.001 \)
- Interaction between film group and time on negative affect, \( F(1, 47) = 5.23, p < 0.027 \)
- Significant difference in negative affect between film groups at T2, \( p = 0.002 \)
- Main effect of time point on happiness, \( F(2, 90) = 14.5, p < .001 \)
- Main effect of film group on happiness, \( F(2, 90) = 17.8, p < .001 \)
- Interaction between film group and time on happiness, \( F(1, 45) = 27.7, p < .001 \)
- Significant difference in happiness between film groups at T2, \( p < 0.001 \)
- Main effect of time point on sadness, \( F(2, 94) = 26.3, p < 0.001 \)
- Main effect of film group on sadness, \( F(2, 94) = 14.8, p < 0.001 \)
- Interaction between film group and time on sadness, \( F(1,47) = 9.32, p = 0.004 \)
- Significant difference in sadness between film groups at T2, \( p < 0.001 \)

Film Influence on MW

- * Negative film group had higher overall MW than positive film group, \( t(47) = 2.002, \)
Film Influence on SART Performance

- Participants in the negative film group pressed the non-target significantly more than participants in the positive film group, \( t(47) = -2.094, p = 0.042 \)
- * Participants in the positive film group accurately pressed the target more than participants in the negative film group, \( t(47) = -1.686, p = 0.098 \)

Film Influence on P300 Response

- P300 response was higher for targets than non-targets, \( F(1,46) = 112.753, p < .001 \)
- Two-way interaction between trial type and film clip on P300 response, \( F(1, 46) = 73.142, p = 0.025 \)
  - Participants in the positive film group had a larger difference in P300 response to targets versus non-targets than participants in the negative film group did.
- Two-way interaction between trial type and site on P300 response, \( F(2, 92) = 3.673, p = 0.002 \)
  - * Between subjects effect for film clip, \( F(1,46) = 3.19, p = 0.081 \)

Individual Differences

- In the positive film group, participants with higher positive affect at T2 were more likely to deliberately MW during the SART (retrospective report of deliberate MW: \( r = 0.433, p = 0.034 \); probe-caught deliberate MW: \( r = 0.487, p = 0.018 \))
- In the positive film group, participants with a higher negative affect at T2 were likely to report more overall MW during the SART, \( r = 0.490, p = 0.015 \)
- * Participants with more deliberate MW had longer reaction times to targets during the SART, \( r = 0.252, p = 0.087 \)
- * Higher non-target accuracy was associated with more spontaneous versus deliberate MW (retrospective report of deliberate MW: \( r = -0.268, p = 0.069 \); probe-caught deliberate MW: \( r = -0.275, p = 0.056 \))

- Less overall MW was associated with more target accuracy, \( r = -0.314, p = 0.028 \)

- Less overall MW was associated with more non-target accuracy, \( r = -0.327, p = 0.022 \)

- * More overall MW was associated with longer reaction times to targets, \( r = 0.265, p = 0.066 \)