Attentional and Psychophysiological Correlates of Future Time Perspective Manipulation: An Eye-Tracking Study

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Abstract

Socioemotional Selectivity Theory posits that as person progresses through the life cycle, he or she makes concerted steps to maximize social and emotional wellbeing through selective patterns of emotional processing (Carstensen, 1995). The temporal positioning of an individual's goals, motivations, and social orientations, or future time perspective (FTP), drives this change in emotional processing. The association between FTP and age is a naturally-occurring phenomenon as FTP becomes more limited as a person ages; however, it is believed that the construct of future time perspective is sufficiently malleable to be experimentally manipulated (Carstensen, 2003). The current study assessed the effects of a future time perspective manipulation on the emotional processing of positively and negatively valenced IAPS images in a college sample. Emotional processing was indexed by heart rate variability (HRV), skin conductance, memory recall, and eye-tracking. Young adult volunteers (N=22) were randomly assigned to one of two experimental conditions, wherein their future time perspective was manipulated to become either more limited or more expansive. Participants viewed a series of positive and negative cues followed by corresponding valenced images before and after the future time perspective manipulation. Preliminary results of the current study suggest the imagery task had no significant effect on FTP. Due to limitations from the small sample size, a larger sample size will be needed to conduct valid group comparisons to sufficiently test the effectiveness of the manipulation. Results of this study show participants with a more limited FTP had lower LF and greater HF HRV, indicating greater emotional regulation of arousal during the task. Interestingly, our results also indicate that positive affect ratings on the PANAS were related to avoiding negative emotional content (lower fixation percentage for negative images and cues), remembering more positive information (greater positive memory recall), detecting a greater saliency for positive information (longer skin conductance rec t/2), lower sympathetic activity (lower posttest LF and SCL) and greater parasympathetic activity (greater posttest HF and RMSSD). These data suggest that reports of affect might provide more sensitive indication of emotional processing than future time perspective.

Key words: socioemotional selectivity theory, future time perspective, skin conductance, heart rate variability, eye-tracking

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Biases in attention for information processing have been well documented in the past, specifically with regard to the maintenance of emotional well-being (Mikels et al., 2005; Cisler & Koster, 2010; De Raedt & Koster, 2010; Grupe & Nitschke, 2011). The allocation of attention toward particular types of information and away from others has been shown to be an effective strategy of emotion regulation (Gross, 1998). The pattern of attentional deployment an individual utilizes to process the emotional information in their environment has been theorized to differ according to certain individual-level characteristics. Socioemotional selectivity theory proposes that patterns of attentional deployment associated with emotional information processing vary by stage of the life cycle (Carstensen, Isaacowitz, & Charles, 1999). It is thought that chronological age is associated with ranging patterns of attentional deployment due to differing perceptions of the future and the temporal orientation of a person’s motivations and goals. Young adults typically perceive time as expansive as they see life as new with the future holding opportunities for growth. Correspondingly, they seek out novel experiences, indiscriminately processing both positive and negative content in their environment in order to obtain information about their social world. Contrastingly, older adults do not show a similar predilection for information seeking behavior. People in later stages of the life cycle typically demonstrate a limited time perspective due to their recognition of a ticking biological clock (Carstensen, 2003). As a result, older adults prioritize the processing of emotionally and socially gratifying information in the present and avoid situations that would impair these pleasant feelings. This pattern of attentional deployment, to seek out positive information in a person's environment and to avoid negative information with the aim to enhance positive experiences, has been described as a *positivity effect* (Carstensen & Mikels, 2005). The antecedent emotion regulation strategies typified by age-related positivity effects have been shown to influence memory (Carstensen, 1995; Charles, Mather, & Carstensen, 2003; Mikels et al., 2005) as older adults with a limited future time perspective tend to forget negative information and remember positive information due to positive attention biases at the point of encoding.

Future time perspective, although highly correlated with chronological age, Carstensen et al. suggests that experimentally manipulating a person's future time perspective might result in the corresponding changes to emotional processing. In a recent study, the future time perspectives of a young adult sample were manipulated using a mental imagery task (Demeyer & De Raedt, 2013). Participants were randomly assigned to one of two experimental conditions, wherein each participant's time perspective was manipulated to either be limited and short-term (STP) or to be expansive and long-term (LTP). After a manipulation check demonstrated the manipulation was effective, participants engaged in an exogenous cueing task to assess attentional bias to negative and positive content. Results indicated attentional bias to valenced information was not predicted by future time perspective. Interpretations of this finding consider the lack of accuracy in judging participant's precise patterns of attentional deployment as a potential limitation. Some previous studies investigating visual attention and the processing of emotional content utilize eye-tracking methods to combat the issue of attention measurement precision (Mather & Carstensen, 2003; Isaacowitz et al., 2006a; Isaacowitz et al., 2006b; Allard & Isaacowitz, 2008; Bardeen & Daniel, 2017).

Other Considerations

Emotional processing and psychophysiological adaptability. Measurement of activity in the autonomic nervous system provides another mechanism by which the processing of emotional information can be assessed. Psychophysiological adaptability describes the regulative interplay between sympathetic and parasympathetic influences on the nervous system. The varying levels of each autonomic system can be assessed via psychophysiological measurement of electrodermal activity (EDA) and heart rate variability (HRV). Heightened levels of EDA, or skin conductance levels, are indicative of influences from the sympathetic nervous system and have been previously related to poor emotion regulation (Gross, 2002). In contrast, smaller phasic skin conductance responses (SCR) to discrete events indicate greater emotion regulation (Raio et al., 2013). In addition to skin conductance, measurements of HRV supply indices of autonomic activity. Both parasympathetic and sympathetic nervous systems are implicated in affecting HRV. Results from a recent meta-analysis suggest low HRV to be related to perseverative negative affect (Ottaviani et al., 2016). Low HRV has also been related to negative attention biases, indicating greater sympathetic activity and lower parasympathetic activity to be demonstrative of maladaptive emotional processing (Gillie, Vasey, & Thayer, 2015). To our knowledge, the relationship between these autonomic measurements and the eye-tracking indices of emotional processing have not previously been studied together within the framework of socioemotional selectivity theory.

Cognitive costs of task demands and emotion regulation. Parasympathetic influences on heart rate variability have previously been shown to decrease over time as a result of task demands (Taelman et al., 2009). As ratings of cognitive performance and cognitive control decline, so too do the vagal influences on HRV. The conjecture that mental fatigue can be indexed by autonomic measures is supported by the neurovisceral integration model (NIM; Thayer & Lane, 2000), which argues that autonomic modulation shares a common neural circuit with specific areas of the brain associated with cognitive control. Recent research investigating changes in autonomic modulation of HRV following a 50-minute Go/NoGo task found evidence to suggest time-on-task effects decrease parasympathetic influences on HRV as well as increase self-reported mental fatigue, a conscious phenomenological state reflecting a depleted attentional resource state (Melo et al., 2017). The introduction of task demands has also been shown to impact patterns of attentional deployment to certain types of emotional content (Mather & Knight, 2005; Knight et al., 2007; Allard & Isaacowitz, 2008), as a requisite level of cognitive capacity is needed to maintain the antecedent emotion regulation strategies of the positivity effect.

Current Study

The current study utilized both within-subjects and between-groups frameworks to assess the effects of a future time perspective manipulation on the physiological adaptability to and visual processing of emotional stimuli in a college sample using eye-tracking. Young adult volunteers were randomly assigned to one of two experimental conditions, wherein their future time perspective was manipulated to become more limited or more expansive. Participants viewed a series of positive and negative images before and after the future time perspective manipulation. Each image followed a graphic cue presented on the screen to inform participants of the emotion category of the subsequent image. Eye tracking was utilized to assess preferences in emotional processing via allocation of visual attention during the image viewing task. The autonomic measures of skin conductance and heart rate variability were examined throughout the task, as well as for two 5-minute baseline periods (one pretest and one posttest) in order to investigate the relationship between visual attention and the physiological correlates of emotional processing as a function of future time perspective.

With indications from previous research noting a positivity effect in memory (Kennedy, Mather, & Carstensen, 2004; Mikels et al., 2005) and visual attention (Isaacowitz et al., 2006; Allard & Isaacowitz, 2008) for those with a limited, short-term future time perspective, we hypothesized that participants assigned to the short-term time perspective condition (STP) would demonstrate greater preference for positively valenced content relative to negative content via eye tracking and a posttest recall of the images viewed during the task. In addition, considering those with a limited time perspective's tendency for antecedent emotion regulation (Carstensen, 2003), we hypothesized participants in the STP condition would show greater skin conductance responses (SCR) to the negative emotional cues that preceded the presentation of the negative images and would divert visual attention from the negative cues. For those assigned to the more expansive, long-term future time perspective condition (LTP), we predicted no selection biases in the allocation of visual attention to the different emotional cues and images per literature evidencing indiscriminant seeking behaviors for this group (Carstensen, 1995). Acknowledging the debate in the extant literature for the cognitive costs of emotion regulation strategies typically employed by people with differing future time perspectives (Carstensen, Isaacowitz, & Charles, 1999; Carstensen, 2003; Mather & Knight, 2005; Allard & Isaacowitz, 2008; Melo et al., 2017) and since no explicit task demands were introduced in the current paradigm, no a priori hypotheses were made considering changes in heart rate variability or attentional deployment from pretest to posttest baselines.

Method

Participants

Twenty-five (5 males, 20 females; ages 19-27, *M*=20.91, *SD* = 1.82) student volunteers participated in the present study. Students were recruited from the Department of Psychology's online subject pool at the University of Missouri-Kansas City and were compensated with two hours of research credit for their psychology coursework. Potential participants were excluded from the analyses if they required corrective contacts or glasses that rendered eye tracking data unusable. Other exclusion criteria included abnormalities in heart rate or excessive movement artifacts that prevented the autonomic measures from being scored. Data from three participants (all female) were removed from the analyses based on these criteria, leaving a usable sample of twenty-two student participants.

Stimuli

This study's stimuli were chosen from the International Affective Picture System database (IAPS; Lang, Bradley, & Cuthbert, 2001) based on the images used in Allard & Isaacowitz (2008) due to the similarities in the frameworks used for our studies. Lang et al. employed a normalizing procedure to code images for valence and arousal. The positive and negative images used in the current study were matched for arousal in order to control for potential confounding effects on visual attention and physiological reactivity to the images (positive: *M* = 4.54, *SD* = .28; negative: *M* = 4.63, *SD* = .53; Allard & Isaacowitz, 2008). Non-verbal visual cues presented prior to each image were designed to reliably inform participants of the emotional content of the subsequent image (“+” preceding positive images, “–” preceding negative images).

A total of 48 positive and negative images (24 each) were selected for this study. Twelve images from each emotion category were randomized to be presented in each of two blocks, before and after the future time perspective manipulation. The list of IAPS images used in this study can be found in Appendix A.

Mental Imagery Task

The manipulation of future time perspective chosen for this study was a non-invasive mental imagery task (Demeyer & Raedt, 2013). For each of the two experimental conditions, participants were asked to spend around 30 seconds verbally depicting the qualia of 10 hypothetical events or scenarios that would take place in either the short-term or long-term future. Participants were instructed to envision themselves engaging in the scenario and to describe their associated thoughts, feelings, and surroundings. An overview of all the scenarios used in the mental imagery task can be found in Appendix B.

Equipment

An Applied Sciences Laboratories remote eye tracker was used to monitor gaze fixations while the participants were viewing the emotional images. The eye tracker sampled eye position 60 times per second with an accuracy rating of 0.5° visual angle and provided a continuous stream of data including eye position (X-Y coordinates). Participants were seated in a sound-attenuated room that contains a table and chair, computer monitor, and an Applied Science Laboratories D-6 optics module. The experiment was presented on a 17-inch monitor on a table in front of the participant. The eye-tracking camera, situated in a custom-designed harness just below the computer monitor, received instruction from and sent data to two computers located outside the booth. GazeTracker^{TM} software – GazeTracker software by Eyetellect ("Eyetellect: Intellect at the Speed of Sight,") was used for stimulus presentation, data acquisition, and some preliminary data analysis. In data acquisition mode, GazeTracker converted eye location data provided by the eye tracker into a series of fixations mapped onto to areas of interest (AOIs) corresponding to the different emotional elements of each image. Fixations were defined as a minimum of two sampled eye positions occurring within a fixation diameter of 30 pixels with a minimum duration of 100 msec. Fixation percentage, the main dependent variable for visual attention, is defined as the percentage of time during the stimulus presentation that a participant's gaze fixates within the predetermined AOIs.

A Biopac MP150 system was used for physiological data acquisition. Skin conductance was recorded at 250Hz using two 8mm Ag/AgCl electrodermal activity electrodes placed on the distal phalanges of the participant's left index and middle fingers. Mean non-specific skin conductance response (NS-SCR) amplitudes were calculated from the change in skin conductance at stimulus onset to the peak value of the response (Braithwaite et al., 2013). Heart rate was recorded at 500Hz using two 4mm Ag/AgCl electrocardiography (ECG) electrodes placed on the participant's left wrist and left ankle (the skin conductance sensors served as a sufficient ground for the ECG signal). Heart rate data were scored offline using Kubios HRV Premium software to calculate the time domain variable of the square root of the mean of the sum of the squares of differences between adjacent NN intervals (RMSSD), as well as the frequency domain variables of the power in low frequency (0-04-0-15 Hz) and in high frequency (0-15-0-4 Hz) HRV (European Society of Cardiology [ESC], 1996).

Procedure

During the recruitment process, students completed the Multidimensional Future Time Perspective Scale (Brothers et al., 2014) online prior to their scheduled lab visit. Upon arrival to our lab, participants were administered a series of demographic, trait anxiety, and emotion regulation questionnaires, as well as the Positive and Negative Affective Schedule (PANAS; Watson et al., 1988; see Table 1 for data on these measures). Participants were then seated in the sound-attenuating room in front of the presentation monitor. The eye tracking apparatus located below the monitor was placed at a distance of 24 inches from the participants' right eye. Images presented covered an average pixel dimension of 960 x 720. Image AOIs were located to encompass the central emotional event(s) of each image. Cue AOIs were placed centrally around the positive and negative cues. Average pixel dimensions for the image AOIs was 558.84 x 512.02 and for the cue AOIs was 538.67 x 530.09. Cues were presented for three seconds each, followed by a blank slide for six seconds, with subsequent images presented also for six seconds. Between each trial, variable ISIs of 10-15 seconds were chosen to prevent patterned responses while providing sufficient temporal spacing to time lock stimuli presentation to arousal levels due to skin conductance response and recovery latency. A nine-point calibration slide was used to ensure the right-eye movements of each participant was accurately being measured at all points on the presentation screen. This calibration slide was presented before and after each of the two image viewing blocks to assess accuracy and drift.

A five-minute baseline period was conducted as a pretest in order to measure resting physiological measures for skin conductance and heart rate variability. Following the pretest baseline was the first block of the image viewing task. This first block was performed prior to the future time perspective manipulation in order to judge trait tendencies in visual attention and physiological adaptability. Participants were told that the emotion cues would be presented on the screen before the images so as to inform them of the category of image they were about to see. Participants were also instructed to keep their attention on the presentation monitor and to passively watch the 12 positive and 12 negative images proceed as if they were watching television at home.

After completion of the first image viewing task, participants were guided through the mental imagery task for their assigned condition. Participant descriptions of the hypothetical future events were audio recorded during the manipulation and transcribed later to assess the specific language used in depicting their futures (results of this qualitative analysis not presented here). As a manipulation check, a series of selected items reflective of the three factors from the Multidimensional Future Time Perspective Scale (Brothers et al., 2014) were administered.

Participants then returned to the second block of the image viewing task. The instructions to passively view the images and a description of the predictive cues were repeated. For this block, 12 positive and 12 negative images not yet seen were presented. After the block finished, participants were asked to verbally recall all images they remembered seeing from both image viewing blocks. Responses were audio recorded and later transcribed. A second five-minute baseline period ensued as a posttest of the participants' resting physiology after which articipants completed both the PANAS and Multidimensional Future Time Perspective Scale. On average, the experiment lasted around 90 minutes.

Results

Prior to testing the effectiveness of the manipulation, we first analyzed the descriptive characteristics of our sample (Table 1). Participants showed a relatively normal distribution for

FTP prior to the manipulation, scoring an average future time perspective of 38.14 (6.04) with a median score of 38 on the Multidimensional Future Time Perspective Scale. The sample size collected thus far (n=12 per group) does not allow for valid statistical analyses to be conducted for group comparisons; however, the statistical tests presented here are included to demonstrate the plan for analyses once a larger sample is collected and to display current trends. Preliminary paired samples t-tests were conducted to determine whether group mean FTP scores differed between participants in the two manipulation conditions. Trends in these preliminary findings suggest no main effect of our manipulation on the participants' future time perspectives to this point, STP: $t(10)= -.253$, $p>.05$; LTP: $t(10)= -1.536$, $p>.05$. The descriptives of these groups can be found in Table 1.

Post-hoc Analyses

Based on the general ineffectiveness of the manipulation seen thus far, as well as the relatively normal distribution of FTP scores, all participants' scores were assessed as a continuous variable, instead of grouping by condition, in a post-hoc analysis. Pearson correlations were conducted to test the relationships between the continuous FTP variable and the emotional processing outcome variables. At the end of their participation in the study, students with a more limited, short-term FTP showed lower sympathetic activity and greater parasympathetic activity during the posttest baseline compared to the pretest baseline, indexed by lower levels of low frequency (LF) and greater levels of high frequency (HF) heart rate variability, respectively, ($r(21)=.430$, $p<.05$; $r(21)=-.435$, $p<.05$). No other relationships of significance were observed with this continuous FTP variable.

In order to further investigate the importance of visual attention, memory, and physiological arousal for this paradigm, one of the theorized concomitant factors of future time perspective were tested. A key influence in the greater effectiveness of regulating emotions effectively for older adults and for individuals with a limited FTP is the tendency for these individuals to favor the emotional processing of positive stimuli in order to maintain a positive mood. Therefore, to test the influence of a positive mood on emotional processing, the relationship between scores from the positive factor of the PANAS and fixation percentage, memory recall, and the physiological indices of arousal were assessed.

Positive scores from the posttest PANAS were normally distributed for all participants. Without a natural segregation into distinct groups of scores, positive ratings from the PANAS were examined as a continuous variable in correlational analyses with the emotional processing outcome variables (Figure 1). In relation to the eye-tracking data collected during the two image viewing blocks, participants scoring higher on the positive factor of the PANAS deployed significantly less attention to the cues preceding the negative images as well as to the emotional content of the negative images indexed by a lower fixation percentage within the respective AOIs, ($r(21)=-.423$, $p<.05$; $r(21)=-.451$, $p<.05$). For relating mood ratings to the physiological variables, the posttest baseline period was primarily examined. During the posttest baseline period, positive scores on the PANAS were significantly related to lower sympathetic activity indicated by lower skin conductance levels (SCL) and lower LF ($r(21)=-.452$, $p<.05$; $r(21)=-.442$, $p<.05$).. Conversely, positive mood scores were significantly correlated with greater parasympathetic activity during the posttest baseline via greater HF and greater RMSSD, ($r(21)=.507$, $p<.05$; $r(21)=.512$, $p<.05$). Following the posttest baseline, the participants with higher positive ratings on the PANAS remembered a greater quantity of the positive images they were presented from both image viewing blocks. Ratings on the PANAS showed no relation to skin conductance responses during the task.

Exploratory Analyses

Skin conductance recovery. Due to the lack of evidence relating skin conductance response (SCR) amplitudes during the image viewing blocks to either of our variables of interest (FTP and PANAS scores), a different phasic skin conductance variable was examined to further investigate the relationship between emotional processing and physiological adaptability. Recovery time of the skin conductance response has been previously related to depth of information processing and stimulus significance (Podlesny & Raskin, 1978; Janes et al., 1985). However, research from Bundy et al. (1975) evidences that prestimulus electrodermal activity (EDA) may impact the rate of recovery for phasic skin conductance responses. Their results suggest that recovery half-time (rec t/2) is shorter following repeated and successive stimulation, whereas rec t/2 is longer following a period of relative quiescence. In order to control for these effects, Bundy et al. developed a formula to quantify the relevant prestimulus EDA in order to insure the rate of recovery of skin conductance responses reflects its hypothesized constructs. The formula below, *Bundy's X*, lists the variables for the relevant prestimulus EDA, where

$$\mathrm{X} = \frac{1}{\left(\frac{h_1}{t_1}\right) + \left(\frac{h_2}{t_2}\right)}$$

h_1 and h_2 reflect the amplitudes of the two previous phasic responses prior to the SCR in question, while t_1 and t_2 reflect the respective temporal distances of the two prestimulus phasic responses from the SCR in question.

Skin conductance recovery half-time following stimulation from both the positive and negative trials during the image viewing blocks were examined. Neither the rec t/2 following the positive or negative trials were related to a participant's FTP. Interestingly, for participants scoring higher on the positive factor of the PANAS, rec t/2 was longer following positive trials, $p<.05$. In order to determine if this result was impacted by prestimulus EDA, a simple Pearson correlation between rec t/2 and Bundy's X was conducted (Janes et al., 1985). Prestimulus EDA calculated from Bundy's X was not related to rec t/2 following positive trials ($r(21)=.224$, $p>.05$), suggesting that the stimuli from positive trials was perceived as more salient by participants with ratings of greater positive affect.

Cognitive costs. After observing a decline in parasympathetic activity for participants with more expansive future time perspectives, we analyzed the relationship between parasympathetic activity and visual attention to negative images by computing a Pearson correlation between these variables. Negative images were selected primarily due to the cognitive control necessary to maintain positive affect noted in other visual attention paradigms (Knight et al., 2007; Mather & Knight, 2005). During the second block of the image viewing task, correlations showed that participants who allocated more attention to the negative images showed parasympathetic reduction during the posttest baseline compared to the pretest baseline, indexed by lower HF and RMSSD, ($r(21)=-.490$, $p<.05$; $r(21)=-.443$, $p<.05$).

Discussion

In the current study, we investigated the relationship between visual attention, autonomic indices of arousal and regulation, and memory following a manipulation of future time perspective in a college sample. Per socioemotional selectivity theory, differences in visual processing of emotional content and its consolidation in memory have been noted to exist at certain points in the life cycle, with gaps in the literature about the physiological correlates of these factors. The temporal orientation of a person's emotional and social motivations, or an individual's future time perspective, is a construct seen to be highly correlated with chronological age. As a young adult ages, his or her future time perspective shifts from being more expansive to being more limited. The concomitant change in emotional and social motivations lead to differential emotional processing to suit the person's age-specific demands. It has been argued that future time perspective is a sufficiently malleable construct to allow for differences in emotional processing to be studied within one age group. Our study aimed to test whether manipulating FTP would result in altered emotional processing as indexed by visual attention, physiological adaptability, and memory recall following a manipulation of future time perspective of college student volunteers, as well as to determine the autonomic correlates of these factors.

After assessing the manipulation in the current study, preliminary results of the current study suggest the imagery task had no significant effect on FTP. Due to the current small sample size, we were unable to perform valid statistical tests of our primary hypotheses. Rather, the inter-individual differences in future time perspective after the manipulation were examined to determine the extent to which future time perspective influenced visual processing, physiological adaptability, and memory, independent of condition. Results of these post-hoc correlational analyses demonstrate that a more limited future time perspective is related to lower sympathetic and greater parasympathetic activity during the posttest baseline compared to the pretest baseline than for a more expansive future time perspective, indicating effective regulation of arousal during the task. The inverse of this correlational relationship, indicative of poor regulation for individuals with an expansive future time perspective, is consistent with the results of previous studies showing both a parasympathetic decrease and a sympathetic increase in HRV following extensive and demanding testing (Taelman et al., 2009; Zhao et al., 2012). A decline in cognitive performance during a demanding task measured by indices of activation of the autonomic nervous system have previously been interpreted as mental fatigue and poor autonomic regulation resulting in attention depletion (Melo et al., 2017). Although our task did not explicitly introduce demanding constraints on the participants, as they were instructed to passively view images as they progressed, emotional processing demands a requisite level of cognitive control (Knight et al., 2007).

These interpretations are supported by the additional analysis of the relationship between autonomic modulation of HRV and visual processing. During the second block of the image viewing task, more attention was allocated to the emotional content of the negative images for participants with lower parasympathetic activity during the posttest baseline period, regardless of FTP. These data suggest as the task wore on, participants experienced mental fatigue, indexed by a reduction in parasympathetic regulation of arousal and the diminished cognitive control necessary to avoid processing the negative emotional content to facilitate the experience of positive affect (Thayer & Lang, 2000; Taelman et al., 2009; Melo et al., 2017. However, the lack of self-report ratings of mental fatigue limits these interpretations to be speculative, as future research will need to identify these relationships and make the necessary design decisions a priori.

Due to the limitations of examining the outcome variables with respect to the experimental conditions, the positivity affect, a concomitant behavioral characteristic of a limited future time perspective, was analyzed to determine the extent to which the maintenance of positive affect is enabled by certain strategies and factors of visual attention, physiological adaptability, and memory. Our results indicate that maintaining a positive mood is related to avoiding negative emotional content (lower fixation percentage for negative images and cues), remembering more positive information (greater positive memory recall), detecting a greater saliency for positive information (longer skin conductance rec t/2), lower sympathetic activity (lower posttest LF and SCL) and greater parasympathetic activity (greater posttest HF and RMSSD). The robust relationships seen with positive affect and our outcome variables should not be surprising. Socioemotional selectivity theory posits that certain emotional content will be processed differentially by different FTP groups due to their varying predilection for processing positive information (Carstensen, 2003). Our findings could be interpreted to suggest a preference for positive emotional experiences might be a more sensitive indication of emotional processing than the temporal orientation of an individual’s goals and motivations indicated by future time perspective.

Limitations and Considerations for Future Research

The most significant limitation of this study is the sample size. No valid statistical tests can be conducted for such small group sizes to confidently discuss conclusions about the manipulation’s effectiveness. A larger sample size will be needed to analyze group differences by condition. A previous study utilizing the mental imagery task as a manipulation cited a relatively pronounced effect on future time perspective (Demeyer & Raedt, 2013). The results of this previous research provide promising indications that with a larger sample size, a similar effect on time perspective may be evidenced.

Another limitation of this paradigm comes from the relatively low arousal level chosen for the images presented during the image viewing blocks. Images selected from the IAPS database coded for greater arousal would have provided more pronounced physiological and visual processing differences, as well as a greater level of cognitive resources required to enact certain emotion regulation strategies. Since the original hypothesis of this study was not to examine the task demand effects of emotional processing on visual attention and physiological adaptability, images with moderate arousal values used were selected to reduce the potential for confounding results for the main hypotheses. Considering the promising results of the exploratory analyses that examined the relationship between visual processing and the autonomic indices of mental fatigue, future research should utilize highly arousing images that would require greater cognitive capacities to process in order to explicitly examine this relationship.

The Multidimensional Future Time Perspective Scale was administered twice in this paradigm, once pretest and once posttest. In addition, select items were chosen from each of the three factors described in the psychometrics description of the scale as a manipulation check after the mental imagery task (Brothers et al., 2014). This scale, however, has not yet been examined for test-retest reliability characteristics. Therefore, a limitation of this study might be that the temporal proximity of the Multidimensional FTP Scale's administrations may not have enabled sufficient variability in responses to provide a sensitive assessment of the participants' future time perspective. Other instruments measuring future time perspective were considered for this study, most notably the Future Time Perspective Scale (Carstensen & Lang, 1996), yet no psychometric properties of any kind were found for this scale or others.

Other limitations of this study related to the FTP manipulation, are the inherently positive scenarios presented to the participants during the mental imagery task for both limited and expansive future time perspective conditions. It is possible that the manipulation provided a confounding effect of increasing positive affect by introducing hypothetical scenarios that were positive in nature. The events were selected to be slightly positive, participants may have chosen to not fully process negative scenarios with the sufficient vigor for the manipulation to be effective and neutral scenarios may have been too vague to describe in detail (Demeyer & Raedt, 2013). In addition, positive affect scores from the PANAS did not significantly change from pretest to posttest. The limitation offered by the positive scenarios is then justified yet still deserves note. The significant results found in this experiment relating positive affect with visual processing, physiological adaptability, and memory are not believed to be attributable to the characteristics of the mental imagery task.

The importance of positive affect in this study raises certain questions for future research to investigate. Evidence from previous studies suggests an individual's future time perspective would be an individual difference variable of interest for researchers of cognitive aging due to this construct's corresponding influence on positive affect and its maintenance. Individuals with a limited future time perspective have shown preference for positive content in memory and visual processing in previous studies (Kennedy, Mather, & Carstensen, 2004; Mikels et al., 2005; Isaacowitz et al., 2006; Allard & Isaacowitz, 2008). In this study, however, the relationship between positive affect and the preference for engaging with positive content exists for visual attention and memory, as well as for the physiological correlates of adaptability, all without the influence of the hypothesized requisite limited future time perspective. In the absence of a multitude of robust relationships with future time perspective and the emotional processing outcome variables studied in this paradigm, future research should make sure to assess self-reported positive affect, which showed to be the key individual difference variable relating to several outcome variables in this study.

Although preliminary, the results of this study underscore the importance of including multiple measures of individual difference variables and outcome variables that accurately reflect their respective constructs. Scores from the Multidimensional FTP Scale and the PANAS were used as potential predictor variables since reports of limited FTP and positive affect were suggested to be related to the selective emotional processing patterns associated with a positivity effect. Eye-tracking, psychophysiological indices of autonomic regulation, and memory recall were assessed as the outcome variables for this study since visual attention, physiological adaptability, and memory were thought to be implicated in emotional processing. With the constraints of the limited sample size in this study, future time perspective was not shown to be a convincing predictor of emotional processing, relating to only a few of the outcome variables. However, under these same constraints, the related measure of positive affect showed to be a sufficiently sensitive indicator of emotional processing, relating to several of the outcome variables. In this study, the inclusion of multiple measures of the studied constructs allowed for otherwise unobserved relationships to be elucidated.

Appendix A

IAPS Numbers for Emotional Images	
Positive	*Negative*
2030, 2092, 2222, 2260, 2311, 2340, 2375, 2392, 2395, 2550, 2650, 8162, 8461, 1340, 1440, 1463, 1510, 1721, 1750, 5594, 5849, 7200, 7282, 7470	2141, 2455, 2490, 2750, 2900, 3300, 6311, 9415, 9041, 9046, 9560, 9584, 9912, 1270, 7361, 9010, 9102, 9101, 9110, 9280, 9440, 9471, 9561, 9830

Appendix B

Scenarios of the Mental Imagery Task – Future Time Perspective Manipulation	
Limited, Short-Term (STP)	*Expansive, Long-Term (LTP)*
Going on a little trip	Embarking on the voyage of your dreams
Studying	Working (later job)
Meeting friends	Meeting co-workers
Free morning this weekend	Having time off work
Inviting friends over	Preparing for own wedding/anniversary
Preparing for exams	Preparing for job interview
Birthday party	Birthday party for your firstborn child
Cleaning room	Decorating your own place
Receiving good news about exam/paper	Attending your graduation
Activity with friends	Activity with your child(ren)

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References

Allard, E. S., & Isaacowitz, D. M. (2008). Are preferences in emotional processing affected by distraction? Examining the age-related positivity effect in visual fixation within a dual-task paradigm. Aging, Neuropsychology, and Cognition, 15(6), 725-743.

Bardeen, J. R., Daniel, T. A., Hinnant, J. B., & Orcutt, H. K. (2017). Emotion dysregulation and threat-related attention bias variability. Motivation and Emotion, 41(3), 402-409.

Braithwaite, J. J., Watson, D. G., Jones, R., & Rowe, M. (2013). A guide for analysing electrodermal activity (EDA) & skin conductance responses (SCRs) for psychological experiments. Psychophysiology, 49(1), 1017-1034.

Brothers, A., Chui, H., Diehl, M., & Pruchno, R. (2014). Measuring future time perspective across adulthood: Development and evaluation of a brief multidimensional questionnaire. The Gerontologist, 54(6), 1075-1088.

Buhr, K., & Dugas, M. J. (2002). The intolerance of uncertainty scale: Psychometric properties of the English version. Behaviour research and therapy, 40(8), 931-945.

Bundy, R. S., & Fitzgerald, H. E. (1975). Stimulus specificity of electrodermal recovery time: An examination and reinterpretation of the evidence. Psychophysiology, 12(4), 406-411.

Carstensen, L. L., & Lang, F. R. (1996). Future time perspective scale. Unpublished manuscript, Stanford University.

Carstensen, L. L., & Mikels, J. A. (2005). At the intersection of emotion and cognition: Aging and the positivity effect. Current directions in psychological science, 14(3), 117-121.

Carstensen, L. L. (1995). Evidence for a life-span theory of socioemotional selectivity. Current directions in Psychological science, 4(5), 151-156.

Carstensen, L. L., Fung, H. H., & Charles, S. T. (2003). Socioemotional selectivity theory and the regulation of emotion in the second half of life. Motivation and emotion, 27(2), 103-123.

Carstensen, L. L., Isaacowitz, D. M., & Charles, S. T. (1999). Taking time seriously: A theory of socioemotional selectivity. American psychologist, 54(3), 165.

Charles, S. T., Mather, M., & Carstensen, L. L. (2003). Aging and emotional memory: The forgettable nature of negative images for older adults. Journal of Experimental Psychology: General, 132(2), 310.

Cisler, J. M., & Koster, E. H. (2010). Mechanisms of attentional biases towards threat in anxiety disorders: An integrative review. Clinical psychology review, 30(2), 203-216.

De Raedt, R., & Koster, E. H. (2010). Understanding vulnerability for depression from a cognitive neuroscience perspective: A reappraisal of attentional factors and a new conceptual framework. Cognitive, Affective, & Behavioral Neuroscience, 10(1), 50-70.

Demeyer, I., & De Raedt, R. (2014). The effect of future time perspective manipulation on affect and attentional bias. Cognitive therapy and research, 38(3), 302-312.

Garnefski, N., & Kraaij, V. (2007). The cognitive emotion regulation questionnaire. European Journal of Psychological Assessment, 23(3), 141-149.

Gillie, B. L., Vasey, M. W., & Thayer, J. F. (2015). Individual differences in resting heart rate variability moderate thought suppression success. Psychophysiology, 52(9), 1149-1160.

Gratz, K. L. & Roemer, L. (2004). Multidimensional assessment of emotion regulation and dysregulation: Development, factor structure, and initial validation of the Difficulties in Emotion Regulation Scale. Journal of Psychopathology and Behavioral Assessment, 26, 41-54.

Grös, D. F., Antony, M. M., Simms, L. J., & McCabe, R. E. (2007). Psychometric properties of the State-Trait Inventory for Cognitive and Somatic Anxiety (STICSA): comparison to the State-Trait Anxiety Inventory (STAI). Psychological assessment, 19(4), 369.

Gross, J. J. (1998). The emerging field of emotion regulation: an integrative review. Review of general psychology, 2(3), 271.

Gross, J. J. (2002). Emotion regulation: Affective, cognitive, and social consequences. Psychophysiology, 39(3), 281-291.

Grupe, D. W., & Nitschke, J. B. (2011). Uncertainty is associated with biased expectancies and heightened responses to aversion. Emotion, 11(2), 413.

Isaacowitz, D. M., Wadlinger, H. A., Goren, D., & Wilson, H. R. (2006a). Is there an age-related positivity effect in visual attention? A comparison of two methodologies. Emotion, 6(3), 511.

Isaacowitz, D. M., Wadlinger, H. A., Goren, D., & Wilson, H. R. (2006b). Selective preference in visual fixation away from negative images in old age? An eye-tracking study. Psychology and aging, 21(1), 40.

Janes, C. L., Strock, B. D., Weeks, D. G., & Worland, J. (1985). The effect of stimulus significance on skin conductance recovery. Psychophysiology, 22(2), 138-145.

Kennedy, Q., Mather, M., & Carstensen, L. L. (2004). The role of motivation in the age-related positivity effect in autobiographical memory. Psychological science, 15(3), 208-214.

Knight, M., Seymour, T. L., Gaunt, J. T., Baker, C., Nesmith, K., & Mather, M. (2007). Aging and goal-directed emotional attention: distraction reverses emotional biases. Emotion, 7(4), 705.

Lang, P., & Bradley, M. M. (2007). The International Affective Picture System (IAPS) in the study of emotion and attention. Handbook of emotion elicitation and assessment, 29.

Mather, M., & Carstensen, L. L. (2003). Aging and attentional biases for emotional faces. Psychological science, 14(5), 409-415.

Mather, M., & Knight, M. (2005). Goal-directed memory: The role of cognitive control in older adults' emotional memory. Psychology and aging, 20(4), 554.

Melo, H. M., Nascimento, L. M., & Takase, E. (2017). Mental fatigue and heart rate variability (HRV): The time-on-task effect. Psychology & Neuroscience, 10(4), 428.

Mikels, J. A., Larkin, G. R., Reuter-Lorenz, P. A., & Carstensen, L. L. (2005). Divergent trajectories in the aging mind: Changes in working memory for affective versus visual information with age. Psychology and aging, 20(4), 542.

Ottaviani, C., Thayer, J. F., Verkuil, B., Lonigro, A., Medea, B., Couyoumdjian, A., & Brosschot, J. F. (2016). Physiological concomitants of perseverative cognition: A systematic review and meta-analysis. Psychological Bulletin, 142(3), 231.

Podlesny, J. A., & Raskin, D. C. (1978). Effectiveness of techniques and physiological measures in the detection of deception. Psychophysiology, 15(4), 344-359.

Raio, C. M., Orederu, T. A., Palazzolo, L., Shurick, A. A., & Phelps, E. A. (2013). Cognitive emotion regulation fails the stress test. Proceedings of the National Academy of Sciences, 110(37), 15139-15144.

Taelman, J., Vandeput, S., Spaepen, A., & Van Huffel, S. (2009). Influence of mental stress on heart rate and heart rate variability. In 4th European conference of the international federation for medical and biological engineering (pp. 1366-1369). Springer, Berlin, Heidelberg.

Task Force of the European Society of Cardiology. (1996). Heart rate variability. European heart journal, 17, 354-381.

Thayer, J. F., & Lane, R. D. (2000). A model of neurovisceral integration in emotion regulation and dysregulation. Journal of affective disorders, 61(3), 201-216.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. Journal of personality and social psychology, 54(6), 1063.

Zhao, C., Zhao, M., Liu, J., & Zheng, C. (2012). Electroencephalogram and electrocardiograph assessment of mental fatigue in a driving simulator. Accident Analysis & Prevention, 45, 83-90.

Table 1. Demographics and Self-Reports

Measure	STP	LTP
Total *n*	11	11
Men	2	3
Women	9	8
Age	20.55(1.21)	21.27(2.28)
Pretest		
FTP[a]	39.18(5.79)	37.09(6.38)
STICSA[b]	39.81(9.11)	42.64(10.15)
PANAS-positive[c]	25.18(9.60)	28.18(7.64)
PANAS-negative[d]	12.64(3.04)	16.00(8.31)
ERQ (cog)[e]	30.09(6.83)	29.27(6.87)
ERQ (exp)[f]	19.09(8.57)	19.23(7.43)
DERS[g]	88.27(20.37)	94.91(19.49)
IUS[h]	53.18(18.98)	63.82(17.13)
Posttest		
FTP	39.73(4.69)	40.91(4.55)
STICSA	37.73(10.89)	43.45(8.69)
PANAS-positive	30.00(7.90)	33.18(10.38)
PANAS-negative	16.45(6.52)	17.82(6.48)

Note: Standard deviations in parentheses.

a – Multidimensional Future Time Perspective Scale (Brothers et al., 2014)

b – State Trait Inventory of Cognitive and Somatic Anxiety (Grös et al., 2007)

c – Positive and Negative Affective Schedule – Positive Factor (Watson et al., 1988)

d – Positive and Negative Affective Schedule – Negative Factor (Watson et al., 1988)

e – Emotion Regulation Questionnaire – Cognitive Reappraisal (Garnefski & Kraaij, 2007)

f – Emotion Regulation Questionnaire – Expressive Suppression (Garnefski & Kraaij, 2007)

g – Difficulties in Emotion Regulation Scale (Gratz & Roemer, 2004)

h – Intolerance of Uncertainty Scale (Buhr & Dugas, 2002)

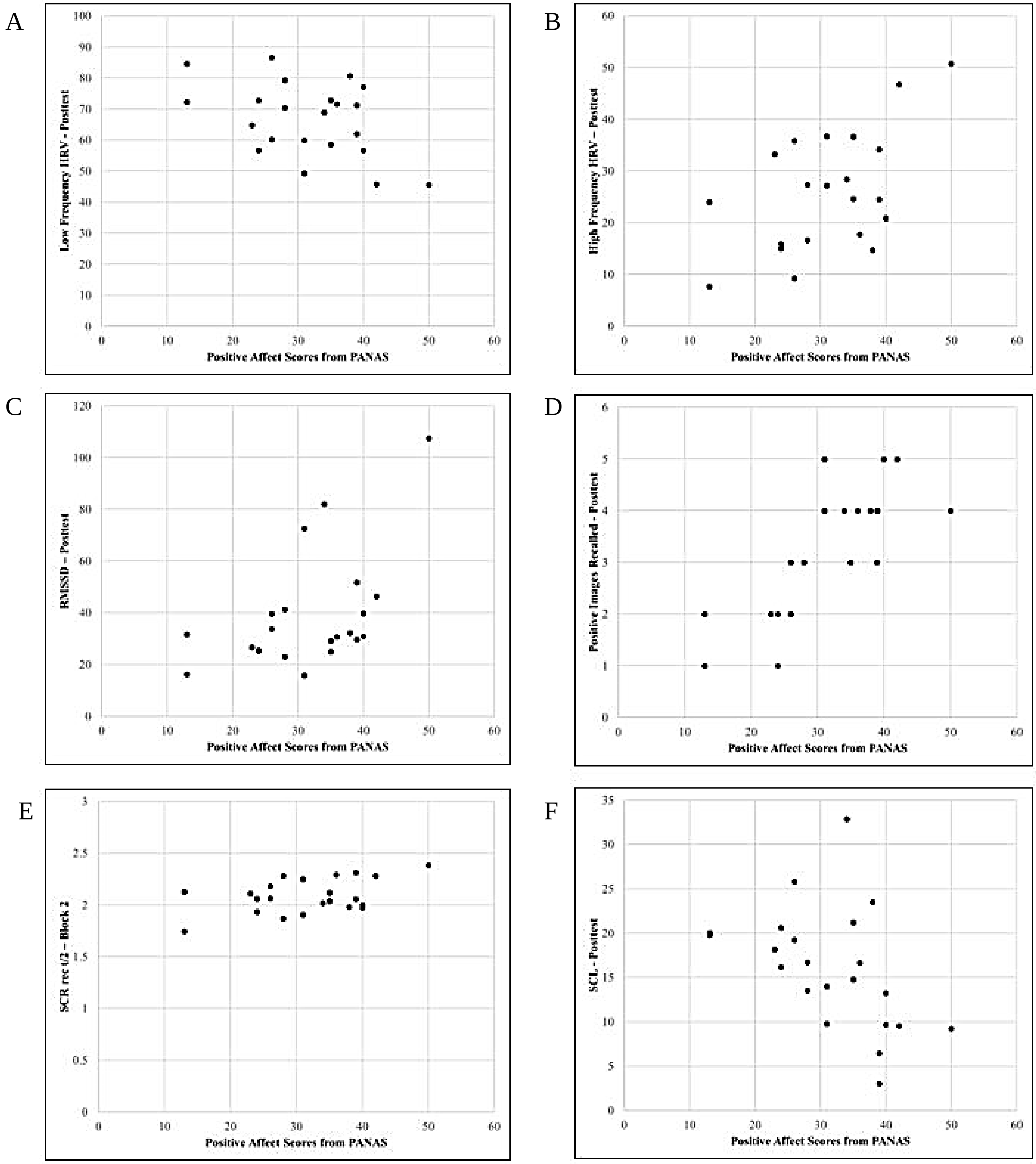

Figure 1. Relationships between positive ratings from the PANAS and *A*) LF HRV, *B*) HF HRV, *C*) RMSSD, *D*) positive image recall, *E*) SCR rec t/2, and *F*) posttest SCL.