The Undoing Effect of Positive Emotion in Children

An honors thesis for the Department of Psychology

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Abstract

The current study was conducted to determine if positive emotions serve to "undo" negative emotion, and to test if this effect varies with individual differences in behavior and temperament. Twenty-two children (11 male, ages 8-11) were presented with two blocks of three film clips. Each began with a low arousal baseline, followed by a sad clip and then either a happy or neutral clip. Contrary to predictions, the undoing effect was not seen in any of the measures. However, children rated high on attention showed less recovery from sadness while those rated high on inhibitory control showed greater recovery. Failure to observe the undoing effect in this sample may mean that this strategy of emotion regulation appears later in development.

The Undoing Effect of Positive Emotion in Children

Experiencing emotion is a part of everyday life. When you miss the bus in the morning, you feel frustrated and angry with your roommate for hogging the bathroom. At your favorite coffee house, the usual 20 minute wait is now five and you feel hopeful about your day and a little more relaxed. When you finally get to work and find that you will have to stay late for a meeting you become disappointed and sad about the lost opportunity to spend time with friends. When you finally get home and your best friend shows up with your favorite movie and some popcorn, you forget about the rest of your day and feel glad that some one thought of you. In this way, emotions are a constant part of our experience and yet evolve from moment to moment.

Gross and Thompson (2007) propose that the meaning of emotion is based in our goals. Events that are relevant to each of us individually elicit emotional reactions that may not be seen in others if they do not view the given occurrence as personally important. Gross and Thompson also propose that emotions are made up of several elements, including the affect that we report feeling, our behavioral reactions, and physiological activity. For example, if your flight has been canceled, delaying the start of your vacation, you would report feeling angry and disappointed, you may express your frustration verbally to an airline employee, and your heart rate and blood pressure would increase. Since this event interferes with your goal of getting to your destination, it elicits a distinct emotional reaction that reflects the personal relevance of the situation.

Emotions are commonly classified on two dimensions, namely valence and arousal. While contentment is positive and associated with relatively low levels of excitement and stimulation, fear is a negative emotion that can be extremely distressing. Though emotions may seem very similar to moods, emotions are more short-term and arise directly as a result of a discrete set of circumstances (Gross & Thompson, 2007). While dark and cold winter weather

may make you feel depressed for days at a time, a pop quiz would make you anxious for a shorter period of time, maybe only a matter of minutes. Additionally, emotions often initiate a call to action that is more specific than that which would arise from a mood. However, as will be explained, we do not always have to follow these behavioral tendencies.

Positive Emotions

Fear and anger prepare us to fight or flee, but joy and contentment do not seem nearly as critical to our survival. Positive emotions have not been studied as extensively as negative emotions and, consequently, are less well understood. Fredrickson (1998) has suggested that positive emotions should not be conceptualized in the same way that negative emotions are. Instead of trying to fit positive emotions into models that have been developed predominantly for negative emotions, Fredrickson offers the Broaden-and-Build Theory of Positive Emotions. In the Broaden-and-Build Theory, positive emotions serve to expand the range of possible reactions to the environment, as opposed to how negative emotions prepare the individual for a specific course of action. The second component of this model suggests that positive emotions may be useful for building personal resources. For example, expressing happiness may make one more likely to form and maintain social contacts. Fredrickson also proposes that an adaptive function of positive emotions may be to counteract the arousal caused by negative emotions. After a negative emotion has triggered a specific mental and physical response, positive emotions could reverse this effect by broadening the scope of cognition and action. This undoing effect of positive emotions may be critical for preventing the harmful long-term effects that negative emotions could cause if left unchecked.

The Undoing Effect of Positive Emotions

Fredrickson and Levenson first illustrated the undoing effect of positive emotions in a study with adults in which films were used to elicit affect (1998). First, participants were shown a film clip that induced fear. Compared to baseline measurements, the fear clip elicited a distinct pattern of cardiovascular activity, including decreased heart rate. The fear clip was then followed by a second clip that elicited neutrality, contentment, amusement, or sadness. They found that a positive (contentment, amusement) follow-up clip allowed for a faster return to baseline cardiovascular activity than a negative (sad) or neutral secondary clip. In effect, positive emotions were shown to undo the reactivity caused by the negative emotion. These results were replicated in a second study that replaced the fear clip with an anxiety-eliciting public speaking task (Fredrickson, Mancuso, Branigan, & Tugade, 2000). This follow-up research suggests that the undoing effect of positive emotions is not unique to the experimental paradigm created by Fredrickson and Levenson (1998). Instead, it may be one that can be extended to a variety of situations.

However, positive emotions could simply be replacing the reactivity to the fear clip with their own pattern of cardiovascular activity. Assuming that a neutral film clip would not elicit any specific pattern of activity, a positive film clip could differ from a neutral film clip in this important way. To eliminate this possible confound, the follow-up study (Fredrickson, Mancuso, Branigan, & Tugade, 2000) to Fredrickson and Levenson's experiment (1998) also confirmed that the mechanism by which positive emotions speed recovery from negative emotions is an undoing effect and not a replacement effect. Adult participants viewed one of the same films used by Fredrickson and Levenson (1998) that elicited contentment, amusement, neutrality, or sadness. In this experiment, however, the participants viewed one of these four films after a

neutral state instead of after experiencing a negative emotion. Despite differing in reported elicited emotion, no significant differences were found in cardiovascular reactivity to the positive or neutral follow-up film clips. Given that the positive and neutral follow-up films did not differ in the cardiovascular activity that they produced, they could not have differentially replaced the reactivity to the fear clip in other studies (Fredrickson & Levenson, 1998; Fredrickson, Mancuso, Branigan, & Tugade, 2000). Thus, positive emotions are unique in their ability to speed recovery from the effects of negative emotions. The undoing effect may therefore be a means by which we can control our emotional experience.

Emotion Regulation

Emotional reactions are often automatic and instantaneous. Thus, it may seem that there is little we can do to modulate the process by which our affect, behavior, and physiology respond to a given situation. However, as seen in the undoing effect of positive emotions, our emotional experiences are subject to change. This is known as emotion regulation and through this means one can increase or decrease the intensity or duration of an emotion or maintain a current state. Gross (1998) proposes that we can regulate our emotions at five different stages of the emotional experience. These include situation selection, situation modification, attention deployment, cognitive change, and response modulation. At each of these points we can alter the way we feel, our physiological reaction, and the emotion we display to others. For example, we may avoid anxiety by not raising our hand in class, reduce our anger by leaving the room during an argument, think of the upcoming weekend to decrease stress while studying, reevaluate a difficult project as a learning opportunity, or put on a happy face despite feeling sad. Thus, from avoiding a situation entirely to modulating our responses to an event that is already unfolding, we can edit our emotional experience. The undoing effect of positive emotion may be an

important way in which we recover from negative emotional experiences by focusing on the positive.

The undoing effect appears to occur at the level of attentional deployment in Gross' model (1998). Instead of manipulating the environment by avoiding a situation or modifying it, attentional deployment depends on an individual changing their focus within a given setting. According to Gross and Thompson (2007), attentional deployment can be further broken down into two subcategories, distraction and concentration. Distraction can be either internal or external and involves changing focus in order to modulate feelings about the current situation, usually causing a decrease in emotion intensity. Conversely, concentration is characterized by focusing attention on a given situation in order to increase the experienced emotion. Distraction is evident in the undoing effect of positive emotions in that after a negative emotion has developed, one can shift their attention to something emotionally positive and alter their emotional state more efficiently than if they had not shifted their attention or if they had instead moved on to something without a positive valence.

Dysregulation and Temperament Vulnerabilities

Emotions can be considered adaptive responses to the environment. However, left unchecked, emotions can lose their utility and even become harmful to the individual. A failure to regulate one's negative emotions can result in behavioral issues. Specifically, internalizing problems, which are associated with depression and anxiety, or externalizing problems, which are associated with aggression, could develop. A study by Joorman, Talbot, and Gotlib (2007) found that adolescent girls were more likely to have a bias toward negative emotional information if their mothers had experienced recurrent depression. After a negative mood induction, these girls' displayed faster reaction times in a dot-probe task when the location of the

dot was probed by a sad face than if it was probed by a happy face. Conversely, controls displayed the opposite effect and were biased toward positive emotional information. These results suggest that children who are prone to depression due to a family history are less likely to focus on positive emotional information after experiencing a negative emotion. This pattern can be interpreted as a deficit in emotion regulation and highlights the potential importance of the undoing effect of positive emotions as an emotion regulation strategy.

Differences across individuals may create a disparity in emotion regulation capabilities, leaving some much less well equipped than others to achieve their goals and interact socially. Importantly, certain temperament profiles have been associated with behavior problems in children. Rothbart and Sheese (2007) define temperament as a set of individual qualities that is both biologically and environmentally influenced. Specifically, temperament is made up of both emotional reactivity and self-regulation. Muris, Meesters, and Blijlevens (2007) argue that both reactive and regulative temperament factors play an important role in the development of behavior problems related to depression and anxiety. Reactive temperament factors include both negative affectivity and surgency, which is also known as positive affectivity, and these both represent how an individual responds to their environment through displays of emotion. The regulative factor is effortful control, also known as self-regulation, and this is the tendency of an individual to modify their affectivity. Thus it is the combination of these reactive and regulative factors that determines one's ultimate emotional experience and how well it is regulated.

Just such a pattern was found in a study of temperament and behavior problems in children (Muris, Meesters, & Blijlevens, 2007). A significant interaction between high negative affectivity and low effortful control was associated with high levels of internalizing and externalizing symptoms. Not only was negative affectivity positively correlated with behavior

problems, but this effect was amplified by deficits in effortful control, further highlighting the potential importance of emotion regulation techniques (such as the undoing effect of positive emotion) in the prevention of behavior problems.

Visser, Huizinga, Hoekstra, van der Graaf, and Hoesktra-Weebers (2006) conducted a study of the relationship between temperament and behavior problems in children who had parents diagnosed with cancer. They examined some of the three factors of temperament described above and also the subscales that often contribute to these factors on temperament questionnaires. It was found that children with high scores on temperament subscales of shyness, fear/worry, and frustration were more likely to have internalizing problems. This was especially true for female children. Questionnaire measures of fear and frustration are often used as indicators of negative affectivity. Internalizing problems were associated with temperament characteristics such as low effortful control and high frustration. Such knowledge could be used to target children at risk for the development of such behavior problems when exposed to stressful life events.

Additionally, it has been shown that children who can keep their negative emotions in check more effectively interact socially with their peers (Eisenberg, Fabes, Carlo, & Karbon, 1992). Thus proper self-regulation and effortful control is critical for the development of relationships in childhood. Not only are these children more capable of regulating negative emotions within themselves, they are more likely to have the regulatory support of others. This finding is consistent with Fredrickson's Broaden-and-Build Theory of Positive Emotions (1998). If one assumes that positive emotions build social resources and that positive emotions work to undo the effects of negative emotions, it is logical to infer that negative affectivity would lead to deficits in these resources. Thus, as seen in this study, less negative affectivity is associated with

better social interactions. Deficits in the ability to engage in regulation between individuals would likely predispose a child to depression or anxiety.

A study of the connection between temperament characteristic and behavior problems in preadolescents also found an important role for surgency (Oldehinkel, Hartman, De Winter, Veenstra, & Ormel, 2004). Also known as positive affectivity or high intensity pleasure, surgency was significantly associated with both internalizing and externalizing problems in the sample. Specifically, low surgency was associated with internalizing problems and high surgency was associated with externalizing problems. This suggests that in addition to effortful control and negative affectivity, surgency may be implicated in the development and persistence of behavior problems related to depression and anxiety.

The Current Study

Further research is warranted given the potential utility of positive emotion as a regulator of negative emotion, as recognized by Fredrickson and Levenson (1998). The purpose of the present study was to extend these findings in three important ways. First, the negative emotion to be undone was sadness instead of fear. Just as the dysregulation of fear may lead to an anxiety disorder, excessive sadness can lead to depression. Extending the undoing effect to other negative emotions will reveal the extent to which it is a regulator of negative affect. Second, the participants in this study were children 8- to 12-years-old. Children differ from adults in their emotion regulation strategies and may be more vulnerable to the effects of negative emotions if they have not yet developed the ability to shift their attention from negative to positive stimuli. Third, individual differences will be examined with regard to how they may influence the tendency of a child to use positive emotions to undo negative emotions. Temperament and

behavior problems will be analyzed with respect to how they varied with whether or not a child displayed the undoing effect.

In the current study, clips from popular children's movies were used to elicit sadness, happiness, and neutrality. Much like in the Fredrickson and Levenson (1998) study, the sad clip was presented and then followed by either a happy or neutral clip. However, we utilized a within subjects design so that each participant would be exposed to each of the ending clips. Thus, each participant saw two blocks of three movie clips. One block was made up of a baseline clip followed by a sad clip followed by a neutral clip while the other was made up of a baseline clip followed by a sad clip followed by a happy clip. After each film clip, participants rated their current level of happiness, sadness, and fear. In addition, cardiovascular and electrodermal activity were measured throughout each of the film clips. The inclusion of a measure of electrodermal activity is a significant expansion on past research because while heart rate is indicative of both sympathetic and parasympathetic activation, skin conductance is reflective of only sympathetic activity. Given this distinction, skin conductance data may reveal important new information about the mechanism responsible for the undoing effect. To measure individual differences within the sample, caregivers completed questionnaires that measured their child's behavior and temperament.

Hypotheses

Three main predictions were made. First, past research (Kreibig, Wilhelm, Roth, & Gross, 2007) found decreased heart rate and increased electrodermal activity in response to films that elicit sadness. In accordance with this finding, it was predicted that heart rate and skin conductance reactivity would follow the same patterns in children relative to a preceding baseline recording period. Second, it was predicted that an undoing effect of positive emotion

would be found in children, allowing for a facilitated recovery of negative emotion much like that seen in adults. Specifically, similar to the Fredrickson and Levenson (1998) study, it was predicted that physiology would return closer to baseline levels when the sad clip was followed by a happy clip than when the sad clip was followed by a neutral clip. Third, given past research that has shown certain behavior problems and temperament characteristics are vulnerabilities for emotion dysregulation, it was hypothesized that these individual differences would affect how the children regulate their emotions during the experiment. Children who have internalizing behavior problems would be less able to use positive emotions to undo sadness. Assuming that attentional deployment is important for the undoing effect of positive emotions (Gross, 1998), children with attention problems should be less able to shift their attention from sadness to happiness. Further, temperament characteristics would also affect each child's likeliness to display the undoing effect of positive emotions. Specifically, it was predicted that low effortful control, high negative affectivity, and low surgency would be associated with less recovery from the sad clips and thus an absence of the undoing effect of positive emotions.

Method

Participants

22 children (11 boys and 11 girls) participated in the study. All were from the Boston area and ranged in age from 8- to 11-years-old (M = 10.07 years, SD = 0.77). Most participants were Caucasian (n = 21, 95.45%) and one participant was Asian (4.55%). This sample was recruited from a database that was created based on past participation in studies in the Psychology Department at Tufts University and interest expressed in response to a mailing to the community. Caregivers of the participants were contacted via phone or email and given information about the study. It was required that all participants had previously seen at least two

of the films that had been prepared for the study. The study was approved by the Institutional Review Board of Tufts University. Participants were given a few small gifts at the completion of the study and caregivers were compensated for their travel expenses with a $5 gift card for gas.

Testing Environment

Participants viewed the films in a 2.18m x 2.13m soundproof booth in the Psychology Department of Tufts University in order to minimize the influence of outside artifacts on physiological recordings and reduce distraction. Films were presented on a 17cm Tobii Technologies T120 Eyetracker monitor (13.5cm x 11cm). Participants were seated approximately 60cm away from the monitor in a standard office chair. Eye tracking data are not presented here.

The soundproof testing booth was located within a larger control room. Experimenters were located outside the booth in the control room and communicated with participants during the self-report scales and between film clips via a two-way microphone-speaker system. One experimenter recorded eye tracking data and controlled the presentation of film clips and self-report scales while the other guided the participant through the self-report scales after each film clip and recorded electrocardiogram (ECG) and skin conductance level (SCL) data during the film clips.

Movie Clips

Three clips each from 12 popular children's films were prepared for the study. Since it was required that a child had previously seen each of the two films that would be presented to them during the study, only ten of the 12 films were presented across the 22 participants based on their viewing history (see Appendix A). For each film, the three prepared clips included a clip to elicit sadness, a clip to elicit happiness, and an emotionally neutral clip. For example, for

the film *My Girl* (Caracciolo, Friendly, Grazer, & Zieff, 1991) the sad clip was the scene in which Veda approached Thomas J.'s casket at his funeral, the happy clip depicted the two friends riding their bikes through town, and the neutral clip showed Veda grocery shopping with her father. Film clips ranged in length from 4.35 minutes to 5.63 minutes (M = 5.03, SD = 0.44). Additionally, two baseline clips were used. The baseline clips each depicted an aquatic scene with background music and were utilized to establish neutral affect and baseline physiological activity before each block of emotional movie clips. The baseline clips were 1.17 and 1.12 minutes in length (M = 1.14, SD = 0.04).

Self-Report Ratings

In order to record elicited affect, a modified version of the Self-Assessment Manikin (SAM; Lang, Bradley, & Cuthbert, 2005) was presented on the participant's monitor immediately after each film clip via E-Prime Software (Psychology Software Tools, Pittsburgh, PA). The original SAM is a series of three scales through which a participant can report their affect, arousal, and feeling of dominance. In this study, the SAM was modified so that it was composed of three five-point scales on which participants could report the extent to which the film clip they had just viewed made them feel happiness, sadness, and fear. Each scale ranged in magnitude from 1 (*not at all*) to 3 (*a little*) to 5 (*very*), with 2 and 4 serving as intermediate points (see Figure 1).

Questionnaire Measures of Behavior Problems and Temperament

A caregiver of each participant filled out two questionnaires while the participant completed the study. These included the Child Behavioral Checklist (CBCL; Achenbach, 1991) and the revised version of the Early Adolescent Temperament Questionnaire (EATQ-R; Capaldi & Rothbart, 1992; Ellis & Rothbart, 2001).

The CBCL is a caregiver report of emotional and behavioral problems in children 6- to 18-years-old. The CBCL is made up of 120 problem items and these are responded to on a three-point scale ranging from 0 (*not true*) to 1 (*somewhat or sometimes true*) to 2 (*very true or often true*) with regard to how true each item was for their child. These problem items are grouped into the subscales of withdrawn and depressed, somatic complaints, anxious and depressed, social problems, thought problems, attention problems, delinquent behavior, and aggressive behavior. Internalizing behavior problems and attention problems were examined here as they related to the undoing effect. Internalizing behavior problems were defined as the internalizing total scale on the CBCL, which is made up of the subscales of anxious and depressed behaviors, withdrawn and depressed behaviors, and somatic complaints, while attention problems is its own subscale.

The EATQ-R is made up of eight temperament subscales that measure a wide range of temperament characteristics. These subscales include activation control, affiliation, attention, fear, frustration, inhibitory control, shyness, and high intensity pleasure/surgency. The caregiver responded to the 62 items of the EATQ-R on a five-point scale, ranging from 1 (*almost always untrue*) to 5 (*almost always true*) based on the relevance of that statement to their child. Effortful control, negative affectivity, and surgency were examined here as they related to the undoing effect. As per Muris, Meesters, and Blijlevens (2007), the subscales of attention, activation, and inhibitory control were each examined with regard to their relationship to the undoing effect given their association with effortful control. In addition, the subscales of fear and frustration were each compared to the undoing effect. Surgency is its own subscale on the EATQ-R.

Attention as measured by the EATQ-R differs from attention problems as measured by the CBCL in that attention is a measure of a child's ability to concentrate on a given situation and also change the focus of attention when appropriate while attention problems measures problem behaviors associated with deficits in attention. Thus, while attention problems on the CBCL only reveals if a child has difficulties with attention, attention on the EATQ-R more broadly illustrates a child's allocation of attention to everyday tasks.

Physiological Recordings

An MP150 data acquisition system (Biopac Systems, Inc., Goleta, CA) recorded ECG and SCL data during each of the film clips, including the baseline clips.

ECG recording was done using repositionable neonatal electrodes, one placed below the collarbone on each side of the participant's chest and one on the participant's right shoulder blade. ECG was recorded at a sampling rate of 500 Hz. Data was resampled at 400 Hz offline and bandpass filtered from 0.5 to 20 Hz to reduce noise. The R-spikes were identified using local slope and timing criteria specified in Autonomic Nervous System Laboratory (ANSLAB), a series of Matlab routines written by Wilhelm and Peyk (2005). The interbeat interval (IBI), the time in milliseconds between successive R-spikes in the ECG, was then converted into heart rate. Average heart rate in beats per minute (BPM) was calculated for each film clip.

SCL was recorded at a sampling rate of 31.25 Hz using DC coupling and constant voltage (0.5 V) excitation between two Ag/AgCl electrodermal electrodes placed on the distal phalanges of the index and middle fingers of the participant's non-dominant hand. Mean SCL was measured in microsiemens (μS). ANSLAB was used to edit movement artifacts.

Procedures

Two experimenters carried out the experiment. A caregiver of each participant completed a consent form before the study began. Verbal assent was obtained from each child before training. The study was briefly explained to both the participant and the caregiver. Then, with the assistance of an experimenter, the child filled out a questionnaire regarding the film clips that would be shown. The questionnaire addressed how recently the child had seen the films, how many times the child had viewed each film, and how much the child enjoyed each of the films. Next, the participant was introduced to the electrodes that would be used to record physiological measures and the self-report scales that would be used to rate affect after each film clip. At that time, the experimenter and caregiver used Electrode Skin Prep Pads and other wipes to clean the area on the child where the ECG and SCL electrodes would be placed. After training was completed and the electrodes had been placed on the participant, the child was ushered into the testing booth. There, the caregiver assisted an experimenter in attaching the electrodes to the necessary hardware for collecting ECG and SCL data. The child was made comfortable in the chair and positioned approximately 60 centimeters away from the screen. Finally, the participant was instructed to remain seated, to minimize movement in the hand with SCL electrodes, and to remain focused on the monitor throughout the study.

Before the experimenter and caregiver left the testing booth, it was confirmed that the hardware for collecting physiological data was properly connected and that the child was properly positioned for the collection of eye tracking data (not reported here). Immediately after the caregiver and experimenter exited the booth and shut the soundproof door, the second experimenter ran eye tracking calibration procedures, and then presentation of the film clips began.

Each participant viewed six film clips in total. This total was made up of two blocks of three clips each. In each block, the first clip was a baseline clip, the second clip was sad, and the third clip was either happy or neutral. The order of these two types of emotional clip blocks was counterbalanced across participants to avoid an ordering effect. Within each block, the sad and ending clips were from the same film and films for the two blocks were chosen based on which films the child had seen prior to participating in the study. A different film was used for each movie block. The experimenters did not communicate with the participant during the presentation of film clips unless the participant indicated that they no longer wanted to continue with the study.

The three self-report affect scales were presented one at a time immediately after each of the film clips ended. Each participant was prompted to respond to the scales by an experimenter who communicated with the participant through the two-way system that connected the control room and the testing booth. The scales were presented in random order and remained on the screen until the participant responded. Participants responded by pressing a number key on a standard keyboard that corresponded to any one of the five possible numerical choices on each of the scales (1-5). Responses were recorded via the E-Prime Software. Once the participant had responded to all three of the affect scales, an experimenter verified that the participant wanted to continue with the study and the next film clip was presented.

While the child completed the study, the caregiver was in the control room with the experimenters and filled out the CBCL and EATQ-R. Beforehand, an experimenter briefly explained how to answer the questions included on each questionnaire based on the scales associated with that questionnaire. Caregivers were instructed to omit questions that they did not

wish to answer or that they felt did not apply to their child. The caregiver did not have contact with the child during the study unless it was requested by either the child or the caregiver.

Once the child had viewed each of the six film clips and rated their affect for each of the clips, the experimenter and caregiver entered the testing booth to remove the ECG and SCL electrodes and to assist the child in exiting the booth. The child and caregiver were presented with gifts in appreciation for their participation and they were given the opportunity to ask any remaining questions about the study.

Design and Analysis

The current study was conducted in order to determine if film clips can be used to elicit sadness in children 8- to 11-years-old, if the undoing effect of positive emotion can be observed in this population, and if individual differences in behavior problems and temperament affect this potential mechanism of emotion regulation. A 2 (ending: neutral, happy) x 3 (film clip: baseline, sad, ending) repeated measures factorial ANOVA was conducted to answer each of these questions.

To answer whether sadness was elicited, scores from the baseline clips and the subsequent sad clips were compared on measures of self-reported affect, heart rate, and skin conductance. A significant main effect of clip with differences between the baseline and sad clips would support the elicitation of sadness. To determine if the undoing effect was observed, responses to the sad clips were compared to responses to the two types of ending clips (happy and neutral), to see if each facilitated recovery to baseline levels of self-reported affect, heart rate, and skin conductance. A significant ending x clip interaction in which there was greater recovery in the happy movie block would support the possibility of an undoing effect. Finally, regression analyses were conducted to see if recovery was associated with internalizing

behaviors and attention problems as measured on the CBCL and the temperament characteristics of effortful control, negative affectivity, and surgency as measured by the EATQ-R. Given that individual subscales on the EATQ-R related to the three main temperament factors were examined with regard to their relation to recovery from sadness instead of combining the subscales into these larger categories, the previously described hypotheses that low effortful control and high negative affectivity would be associated with less recovery from the sad clips and thus an absence of the undoing effect of positive emotions were further broken down into hypotheses for the individual subscales. Thus, for the subscales related to effortful control, it was predicted that less of an undoing effect would be associated with low inhibitory control, low attention, and low activation control. For the subscales related to negative affectivity, it was predicted that less of an undoing effect would be associated with high fear and high frustration. Since surgency is its own subscale on the EATQ-R, the hypothesis for this temperament factor was as previously mentioned, that low surgency would be associated with less recovery.

Data Exclusions

An additional four children participated in this study but were not included in the sample. One child had not previously seen one of the films presented during participation in the study, two children were excluded due to disclosed developmental issues, and one child was excluded due to technical difficulties during data collection.

Results

Question 1. Did the film clips elicit the appropriate emotions in the children?

It was hypothesized that sadness, the negative emotion to be "undone", would be successfully elicited in children by short film clips from popular children's movies. To answer whether sadness was elicited, scores from the baseline clips and the subsequent sad clips were

compared on measures of self-reported affect, heart rate, and skin conductance. The General Linear Model results are presented in Table 1.

Children reported feeling sadder during the sad clips ($M = 3.17$, $SE = 0.23$) compared to the baseline clips ($M = 1.41$, $SE = 0.15$) ($p < 0.001$) (see Figure 2). Children also reported feeling more fearful during the sad clip ($M = 2.14$, $SE = 0.19$) compared to the baseline clips ($M = 1.21$, $SE = 0.09$) ($p < 0.001$) (see Figure 3). There was no significant difference in heart rate across clips ($p > 0.050$) (see Figure 4). However, as can be seen in Figure 5, mean SCL increased from the baseline clips ($M = 11.95$, $SE = 0.97$) to the sad clips ($M = 13.20$, $SE = 1.06$) ($p < 0.001$) in each movie block. This pattern indicates that sadness was successfully elicited by the sad clips on measures of self-report and electrodermal activity. It is critical for the negative emotion to have been elicited in order for an undoing effect to occur. Note that the happy ending clips were rated as significantly happier ($M = 4.10$, $SD = 1.22$) than the neutral ending clips ($M = 3.34$, $SD = 1.28$) ($p = 0.008$) (see Figure 6), allowing for potential differences in recovery from sadness in the two movie blocks.

Question 2. Was the undoing effect observed?

It was predicted that, like adults, the undoing effect of positive emotion would be observed in the children. This would require a more significant return to baseline levels of self-reported sadness, heart rate, and skin conductance when a sad clip was followed by a happy clip than when a sad clip was followed by a neutral clip. An interaction between ending and clip with greater recovery in the happy movie block would thus suggest the possibility of an undoing effect. As shown in Table 1, there was no interaction between clip and ending for ratings of sadness, heart rate, or SCL. This pattern indicates that recovery from sadness was equivalent for

the happy and neutral endings meaning that undoing effect of positive emotions was absent in this sample.

Question Three. Do individual differences related to behavior and temperament modulate the undoing effect?

It was predicted that individual differences in behavior and temperament, as measured by parent-report on the CBCL and EATQ-R, would modulate the tendency of a child to display the undoing effect. Even though there were no significant undoing effects found in the sample for the analyses reported above, the possibility remained that variance in the extent to which sadness was undone by happiness within the sample might be related to individual differences in behavior and temperament.

Behavior Problems. Multiple linear regression models were used to determine if internalizing problems and attention problems (as measured by the CBCL) predicted self-report and physiological reactivity during the ending clips in each movie block, taking into account these measures during the sad clips. The criterion variable was the participant's behavior (self-reported affect, heart rate, and SCL) recorded during the ending clips in each movie block. The predictors were the participant's behavior recorded during the sad clips and internalizing total and attention problems.

Neither the internalizing total nor attention problems were significantly related to self-report ratings of sadness (all $p > 0.228$), mean heart rate in BPM (all $p > 0.131$), or mean SCL for the ending clips in either movie block (all $p > 0.322$). This pattern indicates that, contrary to predictions, internalizing problems and attention problems were not associated with recovery, with higher problem ratings being associated with less of an undoing effect of happiness on sadness.

Temperament. Multiple linear regression models were used to determine if effortful control, negative affectivity, and surgency (as measured by the EATQ-R) predicted self-report and physiological reactivity during the ending clips in each movie block, taking into account these measures during the sad clips. The criterion variable was the participant's behavior recorded during the ending clips in each movie block. The predictors were the participant's behavior recorded during the sad clips and effortful control (3 subscales: inhibitory control, attention, and activation control), negative affectivity (2 subscales: fear and frustration), and surgency (a subscale itself).

There were no associations between self-reported ratings of sadness for the ending clips compared to the sad clips and the subscales of the EATQ-R that make up effortful control, negative affectivity, or surgency in either movie block (all $p > 0.286$). There were also no associations between mean heart rate for the ending clips compared to the sad clips in each movie block and the subscales that make up negative affectivity or surgency (all $p > 0.290$). For effortful control, there was no association between the three subscales and mean heart rate for the ending clips compared to the sad clips in the neutral movie block (all $p > 0.160$). There was, however, a significant relationship between mean heart rate and attention in the happy movie block, $\beta = 0.21$, $t(16) = 2.13$, $p = 0.049$ (see Figure 7). Children with higher ratings of attention displayed higher heart rates during the happy clips compared to other children. In addition, there was a trend toward an association between mean heart rate and inhibitory control in the happy movie block, $\beta = -0.16$, $t(16) = -1.97$, $p = 0.067$ (see Figure 8). Thus, there was a trend toward children with higher inhibitory control showing lower heart rates during the happy clips compared to other children. There was no association between mean SCL and effortful control, negative affectivity, and surgency in either movie block (all $p > 0.088$).

Discussion

The current study was conducted to examine whether or not a positive emotion could be used to facilitate recovery from a negative emotion in children. This study expanded on previous research (Fredrickson & Levenson, 1998) in that it examined the undoing effect of positive emotion in a younger population and the negative emotion to be undone was sadness. Furthermore, individual differences among the children in behavior and temperament were analyzed with respect to how they varied with occurrence of the undoing effect. Additionally, this study differed from past studies in that it examined electrodermal activity in addition to heart rate.

Emotion Elicitation

It was predicted that films could be used effectively to induce sadness in children 8- to 11-years-old. The predictions for self-report were confirmed in this study. Children reported the sad clips as being significantly sadder than the baseline and ending clips in each movie block. In addition, there was a significant increase in SCL during the sad clip compared to baseline levels as was expected, which supports physiological activation during sadness to match the self-report ratings. Given that a similar pattern was not seen in the heart rate data, the measurement of electrodermal activity as an additional correlate of the emotional experience proved to be an important expansion on past research (Fredrickson & Levenson, 1998; Fredrickson, Mancuso, Branigan, & Tugade, 2000).

Interestingly, the sad clips were reported as significantly more fearful than the baseline clip. This may be because the film clips used to induce sadness also contained elements of fear. For example, children may find the death of a friend to be both a sad and frightening concept. This may help explain the fact that heart rate did not decrease during the sad clips as expected.

Kreibig, Wilhelm, Roth and Gross (2007) also utilized fear-inducing film clips in their study of physiological measures of emotional responses and they inferred that fear is characterized by increases in both heart rate and skin conductance. Perhaps the opposing forces of fear and sadness on cardiovascular activity during the sad clips resulted in no significant changes from baseline levels.

In addition, while Kreibig, Wilhelm, Roth and Gross found decreased heart rate and increased electrodermal activity in response to sadness, they also conducted a comprehensive review of past reports of physiological responses to this particular negative emotion and found mixed results on these two measures (2007). Moreover, a recent study in our lab (DiCorcia, 2009) found heart rate and skin conductance increases for sad film clips. Thus, it is not entirely clear whether heart rate and skin conductance increase or decrease during experiences of sadness compared to baseline or neutral levels.

The Undoing Effect

Given that past research on the undoing effect was conducted with adults (Fredrickson & Levenson, 1998; Fredrickson, Mancuso, Branigan, & Tugade, 2000), it was not clear if children would be capable of shifting their attention from an emotionally negative stimulus to an emotionally positive one. In fact, there was no evidence for the undoing effect of positive emotion in this study. For one, similar ratings of sadness were reported during the happy and neutral endings following the sad film clips. Second, heart rate was not significantly different between the baseline and sad clips, thus there was no opportunity for differential recovery in the happy versus neutral ending clips. Finally, mean SCL continued to increase from the sad clips to the ending clips in each block. Contrary to the expected pattern of recovery, this result suggests that reactivity to the negative emotion continued to increase during the ending clips.

Development of Emotion Regulation

Across a series of studies with varied samples, it has been found that the ability to effectively regulate one's emotion improves with age (Gross, Carstensen, Pasupathi, Tsai, Götestam Skorpen, & Hsu, 1997). Older adults experienced more positive emotion, less negative emotion, and higher control over their own emotions, compared to younger adults. However, the most important advances in emotion regulation are made even earlier, in infancy and childhood, when external sources of regulation are critical to development. Infants depend on their caregivers to aid them in regulating their emotions and throughout childhood individuals gradually gain the ability to self-regulate. Calkins (1994) proposes that the development of emotion regulation is centered on a child's innate neuro-regulatory mechanisms, an array of behavioral traits, and cognitive components. These factors interact with input from the caregiver in a dynamic and reciprocal relationship that shapes the type of emotion regulator the child will grow to be.

However, given that the undoing effect was not observed in this study, it may be that 8- to 11-year-old children have not yet developed this strategy of emotion regulation. While attentional control has been shown to develop early in life (Rothbart, Ziaie, & O'Boyle, 1992) and self-regulation plays an important role in social interactions as early as preschool (Kopp, 1992), preadolescent children may not yet have the ability to shift their attention from a negative experience to a positive one, thus decreasing the impact of negative emotions such as sadness or fear by allowing for facilitated recovery. Further research is needed to determine at what point the undoing effect may become an important regulatory skill.

The Undoing Effect and Individual Differences

Previous research has shown that certain behavior problems and temperament characteristics have been associated with deficits in emotion regulation. Thus, it was predicted that children high in internalizing behaviors, which are associated with depression and anxiety, may be less likely to move on from the sad clips to the happy clips. In addition, those with behavior problems related to attention may also be less able to regulate their emotion by adjusting their attentional deployment. Similar patterns were expected with temperament. Specifically it was predicted that low effortful control, high negative affectivity, and low surgency would be associated with less of an undoing effect, and thus a less effective recovery from sadness.

Only one significant relationship was found between the measures of behavior problems and temperament and recovery from the sad clips to the ending clips in each movie block. In the happy block, there was significant positive correlation between attention, a component of the temperament factor of effortful control, and mean heart rate in the happy ending clips compared to the sad clips. Those children who scored highest on attention had the highest mean heart rate for the happy clips, taking into account mean heart rate in the preceding sad clips.

Given that no significant differences in heart rate were observed across all clip types in this study, mixed findings on past research with heart rate patterns in sadness (Kreibig, Wilhelm, Roth, & Gross, 2007), and a significant increase in heart rate during sadness seen in a previous study with children in this lab (DiCorcia, 2009), it is worth considering this relationship in the context of an increase in heart rate representing reactivity to sadness instead of our original, opposite prediction. Thus, displaying a higher heart rate in the ending clip compared to other children would signify less recovery and displaying a lower heart rate would signify greater

recovery. Further, if a lower heart rate was found in the happy block and not the neutral block this would represent a greater undoing effect of the positive emotion on the negative emotion, compared to other children.

In this context, the observed positive correlation between ratings of attention and heart rate suggest that a high rating for attention is associated with less recovery from sadness. Past research has found an opposite relationship between attention, a component of the regulative temperament factor of effortful control, and internalizing problems, with low levels of attention being associated with a higher occurrence of these behavioral issues (Muris, Meesters, & Blijlevens, 2007). However, given the finding here that high ratings for attention may be related to less of an undoing effect, it may be that there is a U-shaped relationship between attention and emotion regulation, with both relatively high and low levels of attention being associated with poor emotion regulation and thus internalizing problems. High attention to negative stimuli is responsible for the negative bias associated with internalizing problems in children (Reid, Salmon, & Lovibond, 2006). Therefore, elevated attention can be a detrimental temperament characteristic. A negative attentional bias is a serious risk factor for mood disorders such as anxiety and depression.

Additionally, while not significant, there was a trend toward a negative correlation between inhibitory control and mean heart rate in the ending clips compared to the preceding sad clips, also observed in the happy movie block. Once again, as previously observed (DiCorcia, 2009), if we consider an increased heart rate to be a reactive response to sadness, a higher heart rate in the happy clip compared to other children would signify less recovery and a lower heart rate would signify greater recovery. Thus, those children with a higher rating of inhibitory control, which like attention is also a component of effortful control, displayed a greater undoing

of sadness by happiness. Inhibitory control, defined as the ability to inhibit socially inappropriate reactions (Capaldi & Rothbart, 1992; Ellis & Rothbart, 2001), is clearly important for the regulation of emotional responses. For example, a child that often displays negative affect may be less able to form stable social relationships. Kopp (1992) suggests that children begin to consciously connect their self-regulatory abilities to the regulation of emotion during the preschool years, when compliance to social standards of appropriate behavior become increasingly important. The importance of effective inhibitory control in children has been confirmed in a study with children in 3rd- through 5th-grade, in which higher inhibitory control was associated with fewer behavior problems and better social skills (Lengua, 2003). Thus, the suppression of negative emotion may be just as important for the tendency of a child to display the undoing effect as the extent to which attention remains focused on negative emotion.

Limitations and Future Directions

One limitation of this study that may have hampered our ability to find additional relationships between individual differences in behavior and temperament and the undoing effect is that our sample came from a non-clinical population. All children included in the analysis were without diagnosis of any psychiatric disorders, and most had very low scores for problem behaviors and temperament ratings in the typical range. This factor potentially created a floor effect with regard to variability within the group. Given that children were predominantly well within the normal range on these measures, vulnerabilities did not arise that may have varied with a child's emotion regulation capabilities.

Another contributing factor to the lack of variability across behavior and temperament measures in the current study was the small sample size. Within a larger group of children, it is likely that the effect of the clips on cardiovascular and electrodermal activity would have been

more pronounced and associations between individual variability within the sample and the undoing effect may have arisen.

Another limitation of the study is that the analysis of physiological recordings was relatively conservative. Mean heart rate in BPM and mean SCL were calculated across the entire duration of each clip. This technique makes it more difficult to detect emotional responses that occur for only part of a film clip. Additionally, given that recovery was not defined as time required to reach baseline levels, as in the original Fredrickson and Levenson (1998) study, neutral and happy clips could only be compared in their ability to facilitate recovery by observing changes in the measures averaged over the duration of each clip. Future analyses of these data should focus on the time required to return to baseline levels, which might be a more sensitive measure of the undoing effect.

As mentioned previously, an emotional episode is made up of several components. These include the affect we report feeling, our physiological responses, and also our displayed affect. While self-report and physiological reactivity were measured here, a final limitation is that we do not have measures of displayed affect. Examining this third element may reveal additional information about emotion elicitation, recovery from negative emotions, and how individual differences affect these processes. In fact, research in children has shown that facial affect converges significantly with physiological measures of emotion while the relationship between measures such as heart rate and self-report is less clear (Anastassiou-Hadjicharalambous & Warden, 2007). Taking these three components of the emotional experience together may allow future studies of the undoing effect in children to be more conclusive.

Conclusion

In conclusion, the undoing effect was not observed in children 8- to 11-years-old across the self-report and physiological measures collected in response to emotion-eliciting film clips. While sadness was successfully elicited in self-reported affect and skin conductance, the undoing effect was not observed for the happy versus neutral ending conditions for any of the three measures. Finally, the only relationship between recovery and individual differences found involved factors that make up the temperament factor of effortful control. Higher ratings of attention were associated with greater average heart rate in the happy clips, indicating less recovery from sadness. This result suggests that children with high ratings of attention may have had a bias toward emotionally negative information that could lead to dysregulation, internalizing problems, and a mood disorder such as anxiety or depression. Additionally, there was a trend toward a significant negative correlation between ratings of inhibitory control and average heart rate in the happy clips, indicating that higher inhibitory control was associated with greater recovery from sadness. This trend was in line with predictions given that a higher rating on this measure of effortful control is defined as more effective inhibition of reactions that are socially inappropriate. Thus, these children are more likely to suppress responses to negative emotions and therefore recovery more quickly when presented with a more socially appropriate, positive emotion such as happiness. Future studies that account for some of the limitations listed here are required to clarify the undoing effect of positive emotion in children.

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Appendix A

List of Films Presented during the Study

Note: This list does not include films prepared for the study but not presented.

Annie (Layton, Stark, & Huston, 1982)

Babe (B. Miller, G. Miller, Mitchell, & Noonan, 1995)

Bridge to Terabithia (Paterson, Levine, Lieberman, & Csupó, 2007)

Casper (Molen, Montgomery, Spielberg, & Silbering, 1995)

Charlotte's Web (Kerner & Winick, 2006)

E.T.: The Extra-Terrestrial (Kennedy & Spielberg, 1982)

Harry Potter and the Prisoner of Azkaban (Columbus, Heyman, Radcliffe, & Cuarón, 2004)

Harry Potter and the Sorcerer's Stone (Heyman & Columbus, 2001)

My Dog Skip (Hancock & Russell, 2000)

My Girl (Caracciolo, Friendly, Grazer, & Zieff, 1991)

Table 1

General linear model results for measurements of self-reported affect, heart rate, and skin conductance across the three clip types in each movie block. A 2 (ending: neutral, happy) x 3 (film clip: baseline, sad, ending) repeated measures factorial ANOVA was conducted for each measurement.

Measurement	**Ending**			**Clip**			**Ending x Clip**		
	F	*p*	η^2_p	*F*	*p*	η^2_p	*F*	*p*	η^2_p
Happy Scale	1.47 (1, 20)	0.240	0.07	20.92 (2, 40)	< 0.001	0.51	5.51 (2, 40)	0.008	0.22
Sad Scale	1.70 (1, 20)	0.208	0.08	46.96 (2, 40)	< 0.001	0.70	1.26 (2, 40)	0.294	0.06
Fear Scale	0.11 (1, 20)	0.748	0.01	26.55 (2, 40)	< 0.001	0.57	0.75 (2, 40)	0.481	0.04
Heart Rate	1.64 (1, 21)	0.214	0.07	0.37 (2, 42)	0.690	0.02	0.03 (2, 42)	0.973	0.001
Skin Conductance	0.26 (1, 19)	0.618	0.02	36.86 (2, 38)	< 0.001	0.66	0.30 (2, 38)	0.745	0.02

Figure Captions

Figure 1. Self-report scales. The scales were adapted from the Self-Assessment Manikin (SAM; Lang, Bradley, & Cuthbert, 2005). A: Happy Scale, B: Sad Scale, C: Fear Scale. Each scale ranged from 1 (*not at all*) to 3 (*a little*) to 5 (*very*), with 2 and 4 serving as intermediate points.

Figure 2. Mean self-report ratings for sad scale. There was a significant effect of clip for sad ratings for both of the ending blocks in that the sad clips were rated as significantly sadder than the baseline or ending clips. There were no significant differences between the sad ratings for the ending and baseline clips and there was no significant clip by ending interaction. Error bars represent standard error.

Figure 3. Mean self-report ratings for fear scale. There was a significant effect of clip for both of the ending blocks in that the sad clips were rated as significantly higher on the fear scale than the baseline or ending clips. There were no significant differences between the fear ratings for the ending and baseline clips and there was no significant clip by ending interaction. Error bars represent standard error.

Figure 4. Mean heart rate. There was no significant effect of clip for mean heart rate in either of the ending blocks. There was no significant interaction between clip and ending. Error bars represent standard error.

Figure 5. Mean skin conductance level (SCL). There was a significant effect of clip for the mean skin conductance level for both ending blocks. Mean SCL was significantly higher for the sad clips than for the baseline clips and significantly higher for the ending clips than for the sad clips. There was no significant clip by ending interaction. Error bars represent standard error.

Figure 6. Mean self-report ratings for happy scale. There was a significant effect of clip for both of the ending blocks in that the baseline clips were rated as significantly happier than the sad

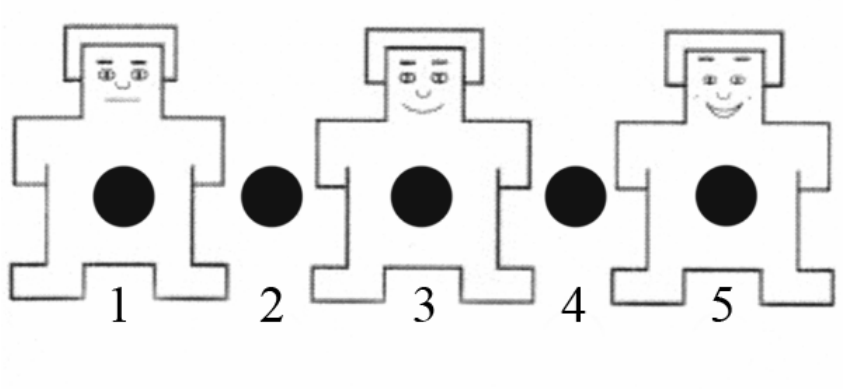
clips and the ending clips were rated as significantly happier than the sad clips. There was also an interaction clip by ending in that the ending clip in the happy blocks were rated as significantly happier than the ending clip in the neutral blocks. Error bars represent standard error.

Figure 7. Association between change in mean heart rate in BPM from sad clips to happy and neutral clips and ratings of attention on the EATQ-R. There was a significant positive correlation between change in mean heart rate in BPM from the sad clips to happy clips and ratings of attention (A). Higher ratings of attention were associated with higher heart rate in the happy clips taking into account heart rate during the sad clips. However, there was no significant correlation between change in mean heart rate in BPM from the sad clips to the neutral clips and ratings of attention (B).

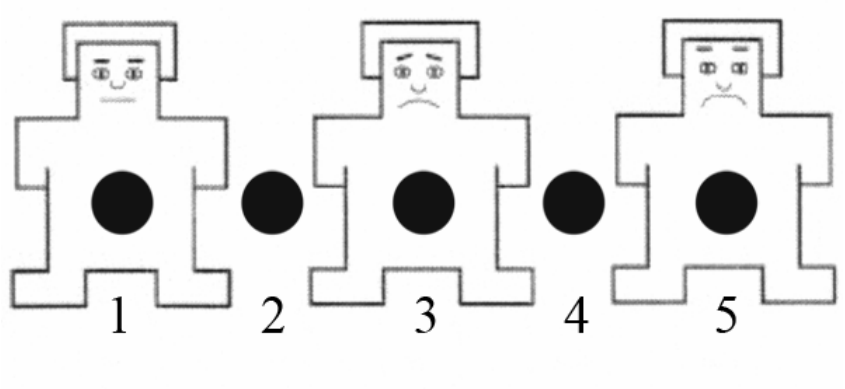
Figure 8. Association between change in mean heart rate in BPM from sad clips to happy and neutral clips and ratings of inhibitory control on the EATQ-R. There was a trend toward a negative correlation between change in mean heart rate in BPM from the sad clips to the happy clips and ratings of attention (A). Thus, there was a trend toward children with higher inhibitory control showing lower heart rates during the happy clips taking into account heart rate during the sad clips. However, there was no significant correlation between change in mean heart rate in BPM from the sad clips to the neutral clips and ratings of inhibitory control (B).

Figure 1.

A.



B.



C.

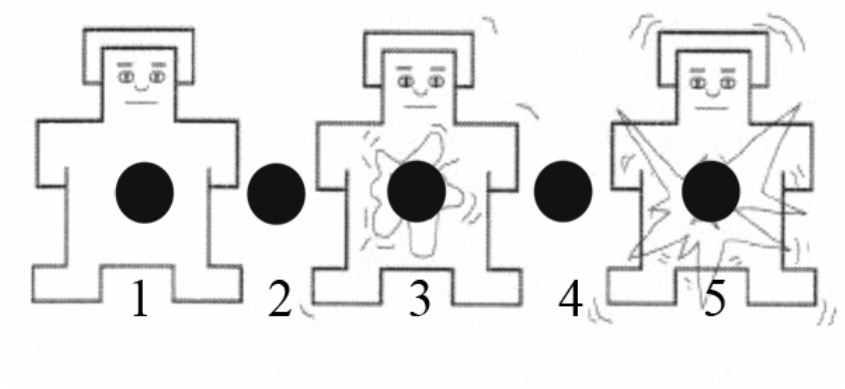


Figure 2.

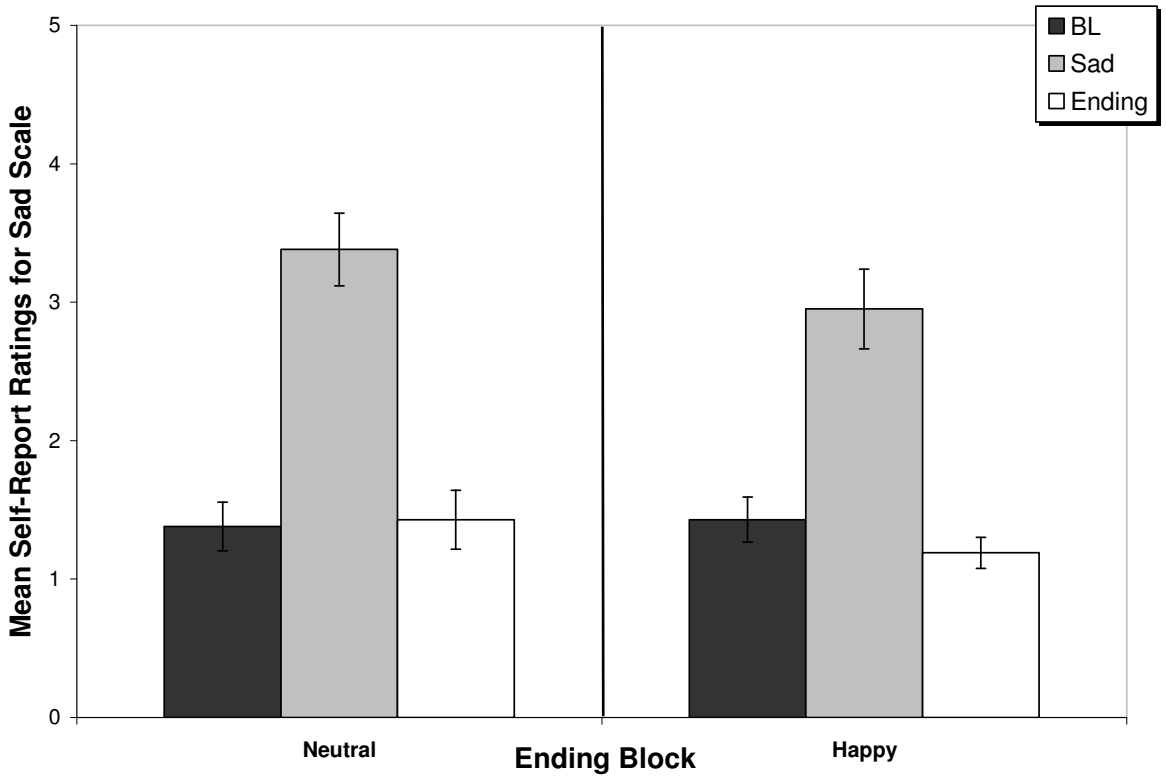

BL
Sad
Ending
Mean Self-Report Ratings for Sad Scale
5
4
3
2
1
0
Neutral
Ending Block
Happy

Figure 3.

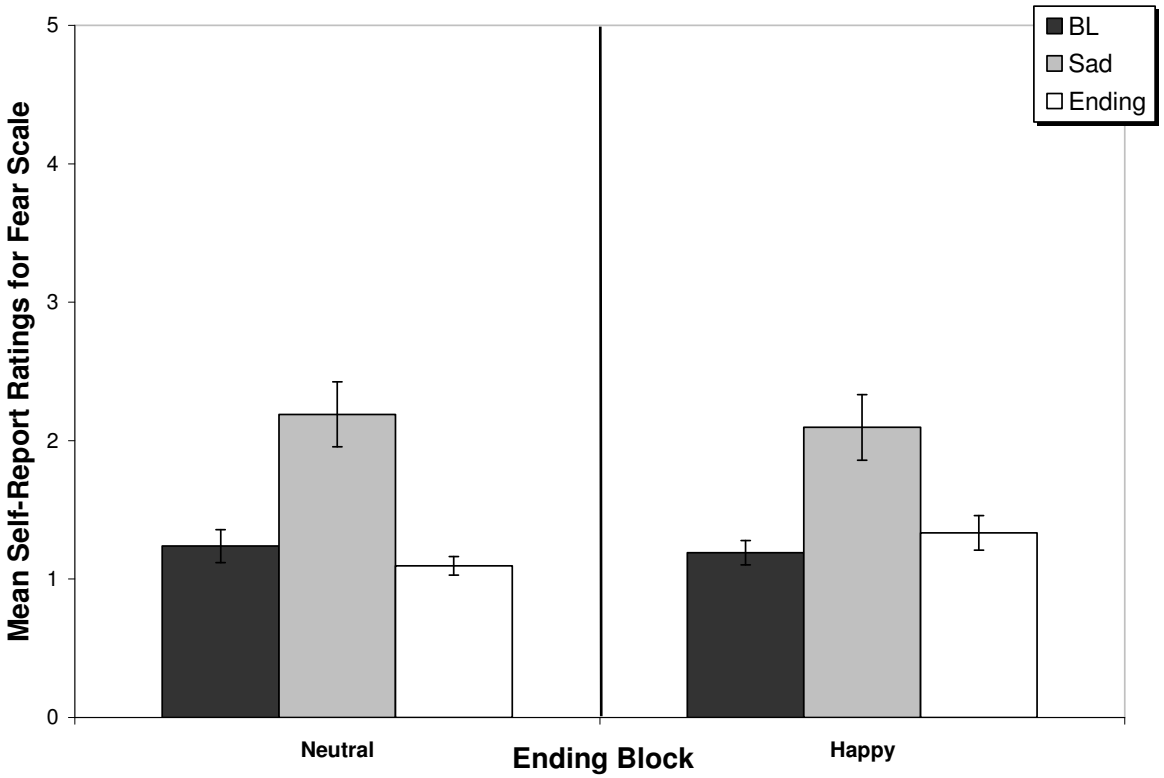

BL
Sad
Ending
Mean Self-Report Ratings for Fear Scale
5
4
3
2
1
0
Neutral
Ending Block
Happy

Figure 4.

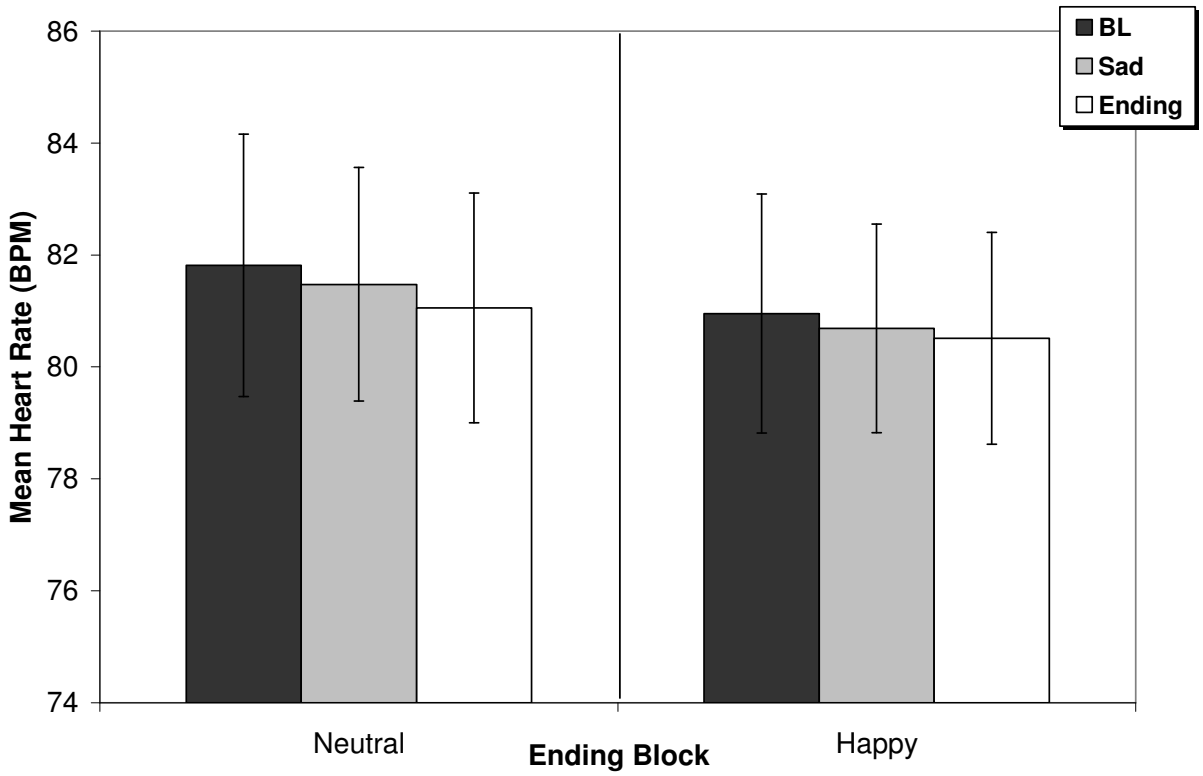

BL
Sad
Ending
86
84
82
80
78
76
74
Mean Heart Rate (BPM)
Neutral
Ending Block
Happy

Figure 5.

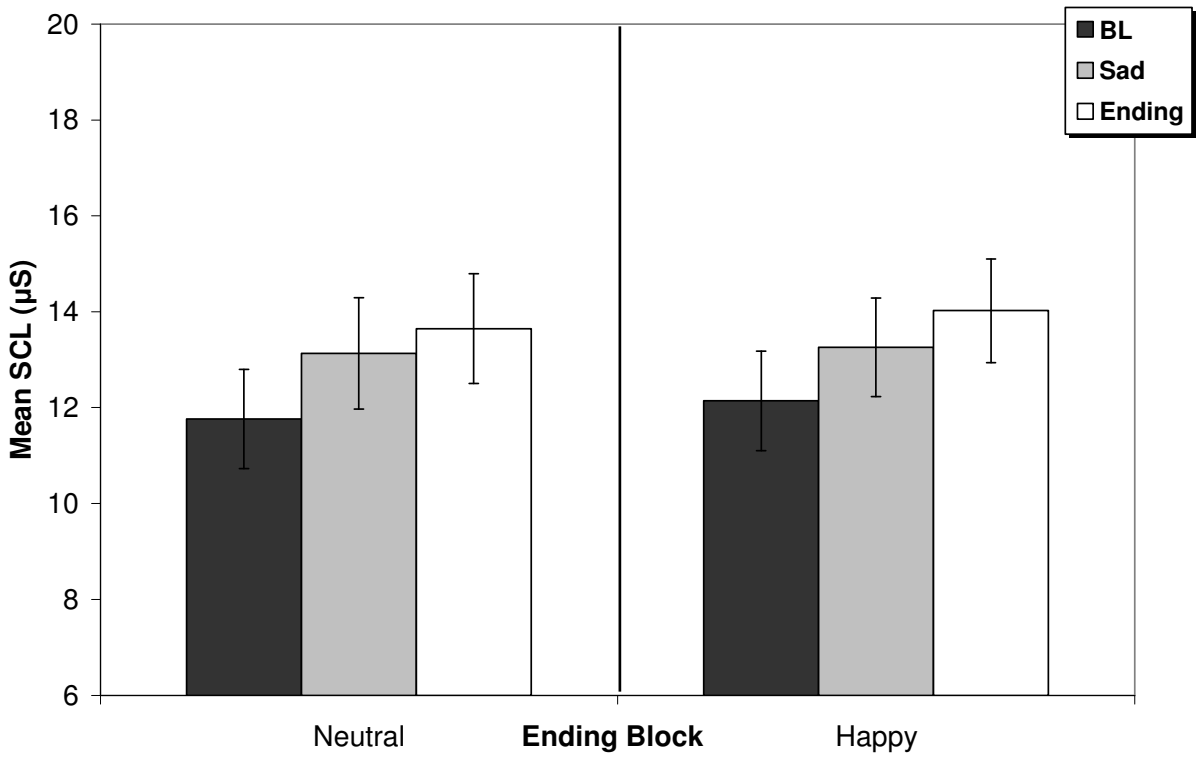

20
18
16
14
12
10
8
6
Mean SCL (µS)
BL
Sad
Ending
Neutral
Ending Block
Happy

Figure 6.

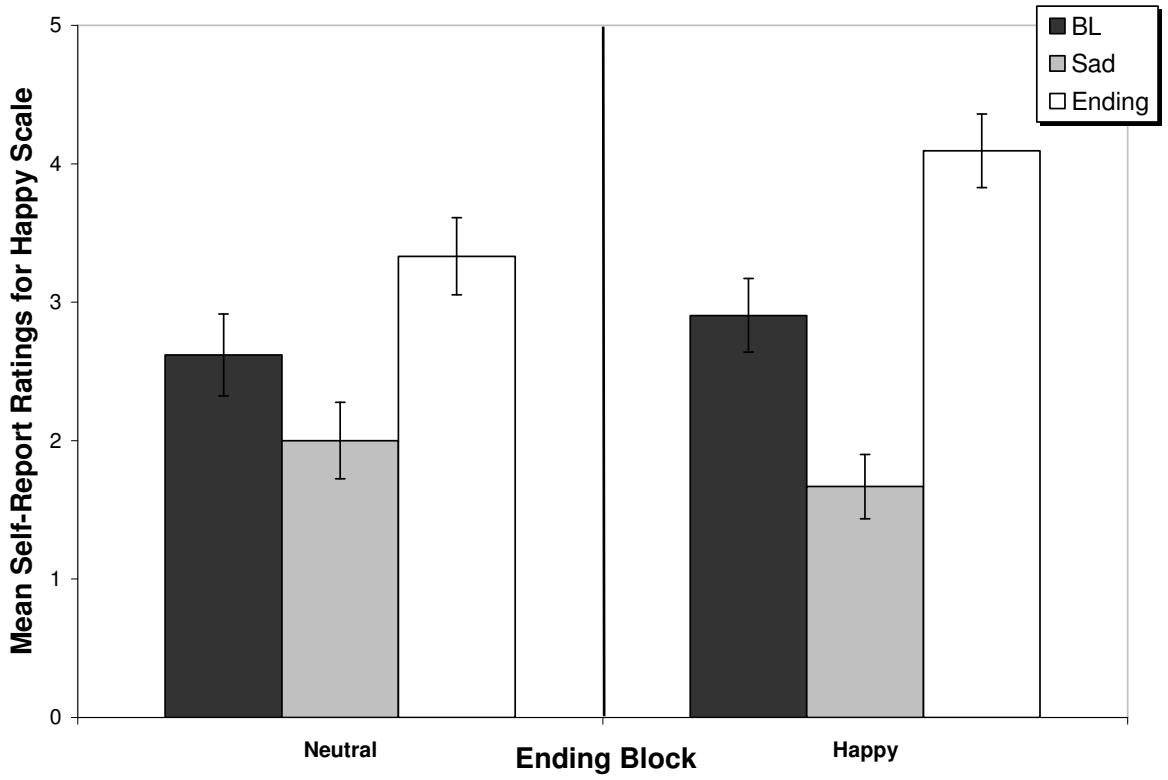
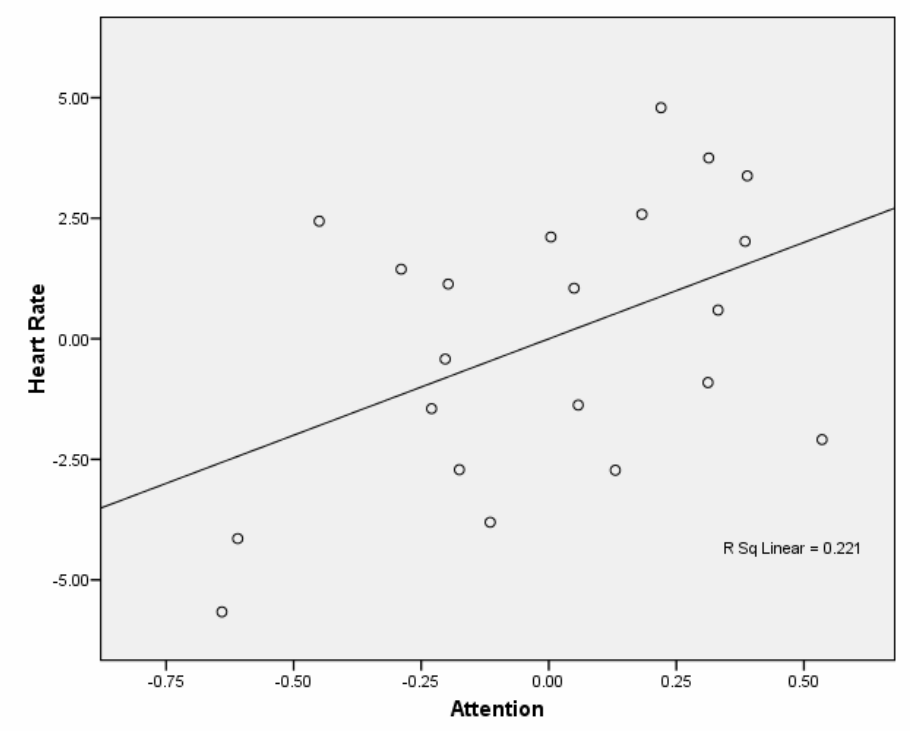

BL
Sad
Ending
Mean Self-Report Ratings for Happy Scale
5
4
3
2
1
0
Neutral
Happy
Ending Block

Figure 7.

A.


Heart Rate
5.00
2.50
0.00
-2.50
-5.00
-0.75
-0.50
-0.25
0.00
0.25
0.50
Attention
R Sq Linear = 0.221

B.

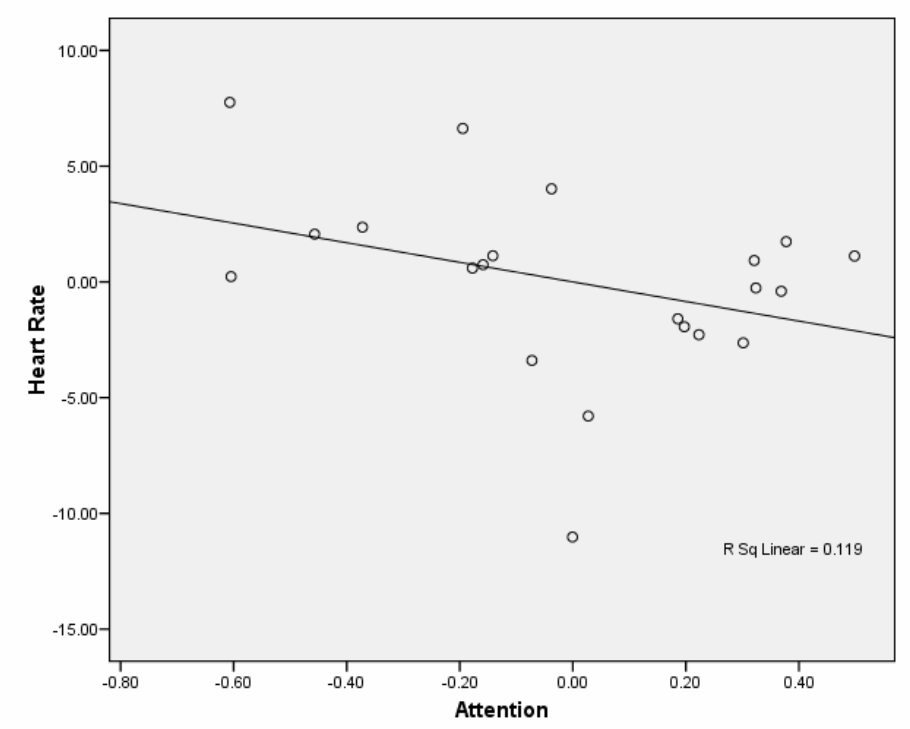
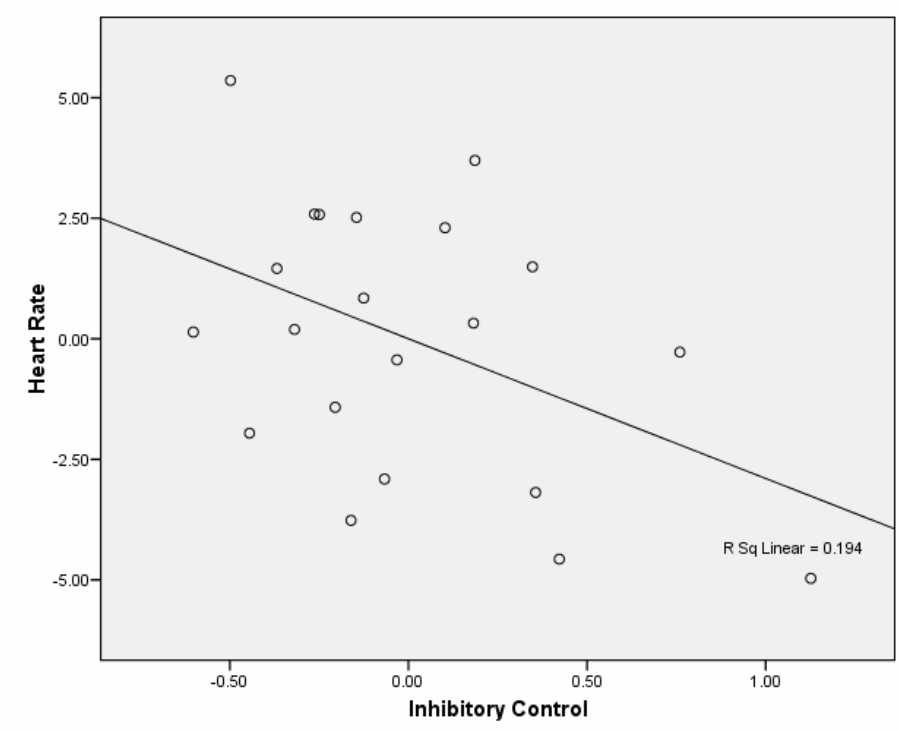
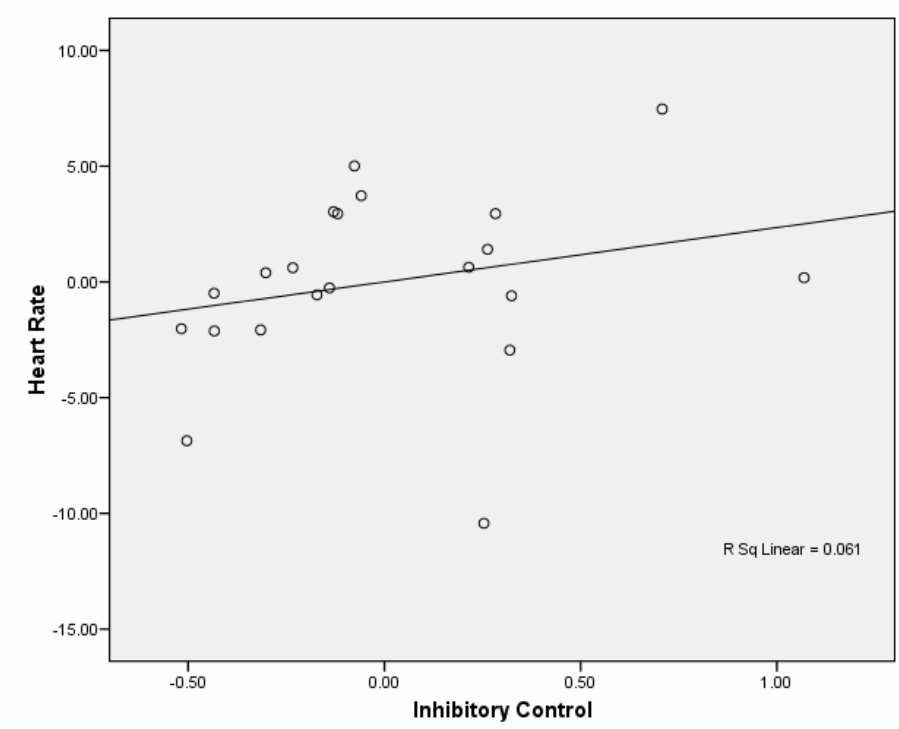

Heart Rate
10.00
5.00
0.00
-5.00
-10.00
-15.00
-0.80
-0.60
-0.40
-0.20
0.00
0.20
0.40
Attention
R Sq Linear = 0.119

Figure 8.

A.


Heart Rate
5.00
2.50
0.00
-2.50
-5.00
-0.50
0.00
0.50
1.00
Inhibitory Control
R Sq Linear = 0.194

B.


Heart Rate
10.00
5.00
0.00
-5.00
-10.00
-15.00
-0.50
0.00
0.50
1.00
Inhibitory Control
R Sq Linear = 0.061