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Age-Related Differences in Emotional Reactivity, Regulation, and Rejection Sensitivity in Adolescence

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Abstract

Although adolescents' emotional lives are thought to be more turbulent than those of adults, it is unknown whether this difference is attributable to developmental changes in *emotional reactivity* or *emotion regulation*. Study 1 addressed this question by presenting healthy individuals aged 10–23 with negative and neutral pictures and asking them to respond naturally or use cognitive reappraisal to down-regulate their responses on a trial-by-trial basis. Results indicated that age exerted both linear and quadratic effects on regulation success but was unrelated to emotional reactivity. Study 2 replicated and extended these findings using a different reappraisal task and further showed that situational (i.e., social vs. nonsocial stimuli) and dispositional (i.e., level of rejection sensitivity) social factors interacted with age to predict regulation success: young adolescents were less successful at regulating responses to social than to nonsocial stimuli, particularly if the adolescents were high in rejection sensitivity. Taken together, these results have important implications for the inclusion of emotion regulation in models of emotional and cognitive development.

Keywords

emotion regulation; adolescent development; rejection sensitivity; reappraisal

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For more than a century, scientists have debated whether adolescence is by definition a time of emotional “storm and stress” (Arnett, 1999; Casey et al., 2010; Hall, 1904). Although there is considerable evidence that on average adolescents experience more extreme affect (both positive and negative) and more variable mood states in their everyday lives than do their adult counterparts (Larson, Csikszentmihalyi, & Graef, 1980; Larson, Moneta, Richards, & Wilson, 2002; Larson & Richards, 1994), two issues regarding adolescent emotional development remain unre solved. First, the research to date has been contradictory with regard to whether age-related differences in emotional responsivity are linear, with emotionality being highest in children and tapering in adolescents (Carthy, Horesh, Apter, Edge, & Gross, 2010; Murphy, Eisenberg, Fabes, Shepard, & Guthrie, 1999), quadratic, with emotionality being highest in adolescents (Casey, Getz, & Galvan, 2008; Casey et al., 2010), or both linear and quadratic in nature (Larson et al., 2002; Thomas, De Bellis, Graham, & LaBar, 2007). Second, although efforts have been made to characterize age-related changes in emotional reactivity (how strong one's emotional response is to affective vs. neutral stimuli) and regulation (how effectively one regulates emotional responses) during childhood (Murphy, Eisenberg, Fabes, Shepard, & Guthrie, 1999), little research has examined such changes during adolescence (for a notable exception, see Silk, Steinberg & Morris, 2003). Hence, it is unclear whether differences in emotional responsivity observed between adolescents and adults are attributable to differences in emotional reactivity or emotion regulation ability. For example, if older adolescents report less negative daily affect than younger adolescents, it would be unclear whether this is attributable to emotional triggers becoming less upsetting, increased emotion regulatory ability, or both. Disentangling whether adolescents’ natural, bottom-up emotional responses are stronger than adults’ or whether their controlled, top-down regulatory processes are weaker than adults’ may have important implications for basic and applied models of emotional development.

The present study addressed these issues by examining emotional reactivity and one's ability to use reappraisal in adolescence. Reappraisal is a powerful and flexible regulation strategy that involves changing how one thinks about an emotional stimulus so as to alter one's emotional response to it. Although prior work has examined reappraisal in limited age groups (Carthy et al., 2010; Lévesque et al., 2004; Moore, Mischel, & Zeiss, 1976; Pitskel, Bolling, Kaiser, Crowley, & Pelphrey, 2011), only one other study (McRae et al., 2012) has examined reappraisal ability in a broad adolescent age range. While children as young as 3 years can use reappraisal to modulate emotions when instructed to do so (W. Mischel & Baker, 1975), two types of evidence suggest that over the course of child and adolescent development, individuals become more frequent and effective reappraisers. First, laboratory and survey measures indicate that spontaneous use of cognitive regulatory strategies increases during childhood and adolescence (Fields & Prinz, 1997; Garnefski & Kraaij, 2006; H. N. Mischel & Mischel, 1983; Rodriguez, Mischel, & Shoda, 1989; Williams & McGillicuddy-De Lisi, 1999). Second, behavioral and neural markers of cognitive control processes used in reappraisal improve over the course of adolescence (Casey, Tottenham, Liston, & Durston, 2005; Durston et al., 2006; Gogtay et al., 2004; Luna, Padmanabhan, & O'Hearn, 2010). To directly test for age-related differences in regulation ability during adolescence, we conducted two studies that assessed emotional reactivity (baseline

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responsiveness to affective stimuli) and reappraisal success (the ability to use reappraisal to modulate emotional responses) in individuals at the beginning, middle, and end of adolescence.

Study 1: Age-Related Differences in Reactivity and Regulation

In Study 1, we used a reinterpretation variant of cognitive reappraisal (Ochsner & Gross, 2008) to identify age-related differences in emotional reactivity and regulation in response to aversive images. As described above, age has been associated with linear improvements on cognitive control tasks and both linear and quadratic changes in emotional responsivity. Given that regulation success involves using control processes to modulate emotional responses, we expected that age would exert both linear and quadratic effects on regulation success. For reactivity, however, we made no predictions because the varying methods (e.g., questionnaire vs. observational measures) and age ranges used in prior work have produced mixed findings about how reactivity differs between children and adolescents (Larson & Lampman-Petraitis, 1989; Murphy et al., 1999) and between children, adolescents, and adults (Diener, Sandvik, & Larsen, 1985; Larson et al., 1980; McManis, Bradley, Berg, Cuthbert, & Lang, 2001). While emotional responses to both positive and negatively valenced affective stimuli may vary as a function of age, the present study sought to focus on negative affect for two reasons. First, problems with regulation of negative affect are a marker for a host of psychiatric and clinical disorders, including ones such as depression and anxiety that have high rates of onset in adolescence (Glied & Pine, 2002; Pine, Cohen, Gurley, Brook, & Ma, 1998). Second, the behavioral and neural bases of regulation of negative affect are better understood in adults than regulation of positive affect, and as such, we have better benchmarks for assessing development for negative emotion (Ochsner & Gross, 2008).

Affective reactivity was assessed through self-reported experience. Our decision to use self-report was based on the following: (1) prior work has shown that reappraisal-related changes in self-reported negative affect track well with physiological (e.g., corrugator response; Ray, McRae, Ochsner, & Gross, 2010) and neural changes (e.g., amygdala activation; Ochsner & Gross, 2008) in both adults and children (Lévesque et al., 2004; McManis et al., 2001), (2) self-report provides a unique and relatively direct window into the emotional experiences of participants that other physiological and observational measures cannot provide (Gilbert, 2006; Larsen & Prizmic-Larsen, 2006), and (3) self-reports of experience can be used as indicators and predictors of numerous forms of affective dysfunction throughout the life span (Bradley et al., 2011; Edelbrock, Costello, Dulcan, Kalas, & Conover, 1985; Lonigan, Phillips, & Hooe, 2003; Silk, Steinberg, & Morris, 2003).

Method

Participants—Forty-four healthy volunteers (19 female; aged 10–23, *M* = 16.08 *SD* = 3.62) participated in the experiment. Figure 1a depicts the distribution of ages represented in this sample. Before participating in the study, parents of minor participants completed a brief prescreening telephone interview to confirm that their child could read and write in English, had normal or corrected vision, had never been diagnosed with a developmental or psychiatric disorder, and were not taking any psychotropic medication. Participants over the

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age of 18 completed a brief telephone prescreening interview to confirm that they met these same inclusionary criteria. Only participants who met inclusionary criteria were tested.

Task Procedure—Participants were trained extensively on task procedures. During training, participants were told to react naturally to (but not reappraise) neutral and aversive images shown to them when they saw the instructional cue "Look," and when they saw the cue "Decrease" to tell themselves a story about the picture that made themselves feel less negative (i.e., to reappraise). This reappraisal strategy has been shown to successfully reduce negative emotion in numerous prior studies (Johnstone, van Reekum, Urry, Kalin, & Davidson, 2007; Kim & Hamann, 2007; Ochsner, Bunge, Gross, & Gabrieli, 2002; Ochsner et al., 2004; Urry et al., 2006; van Reekum et al., 2007). Participants were given examples of how to reappraise (e.g., imagining it's just a scene from a movie) and reported their reappraisals aloud during training to ensure understanding of the instructions. Participants additionally practiced several trials on their own before taking part in the actual experimental task.

To reduce the risk that children might experience distress while viewing aversive images, for participants ages 10–17, all aversive stimuli were prescreened by a parent. Picture stimuli were taken from the International Affective Picture System (IAPS pictures 2200, 2205, 2440, 2493, 2516, 2800, 2840, 3030, 3051, 3160, 3180, 3230, 3250, 3500, 3530, 6150, 6210, 6211, 6250, 6260, 6300, 6312, 6370, 6510, 6830, 6831, 7002, 7004, 7009, 7025, 7050, 7090, 7100, 7211, 7233, 7235, 7950, 8230, 9007, 9050, 9140, 9181, 9210, 9420, 9421, 9430, 9440, 9470, 9490, 9570, 9571, 9600, 9611, 9620, 9910, 9921; Lang, Bradley, & Cuthbert, 2001) and from a set of similar pictures that had been previously used in research with children (Pictures 17, 18, 33, 34, 37, 43 and 81; Cordon, Melinder, Goodman, & Edelstein, unpublished data). Parents were permitted to exclude up to 12 aversive images (six per instruction condition for aversive stimuli). There was no correlation between age and the number of pictures rejected ($r = -.013$, $p = .95$).[1] Across this group, 54% of parents chose not to reject any images at all, and parents rejected an average of 3.42 images. Although not all parents excluded this many images, all participants 10–17 saw exactly 24 stimuli in each condition (aversive stimuli in the two trial types were matched for valence and arousal). This was done so that testing conditions were highly comparable across participants. Because adults completed more trials than younger participants, 24 trials were randomly selected from each trial type for adult participants to be included in analyses. We opted to randomly select which trials were included among adults randomly rather than matching each adult's stimulus set to that of a child's because, aside from gender, there were no clear criteria for how to match adults and children. Normative ratings of valence and arousal for the final sets of stimuli included in analyses did not differ by age group.

On each of the 72 experimental trials (see Figure 2a for trial structure), participants used the strategy indicated by the cue word (Look or Decrease, shown for 2 seconds) while viewing a unique photograph (shown for 10 seconds). Participants then rated their current strength of negative affect using a four-point scale ("How negative do you feel?" 1 = *weak*, 4 = *strong*, shown for 3 seconds). Two sets of 24 negative images were counterbalanced across

[1]Data on how many pictures were rejected by parents were lost for 15% of participants aged 10–17 years because of computer failure.

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participants with Look and Decrease instructions, along with 24 neutral photos that were shown with the Look instruction. No other conditions were administered on the task.

As a manipulation check, *t* tests were performed to assess whether emotional reactivity and regulation success were significantly different from zero. Emotional reactivity was calculated as the percent increase in negative affect elicited on Look negative trials in comparison to Look neutral trials ([Look negative – Look neutral]/Look neutral × 100). Regulation success was calculated as the percent of negative affect that was decreased by reappraisal on Decrease negative trials in comparison to Look negative trials ([Look negative – Decrease negative]/Look negative × 100).

Results and Discussion

Manipulation Check—As shown in Figure 3, across all participants, emotional reactivity ($M = 137.71\%$; $t(43) = 22.89$, $p < .001$) and regulation success ($M = 23.51\%$; $t(43) = 11.58$, $p < .001$) were significantly greater than zero.

Age, Emotional Reactivity, and Regulation Success—Next, regression analyses were performed to test for age effects on emotional reactivity and regulation success. For all analyses, both age and age^2 were entered as predictors into the same equation with each subject's mean emotional reactivity or regulation success entered as the dependent variable. The regression equation for emotional reactivity was nonsignificant, $F(2, 41) = .52$, $p = .60$, $\eta^2 = .03$, and neither linear nor quadratic effects were observed for the relationship between age and emotional reactivity, $\beta_{age} = 17.34$, $t(41) = .98$, $p = .33$; $\beta^2_{age} = –.50$, $t(41) = –.95$, $p = .35$. However, the regression equation for regulation success was significant, $F(2, 41) = 4.42$, $p = .02$, $\eta^2 = .22$, with both linear and quadratic relationships observed between age and regulation success, $\beta_{age} = 12.13$, $t(41) = 2.21$, $p = .03$; $\beta^2_{age} = –.33$, $t(41) = –2.01$, $p = .05$. Visual inspection of the regression line (regulation success = –.33*age^2 + 12.13 × age – 81.74) containing both the linear and quadratic terms (Figure 3c) suggested that these effects were attributable to regulation success improving from age 10 through approximately age 16 before tapering off. To test this interpretation of the data, change point analyses were performed. This was done by centering age at each age point (i.e., 10 years, 11 years, etc.) and using this mean-centered variable along with its resultant mean-centered age^2 as predictors in regression analyses predicting regulation success. This approach allowed us to inspect the “instantaneous” age slope at each age (i.e., the rate of change in regulation success for individuals turning a given age). These regressions revealed that age-related differences in regulation success were observed for each year of age from 10–16 (βs ranged from 1.54 to 5.51, all *p*s < .01) before becoming only marginally nonsignificant at age 17 ($\beta = .88$, $p = .11$). No significant age differences were observed for any ages above 17 (βs ranged from –3.10 to .22, *p*s ranged from .16 to .76).

The present findings indicate that no age-related differences were observed for emotional reactivity, whereas age-related differences in regulation success were observed through late adolescence. These observations provide initial support for the hypothesis that regulation success, but not emotional reactivity, changes during adolescent development. However, our ability to make strong conclusions based on the present results is limited for two reasons.

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First, while the present study found that age predicted improved performance using a reinterpretation strategy, it is unclear whether these results would hold with other reappraisal tactics (McRae, Ciesielski, & Gross, 2012) such as distancing, which has produced mixed results in developmental studies using smaller age ranges than the present one (Kross, Duckworth, Ayduk, Tsukayama, & Mischel, 2011; Rood, Roelofs, Bogels, & Arntz, 2012). These conflicting findings suggest that perhaps the details involving the stimuli, instructions, and training procedures for distancing paradigms can yield different results. Second, because we did not obtain measures of intelligence, we cannot rule out the possibility that IQ differed as a function of age and that this might underlie age-related differences in reappraisal success. While this study provides initial support for developmental changes in emotion regulation capacity, situational and dispositional social factors may play an important role in these changes. In the second study, we addressed the limitations above and explored how social stimuli and individual differences in rejection sensitivity impact emotional reactivity and emotion regulation during adolescence.

Study 2: Social Factors in the Development of Emotion Regulation

The primary goals of Study 2 were threefold. First, we sought to generalize the results of Study 1 to a different reappraisal tactic, distancing. Second, we sought to improve upon the methods used in Study 1 by controlling for potential differences in intellectual ability. Third, given the significant social changes that occur during adolescence, we sought to examine how interactions between situational and dispositional social factors interacted with age to predict emotion regulation success.

While no prior work has directly examined this third issue, two types of evidence suggest that age-related differences in reappraisal success may be influenced by both situational and dispositional social factors. Situationally, adolescents find peer interactions more rewarding than do children (Choudhury, Blakemore, & Charman, 2006) but are more sensitive to peer influence and peer rejection than are adults (Brown, 2004; Choudhury et al., 2006; Gardner & Steinberg, 2005; Larson & Richards, 1991; Steinberg, 2005; Steinberg & Morris, 2001). This suggests that emotion regulatory demands in adolescence may be greatest in social situations, when adolescents must modulate strong emotions elicited by an evolving and expanding set of interpersonal cues and relationships. Dispositionally, how an adolescent reacts to a given social situation may be influenced by factors like rejection sensitivity (RS). RS is the tendency to anxiously anticipate and perceive rejection and may be conceptualized as a cognitive–affective information-processing framework that impacts the ways in which individuals form expectations, interpret interpersonal information and respond to interpersonal cues (Downey & Feldman, 1996). High RS adolescents may be particularly vulnerable to feelings of rejection and ostracism, which may result in part from self-regulatory failures (Downey, Lebolt, Rincon, & Freitas, 1998; London, Downey, Bonica, & Paltin, 2007).

To address these issues, Study 2 assessed how stimulus social content and RS impacted emotional reactivity and regulation success at different ages. In addition to replicating Study 1 findings, we hypothesized that age-related improvements in emotion regulation would be seen earlier for nonsocial than social stimuli. RS has been shown to differentiate individuals

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not only in their responses to actual social interactions but also to a host of other negative social stimuli including rejection-themed art (Downey, Mougios, Ayduk, London, & Shoda, 2004; Kross, Egner, Ochsner, Hirsch, & Downey, 2007), angry faces (Berenson et al., 2009; Olsson, Carmona, Remy, Downey, & Ochsner, 2007), and socially threatening words (Berenson et al., 2009). Therefore, we further hypothesized that high RS individuals would be worse than low RS individuals at regulating emotional responses to social stimuli. Assuming that the effects of RS, social content, and age would be additive, we anticipated that reappraisal success scores would be lowest for younger participants who were high in RS and attempting to regulate emotional responses to aversive, social stimuli.

Method

Participants—Our final sample used for all analyses consisted of 77 healthy volunteers aged 10–23 years (36 female; mean age = 17.4 years, *SD* = 3.63). Figure 1b depicts the age distribution of this sample. Our initial sample consisted of 82 healthy volunteers (41 female; mean age = 17.2 years, *SD* = 3.65). Before participating in the study, parents of minor participants completed a brief prescreening telephone interview to confirm that their child could read and write in English, had normal or corrected vision, had never been diagnosed with a developmental or psychiatric disorder, and had never been prescribed psychotropic medication. Only children who met these inclusionary criteria were tested. Among these children, four (all female) were excluded from data analysis. One was excluded because the child opted to terminate the experiment after just a few experimental trials. Three others were excluded because their total problem scores on the Child Behavior Checklist (Achenbach, 1991), which was used as an additional screening tool for our child participants, were within the clinical range, suggesting that they exhibited atypically poor emotional and behavioral functioning. These four children did not differ from other children included in analyses in terms of age, $t(40) = .92$, $p = .36$ or rejection sensitivity measures, $t(40) = .72$, $p = .47$. Participants over the age of 18 completed a brief telephone prescreening interview to confirm that they could read and write in English, had normal or corrected vision, had never been diagnosed with a developmental or psychiatric disorder, and had never been prescribed psychotropic medication. Only adult participants who met these inclusionary criteria were tested. One adult female (age = 18.33 years) was excluded from analyses because of a computer failure that occurred during her testing session.

Measures of Intellectual Ability—Participants completed the vocabulary, similarities, matrix reasoning, and block design subtests from the WISC-IV (participants aged 10–16) or WAIS-IV (participants aged 17–22). Scaled scores were prorated so that General Ability Index (GAI) scores could be calculated for each participant. Age was positively associated with GAI scores ($r = .24$, $p = .04$) but importantly, when added as a covariate, GAI was not a significant predictor in any of the analyses reported below ($p < .31$ or greater).

Measures of Social Desirability—To ensure that a participant's need to portray oneself positively did not bias task performance, participants 18–22 completed the Marlowe-Crowne Social Desirability Scale (MCSDS; Crowne & Marlowe, 1960) and participants 10–17 (one participant did not complete the questionnaire correctly) completed the Children's Social Desirability Scale (CSDS; Crandall, Crandall, & Katkovsky, 1965). Scores on 19 content-

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matched items from each questionnaire did not vary in accordance with age (r = –.17, *p* = .14). See below for results regarding social desirability and regulation success.

Measures of Social Processing

Social stimuli selection: Nonsocial and social photographs were chosen from the International Affective Picture System (pictures 1050, 1930, 2235, 2270, 2514, 2515, 2575, 5395, 5849, 6838, 7000, 7002, 7009, 7025, 7060, 7080, 7090, 7100, 7150, 7170, 7195, 7224, 7235, 7326; Lang, Greenwald, Bradley, & Hamm, 1993) and public online sources (see http://scnlab.psych.columbi-a.edu/stimuli/reactregsoc/index.html) and were normed by an independent sample of 23 participants aged 10–22 (*M* = 18.17, *SD* = 3.01). This pretesting confirmed that social stimuli reminded participants of social situations (social situations were defined for participants as "situations where people interact with each other") more than nonsocial stimuli, $t(22) = 5.58$, $p < .001$, but did not differ in terms of valence, $t(22) = 1.12$, $p = .27$.

Rejection sensitivity.: To assess individual differences in RS, participants 18 and older completed the Rejection Sensitivity Questionnaire-Personal (RSQ-Personal) (Downey & Feldman, 1996) and participants 17 and younger completed the Children's Rejection Sensitivity Questionnaire (CRSQ) (Downey et al., 1998). While the CRSQ evaluates both anxious and angry expectations of rejection, for the present study we solely examined responses relating to anxious expectations so as to more easily compare the RS-Personal and CRSQ scales. These measures ask participants to assess how anxious they would feel and what they would expect to happen in various hypothetical social situations. The range of possible scores on the RS-Personal is 1–36 (published norms: *M* = 9.69, *SD* = 3.07), and the range for the present sample was 4.39–17.39 (sample: *M* = 9.85, *SD* = 3.02). The range of possible scores for anxious expectations on the CRSQ is 1–36 (published norms: *M* = 8.16, *SD* = 3.91), and the range for the present sample was 1.42–17.75 (sample: *M* = 8.49, *SD* = 3.79). For statistical purposes, standardized scores were calculated for each participant using published norms for each of these measures (Downey & Feldman, 1996; Downey et al., 1998). RS scores did not correlate with age ($r = .04$, $p = .73$).

Task Procedure—Before performing the task, participants were trained extensively on the immersed ("close") and distanced ("far") strategies in accordance with well-validated procedures (Ochsner et al., 2004). On "close" trials, participants were told to imagine themselves standing close to the scene depicted in the photograph and to allow themselves to experience any emotions that the photograph evoked. On "far" trials, participants were told to imagine themselves standing further away from the scene and to focus more on the facts of the photograph than on its emotional details. While participants were not told so, "close" trials were used to assess baseline emotional responsiveness whereas "far" trials were used to assess regulation ability.

In Study 2, 120 experimental trials were completed by all participants, 60 of which contained aversive stimuli and 60 of which contained neutral stimuli. All adults saw the same set of 120 stimuli. One hundred aversive photographic stimuli, 50 social and 50 nonsocial, were prescreened by a parent for all participants ages 10–17. Parents were

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permitted to exclude up to 10 aversive social and 10 aversive nonsocial stimuli so that a pool of 40 stimuli remained for each aversive stimulus type. From this set, 30 aversive social and 30 aversive nonsocial stimuli that were closely matched for valence and arousal were chosen for the experimental task. The remaining stimuli were used for training purposes, and, if needed, to serve as valence-matched task substitutes for pictures that were excluded by parents. Parents of children 10–17 typically rejected a small number of pictures (M = 2.53, SD = 3.57), though the rate of rejection was inversely correlated with age (r = –.39, p = .02). This procedure was an improvement on the one used in Study 1 in that it allowed all participants to complete the same number of trials (120).

On each of 120 trials, participants used the strategy indicated by a cue word ("close" or "far," shown for 2 seconds) while viewing a photographic stimulus for 8 seconds. At the conclusion of each trial, participants rated their negative affect on a five-point scale (1 = *not feeling badly at all*, 5 = *feeling very badly*) via button press. A diagram of the trial structure used is shown in Figure 1b. Conditions differed in terms of stimulus valence (negative or neutral), stimulus social content (social or nonsocial), and regulation instruction (close or far) for a total of eight condition types. The assignment of pictures to instruction was counterbalanced between participants. The task was completed on a desktop computer in a windowless testing room. No other conditions were administered on the task.

Analyses—Analyses took part in three phases. First, a manipulation check was performed to confirm that aversive stimuli elicited more negative affect than neutral stimuli (emotional reactivity) and that the distancing strategy reduced negative affect for aversive stimuli (regulation success). To do this, emotional reactivity ([Close negative – Close neutral]/Close neutral × 100) and regulation success ([Close negative – Far negative]/Close negative × 100) indices were calculated for each participant. Second, we assessed whether age predicted emotional reactivity, regulation success, or both. Third, we used a mixed ANOVA to assess how age, social content, and RS interacted to predict negative affect during emotion regulation.

Results and Discussion

Manipulation Check—The first analysis used t tests to assess the efficacy of the stimuli and regulation strategy. As expected, emotional reactivity (M = 208.17%; $t(76) = 29.96$, $p < .001$) and regulation success scores (M = 25.38%; $t(76) = 14.93$, $p < .001$) were significantly greater than zero across all participants. Neither emotional reactivity ($r = .17$, $p = .14$) nor regulation success ($r = .001$, $p = .99$) correlated with social desirability scores.

Age, Emotional Reactivity, and Regulation Success—In the second analysis, multiple regression analyses were performed to test for age effects on emotional reactivity and regulation. Age, age^2, and GAI were used as predictors and either emotional reactivity or regulation success were entered as dependent variables for each equation. GAI did not predict emotional reactivity, $\beta = -.13$, $t(73) = .31$ $p = .76$, or regulation success, $\beta = .07$, $t(73) = .69$, $p = .49$. The regression equation for emotional reactivity was nonsignificant, $F(3, 73) = 1.52$, $p = .22$, $\eta^2 = .06$, and, as shown in Figure 4b, neither linear nor quadratic effects of age were observed for emotional reactivity, $\beta_{age} = 30.23$, $t(73) = 1.55$, $p = .13$; $\beta^2_{age} = -.81$,

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$t(73) = –1.39$, $p = .17$. However, as shown in Figure 4c, the regression equation for regulation success was significant, $F(3, 73) = 5.33$, $p = .002$, $\eta^2 = .22$. Age exerted a significant linear effect and a marginally significant quadratic effect on regulation success, $\beta_{age} = 9.01$, $t(73) = 2.04$, $p = .045$; β^2_{age} β –.23, $t(73) = – 1.71$, $p = .09$. Visual inspection of the regression line containing both the linear and quadratic terms for age as well as GAI scores (regulation success = $–.23*age^2 + 9.01 \times age + .07 \times GAI – 69.53$) suggested that regulation success improved from age 10 through approximately age 18 before tapering off. As in Study 1, this interpretation of the data was tested using change point analyses. To do this, age was centered at each age point and this mean-centered variable along with its resultant mean-centered age^2 were used as predictors in regression analyses predicting regulation success. Like Study 1, this approach allowed us to inspect the “instantaneous” age slope for each age point. These regressions revealed that significant age-related differences in regulation success were observed for each year of age from 10–17 (βs ranged from 1.46–4.57, all *p*s < .01) and a marginal improvement for age 18 ($\beta = 1.02$, $p = .06$). No significant effects of age were observed for any ages above 18 (βs ranged from –.75 to .58, *p*s ranged from .43 to .88).

Interactions Between Trait Rejection Sensitivity, Social Content, and Age During Emotion Regulation—In the final analysis, we used a mixed ANOVA to examine how social factors (dispositional and situational) and age predicted affective responses on Far Negative trials, the one trial type for which age effects were found. Stimulus social content (social or nonsocial), age, trait rejection sensitivity (RS scores), and GAI scores were entered as independent variables while affect ratings were entered as a dependent variable. GAI was not found to predict negative affect, $F(1, 72) = .61$, $p = .44$. Aversive social stimuli evoked more negative affect than nonsocial stimuli, $F(1, 74) = 6.46$, $p = .01$ and a significant interaction was observed between age and social content, $F(1, 74) = 6.28$, $p = .01$, such that younger participants were less effective at regulating emotional responses to social stimuli than nonsocial stimuli but older participants were not (see Figure 5). RS scores were marginally associated with more negative affect on regulation trials, $F(1, 72) = 2.59$, $p = .11$, and RS scores interacted with age and stimulus social content, $F(1, 74) = 7.01$, $p = .01$, such that for younger individuals high RS scores predicted more negative affect for social stimuli but for older individuals RS did not impact affective responses to social stimuli during regulation.

Together, the results of Study 2 strengthened and extended the findings from Study 1 in two ways. First, Study 2 replicated Study 1 by showing that in the context of a reappraisal task, (1) emotional reactivity does not differ as a function of age, and (2) older adolescents exhibit greater regulation success than younger adolescents. Second, Study 2 demonstrated further that regulation success is impacted by a stimulus's social content and by RS, especially early in adolescence. This constitutes a first step in identifying situational and dispositional factors that may enhance or diminish emotion regulation success during adolescent development.

General Discussion

Demands for emotion regulation are particularly high in adolescence as individuals experience increased independence, hormonal changes, and a changing social environment

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(Blakemore, 2008; Casey et al., 2008; Somerville, Jones, & Casey, 2010). While most adolescents successfully navigate these challenges by developing mature regulatory skills that will help them to cope with stressors for the rest of their lives, for some individuals adolescence marks the beginning of a lifelong struggle with emotion regulation and mental health (Kessler et al., 2005). This suggests that understanding the development of emotion regulation processes in adolescence may be important not only for improving the lives of adolescents but also for preventing dysfunctional regulation in adulthood. However, most of the prior work has not been able to fully (1) experimentally dissociate emotional reactivity and regulation as it develops from late childhood through adolescence into young adulthood and (2) characterize how dispositional and situational social factors impact emotion regulation in adolescence.

The present studies addressed these issues by experimentally differentiating emotional reactivity and regulation success in individuals aged 10–22 years while also determining whether age-related differences in reappraisal success vary as a function of stimulus content and dispositional tendencies. Two key findings were obtained: (1) that age did not predict emotional reactivity but positively predicted regulation across adolescence, and (2) that situational (social content of an emotional stimulus) and dispositional (RS) social factors impacted regulation success in younger adolescents.

Implications for Theories of Emotional and Cognitive Development—The first implication of these results relates to the importance of differentiating emotional reactivity and regulation success in developmental studies of emotion regulation. In a laboratory context, we found effects of age on regulation success but not on emotional reactivity. Although prior work has suggested that baseline mood and emotional variability in daily affect change over the course of adolescence, such observations have derived primarily from experience sampling measures, self-report questionnaires, or from parental/teacher observations (Larson & Lampman-Petraitis, 1989; Larson et al., 2002; Murphy et al., 1999). While such approaches have ecological validity, they lack the ability to fully disentangle emotional reactivity and regulation success. Only one prior study has used a paradigm and participant age range similar to those used in the present design (McRae et al., 2012). Not only do the present two studies replicate the findings reported by McRae and colleagues in two larger, independent samples, they also further this line of work by examining how individual differences and stimulus factors interact with age.

Using the present design, we found that age significantly predicted regulation success, but not emotional reactivity, when using both reinterpretation (Study 1) and distancing (Study 2) strategies. For both studies, age-related differences in reappraisal success were observed up until late adolescence, at which point regulation success stabilized. This is consistent with age effects that have been observed on a host of “cold” cognitive control tasks (De Luca et al., 2003; Huizinga, Dolan, & van der Molen, 2006; Luciana, Conklin, Hooper, & Yarger, 2005; Luna, Garver, Urban, Lazar, & Sweeney, 2004). Interestingly, the age-related differences observed in the present studies dissipated at later ages than is typically observed in “cold” cognitive control tasks. This pattern has also been observed on cognitive control tasks that are highly motivating or emotional in nature (Figner, Mackinlay, Wilkening, & Weber, 2009; Hare et al., 2008; Prencipe et al., 2011). While participants across all ages

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reported significantly less negative affect when reappraising, the fact that reappraisal-related decreases in negative affect were greater for older participants suggests that young adolescents have the ability to regulate using reappraisal but do not do so as effectively as older adolescents. At least two factors could explain this pattern. First, it may be that older adolescents simply have more experience with reappraisal than do younger adolescents (Garnefski & Kraaij, 2006), perhaps in part because they have encountered more negative life events that have required them to adaptively self-regulate (Larson & Ham, 1993). If this is true, then reappraisal training could neutralize or reduce age-related differences in regulation success. Second, regulation success in adolescence may be constrained by brain maturation, given that prefrontal control regions associated with successful emotion regulation in adults are among the last brain regions to fully develop in adolescence (Barnea-Goraly et al., 2005; Giedd et al., 1999; Gogtay et al., 2004; Ochsner & Gross, 2008; Pfefferbaum et al., 1994). Determining whether one or both of these factors restrict emotion regulation success in younger adolescents will be critical for constructing accurate models of emotion regulation development and may lead to further possibilities for creating interventions.

While our finding that regulation success was positively predicted by age during early and mid-adolescence may appear to contradict theories suggesting that adolescents are more emotionally reactive and prone to risk-taking than children (Casey et al., 2010; Somerville et al., 2010; Steinberg, 2008), three points ought to be considered when interpreting the present results. First, it is unclear whether even the youngest participants in this sample ought to be considered children so much as young adolescents given that pubertal development on average begins between the ages of 8 and 10 for girls (Herman-Giddens et al., 1997) and 11 and 12 for boys in the United States (Herman-Giddens, Wang, & Koch, 2001). While the present two studies used two of the widest age ranges tested on a reappraisal paradigm to date, future studies may seek to include younger ages in their samples so as to more clearly examine differences between children, adolescents, and young adults. Additionally, given the growing body of literature suggesting that some affective processes, particularly emotional reactivity, are more strongly impacted by puberty-related effects than age effects (Dahl & Gunnar, 2009; Forbes, Phillips, Silk, Ryan, & Dahl, 2011; Forbes et al., 2010), it may be fruitful for future work to focus on the pre- and early adolescent age range to examine whether age and pubertal status exert differential effects on affective reactivity and regulation success on cognitive reappraisal tasks. Second, although we observed age-related differences in reappraisal success in the present studies, both of these experiments asked participants to reappraise in a relatively controlled environment while using a very specific type of stimuli. Prior work has shown that adolescents perform disproportionately worse on decision making and executive function tasks when tested in the presence of peers or when responding to affectively arousing stimuli (Cauffman et al., 2010; Figner et al., 2009; Gardner & Steinberg, 2005). Thus, future work should examine how developmental improvements in reappraisal success are impacted by social context and stimulus type. Third, while the present two studies suggest that age-related changes in regulation success occur from early to late adolescence, these improvements may not occur similarly for all individuals. For example, prior work has shown that individual differences in sensation seeking (Crone, Bullens, van der Plas, Kijkuit, & Zelazo, 2008) and anxiety (Hare et al.,

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2008) can interact with age to predict variability in decision making and regulation. Therefore, future work may benefit from examining how these or other variables may predict age-related improvements in emotion regulation success both within and across individuals.

While developmental differences in the self-report of emotion have been observed in younger children (Chambers & Johnston, 2002), there are at least three reasons why it is highly unlikely that this would explain the results in the present studies. First, prior work has shown that by age 10, children are sufficiently aware of their emotional states so as to provide valid self-reports for psychiatric assessments (Edelbrock et al., 1985; Lonigan et al., 2003). Second, as in previous studies of adults (Ochsner et al., 2002), self-reported affect in Study 2 did not correlate with individual differences in the tendency to give socially desirable responses. Third, it seems unlikely that self-report biases could be the driving force behind the age effects observed in the present two studies given that age effects were *only* observed on trials in which participants were asked to reappraise negative stimuli. If, for example, younger participants lacked the ability to accurately report on or understand their emotions, or either older or younger participants provide biased reports of emotion attributable to experimental expectancy or other effects, it is not clear why such biases would reveal themselves only on trials that required regulation, and not on trials in which participants were asked to respond naturally or to take an immersed perspective. Further, it is not clear how such biases could explain the age-related trends in responses to social stimuli or effects of RS observed in Study 2.

Implications for Understanding the Development of Individual Differences— The present findings have implications for understanding both the development of individual differences and potentially, psycho-pathology. These implications stem from our findings that (1) age-related differences in regulation success were greater for social than for nonsocial stimuli, (2) individuals who were high in RS were less successful at regulating emotional responses to aversive social stimuli, but (3) this effect was stronger at younger ages than older ages. Taken together, these data suggest that learning to regulate emotional responses in the social domain is a critical developmental hurdle that, for most individuals, is cleared during adolescence. At the same time, the present data also suggest that being high in RS may make overcoming this obstacle more difficult.

Across the life span, individuals who are high in RS are more likely to defensively expect and perceive rejection in social interactions (Downey & Feldman, 1996), yet the degree to which one is high in RS may be particularly important during adolescence. For example, young adolescents who are high in RS are more likely to encounter relationship violence, have low perceptions of self-worth, and experience reduced interpersonal functioning during middle to late adolescence (Ayduk et al., 2000; Purdie & Downey, 2000). Importantly, not all individuals who are high in RS during early adolescence suffer negative outcomes. Research to date has offered two explanations for why this might be the case. The first is that being high in RS may not be detrimental if one possesses other protective factors, such as being highly capable of exerting self-control to delay gratification (Ayduk et al., 2000). Thus, it is possible that the older, high-RS adolescents in Study 2 have acquired strong self-control skills over the course of adolescence, enabling them to be as effective as their low

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RS counterparts at regulating affective responses to social stimuli. The second explanation is that positive social experiences, such as being well-liked by one's peers during early adolescence, may actually reduce one's tendency to anxiously expect and perceive rejection in the future (London et al., 2007). Older, high-RS participants in this group may have undergone such experiences and thus reduced their RS tendencies. While the present results suggest an exciting possibility for how age and RS interact over the course of adolescence, we must also consider the possibility that the younger and older high-RS individuals in this sample differed on a dimension other than age and age-related experiences. In light of this possibility, future studies may seek to use longitudinal, rather than cross-sectional designs.

Conclusions and Future Directions—Our findings that emotion regulation processes are impacted by age, situational factors, and dispositional differences suggest several directions for future basic and applied research as numerous mental health disorders that are associated with poor regulation of negative affect (Gross & Munoz, 1995; Kring & Werner, 2004) have onsets in adolescence (Glied & Pine, 2002; Pine et al., 1998). While the present studies used negative photographic stimuli because it allowed us to control the content and intensity of the stimuli, future studies might seek to include a diversity of affective stimuli to further examine how contextual and stimulus-driven factors beyond social content (e.g., appetitive vs. aversive stimuli, low-intensity vs. high-intensity stimuli) impact both emotional reactivity and regulation ability at different points in development. It may be, for example, that adult levels of reappraisal success are reached later for highly arousing emotional stimuli than for moderately arousing emotional stimuli.

Second, the present studies differ methodologically from prior field studies by using an experimental laboratory paradigm to assess the development of emotion regulation. Future work might seek to integrate experimental assessments of emotion regulation similar to what we have used in our studies with experience sampling, observational, and questionnaire measures used in prior work. Such studies could link information about how well adolescents *can* regulate when instructed to do so to information about *whether* they regulate in their everyday lives.

Third, the present studies used a cross-sectional design to determine which developmental windows were associated with the steepest changes in emotion regulation. While this approach did not allow us to examine within-individual developmental changes, future work may build on the present findings by examining the same individuals longitudinally. This may be particularly fruitful in early adolescence when situational and individual differences appear to be the most critical for emotion regulation success.

Lastly, the present work gives credence to the notion that early adolescence is a particularly critical developmental window for the acquisition of mature self-regulatory processes. That developmental differences were found in regulation success, but not emotional reactivity, indicates that regulation training may be useful for adolescents in general and may be particularly critical for those who are most at risk for self-regulation failures (e.g., individuals high in RS). This suggests that teaching regulatory skills in a social context and focusing such training on individuals with tendencies to negatively perceive social information may offer a targeted approach for improving wellbeing in adolescence.

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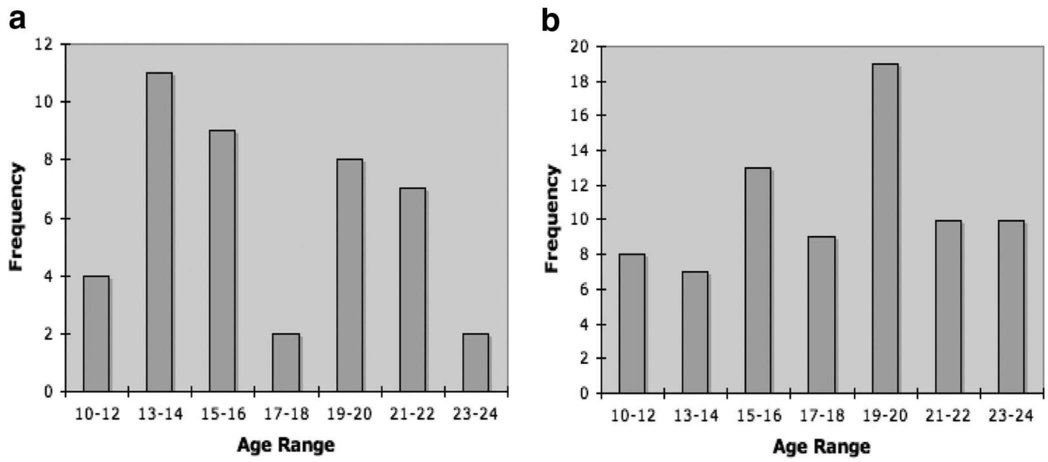

Figure 1.

Age distributions for participants in (a) Study 1 and (b) Study 2.

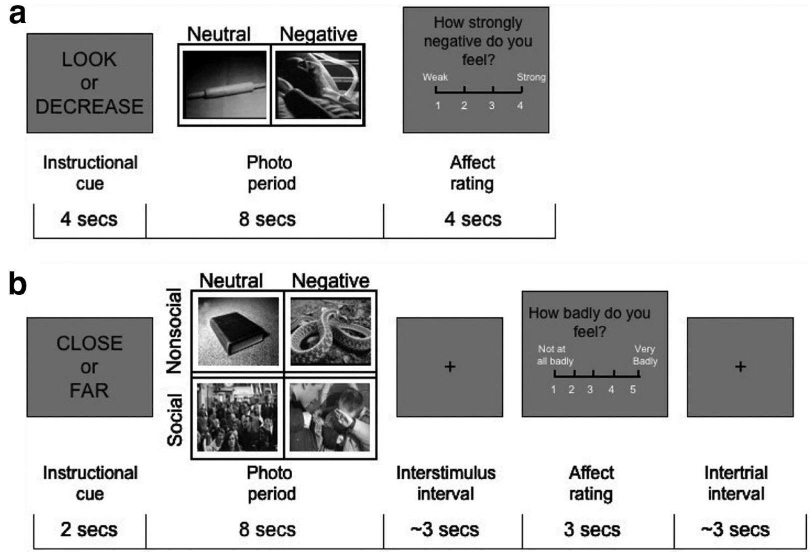

Figure 2.

Visual depiction of trials for (a) Study 1 and (b) Study 2. Note that on actual trials, only one instructional cue and one picture was shown.

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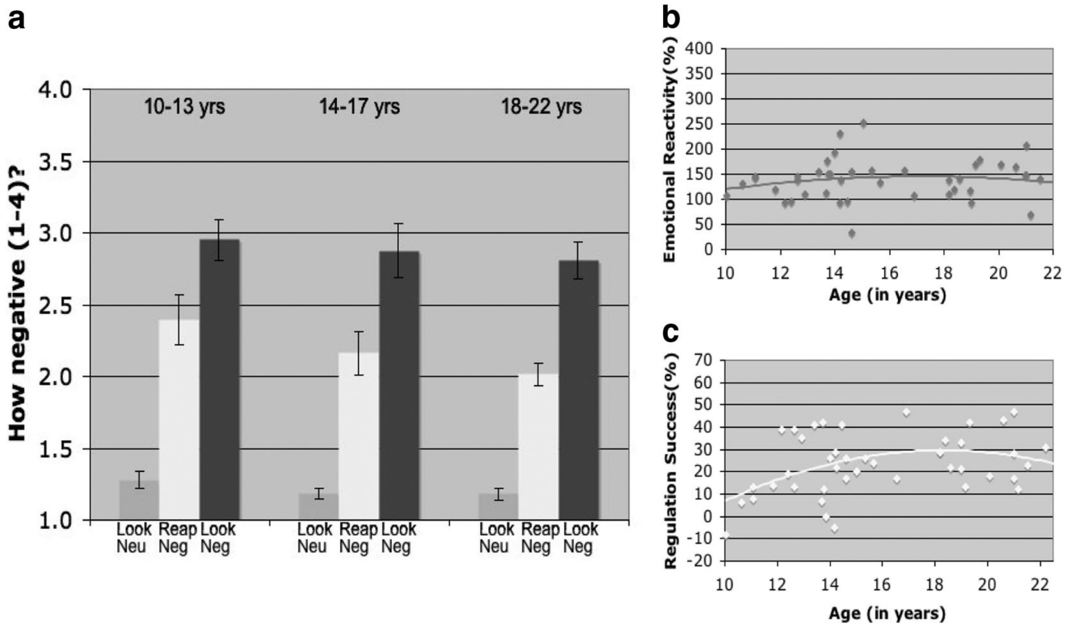

Figure 3.

(a) Negative affect increased when looking (look) at negative (neg) stimuli in comparison with looking at neutral (neu) stimuli and was diminished by reappraising (reap) in Study 1. Analyses were performed using continuous measures of age, but for graphical purposes three age groups were constructed (each representing a 3- to 4-year period). Individual subject data points and the regression equations are plotted as a function of age for (b) emotional reactivity (emotional reactivity = $-0.50 \times \text{age}^2$ +] $17.34 \times \text{age} - 4.28$) and (c) regulation success (regulation success = $-0.33 \times \text{age}^2 + 12.13 \times \text{age} - 81.74$). Neither linear ($p = .33$) nor quadratic ($p = .35$) effects of age were observed for emotional reactivity, but both linear ($p = .03$) and quadratic ($p = .05$) effects were observed for regulation success.

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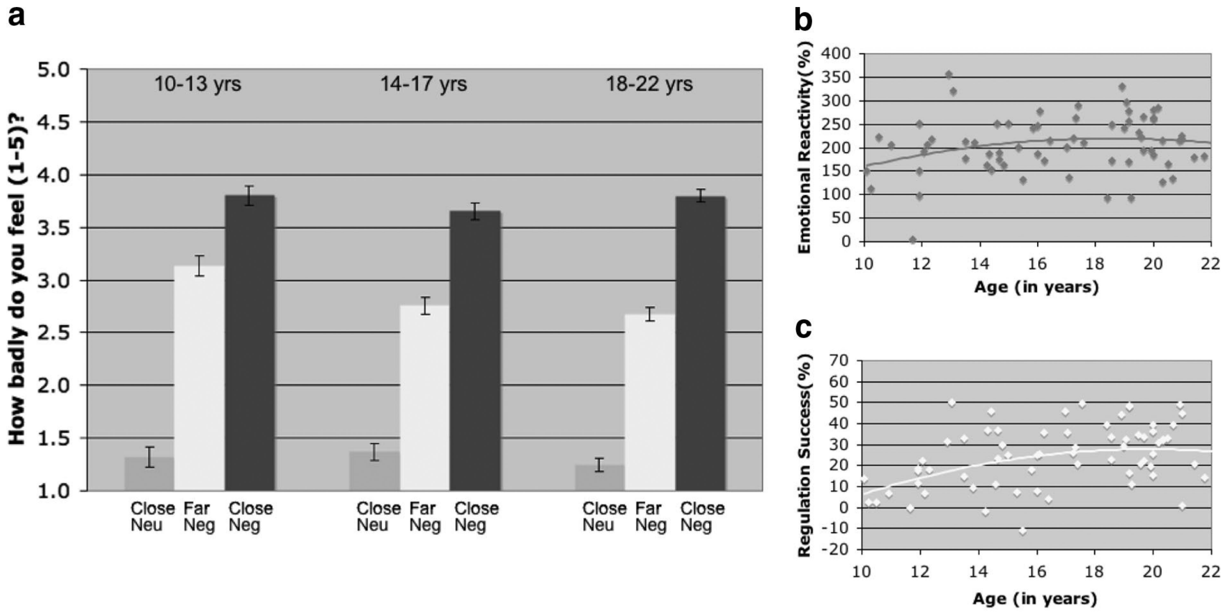

Figure 4.

(a) Negative affect increased when immersing (close) with negative (neg) stimuli in comparison with immersing with neutral (neu) stimuli and was diminished by distancing (far) in Study 2. Analyses were performed using continuous measures of age, but for graphical purposes three age groups were constructed (each representing a 3- to 4-year period). Individual subject data points and the regression equations are plotted as a function of age for (b) emotional reactivity (emotional reactivity = – 0.81 × age^2 + 30.23 × age – .13 × GAI – 47.04) and (c) regulation success (regulation success = – 0.23 × age^2 + 9.01 × age +.07 × GAI – 69.53). Neither linear (p = .13) nor quadratic (p = .17) effects of age were observed for emotional reactivity, but significant linear (p = .045) and marginally significant quadratic (p = .09) effects were observed for regulation success.

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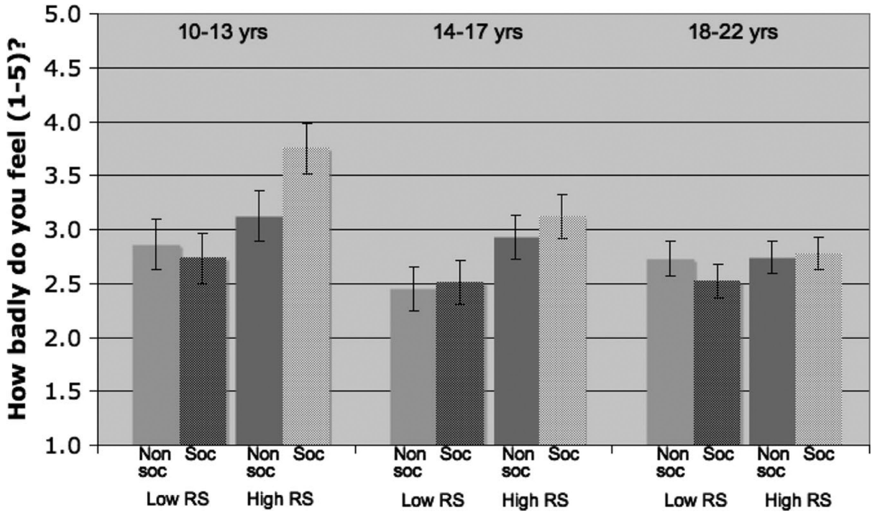

Figure 5.

Affective responses during regulation of emotional responses to aversive stimuli in Study 2 are shown above. Data are presented as a function of age group, stimulus social content (soc), and rejection sensitivity (RS). Analyses were performed on continuous measures of RS and age, but for graphical purposes a median split was performed on RS scores so as to create high and low RS groups, and three age groups were constructed (each representing a 3- to 4-year period).