Use of linguistic distancing and cognitive reappraisal strategies during emotion regulation in children, adolescents, and young adults

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ABSTRACT

Regulating one's emotions is an important psychological skill at all ages. Cognitive reappraisal—changing the meaning of a stimulus to alter its emotional impact—is an effective emotion regulation technique. Prior work shows that adults spontaneously reduce their use of present tense verbs and first-person singular pronouns (e.g., "I," "me," "mine") when engaging in cognitive reappraisal, a linguistic shift that is thought to track increased psychological distance. Here, we investigated whether such *linguistic distancing* during emotion regulation varied across age. Participants aged 10 to 23 ($N = 112$) spoke aloud their thoughts and feelings while completing a classic cognitive reappraisal task. Participants' verbal responses were recorded, transcribed, and analyzed for linguistic distancing, compliance with reappraisal instructions, and use of 8 different reappraisal strategies identified by prior researchers. Results replicated prior work in a developmental sample: Reappraisal decreased negative affect and increased linguistic distancing, and stronger linguistic distancing during reappraisal was associated with more successful emotion regulation. Contrary to hypotheses, we found no age differences in linguistic distancing or reappraisal success, even after excluding trials on which participants did not comply with reappraisal instructions. However, reappraisal strategy use varied across age. Use of the *changing circumstances* and *separating oneself* (i.e., *distancing*) strategies increased across age whereas *changing consequences* use decreased across age. Additionally, in adolescence, *challenging reality* use was elevated and *problem-solving* use was reduced compared to other ages. Results suggest that linguistic distancing during emotion regulation is stable from age 10 to 23 but use of cognitive reappraisal strategies differs.

Keywords: Emotion regulation, psychological distancing, linguistic distancing, development, reappraisal strategies

Emotions play crucial roles in guiding human behavior across all stages of human development. However, emotions can also impair functioning when too intense, too long-lasting, or poorly matched to the events that spur them (Gross & Jazaieri, 2014). Thus people must develop skills for regulating their emotions by learning to guide how their emotional experiences unfold (Gross, 1998b, 2015). One effective technique for regulating emotions—called *cognitive reappraisal*—involves changing the meaning of a stimulus to alter its emotional impact. For example, critical feedback from a parent or peer can be interpreted as helpful guidance for improvement rather than an indication that one is flawed. Substantial evidence demonstrates that cognitive reappraisal is an effective method for regulating emotions (Buhle et al., 2014; Gross, 1998a, 2015) and that greater use of cognitive reappraisal is associated with the absence of several forms of psychopathology (Aldao, Nolen-Hoeksema, & Schweizer, 2010). As such, both basic and applied psychologists are interested in understanding how to facilitate successful cognitive reappraisal. Insight into age related changes in the use of factors that facilitate effective emotion regulation could be especially valuable given that certain periods of development (e.g., adolescence) are characterized by increased risk for the onset of mental illness (Kessler et al., 2005).

Robust evidence shows that one psychological skill that can facilitate self-regulation is a strategy called *psychological distancing* (Ayduk & Kross, 2010; Kross & Ayduk, 2011; Travers-Hill, Dunn, Hoppitt, Hitchcock, & Dalgleish, 2017; White, Kross, & Duckworth, 2015). Psychological distancing involves focusing on ways to separate oneself from sources of distress by increasing the distance between oneself and a distressing cue. These distancing strategies can operate along physical (Silvers et al., 2012), social (Kross, Gard, Deldin, Clifton, & Ayduk, 2012), or temporal (Ahmed, Somerville, & Sebastian, 2018; Bruehlman-Senecal & Ayduk, 2015) dimensions. For example, one could distance oneself from a negative memory of critical feedback by seeing that moment from a third-person rather than first-person perspective (increasing social distance) and by focusing on how long ago that feedback was given (increasing temporal distance). Subtle interventions like these have been shown to increase one's psychological distance from the memory and consequently reduce its emotional impact (Kross, Davidson, Weber, & Ochsner, 2009). Creative designs have shown that even very young children (4-6 years of age) can successfully engage in psychological distancing and that doing so improves their performance on cognitively demanding or frustrating tasks (Grenell et al., 2018; White et al., 2017; White & Carlson, 2016).

Interestingly, the degree to which one has adopted a psychologically distanced perspective can be measured through psycholinguistics (Pennebaker & King, 1999). Use of words that refer to oneself (i.e., first-person singular pronouns; e.g., "I", "me", "mine") and words that refer to the present moment (i.e., present-tense verbs; e.g., "feel", "chase", "lose") indicate that a person is focused on the "here-and-now," whereas less use of these word classes indicates a more distanced perspective. These linguistic markers are thought to arise because the mind scaffolds representations of spatial, social, and temporal distance onto a common neural and linguistic code (Casasanto & Boroditsky, 2008; Maglio, Trope, & Liberman, 2013; Parkinson, Liu, & Wheatley, 2014; Parkinson & Wheatley, 2013). Thus not only can people modulate psychological distance by reimagining situations in a distanced perspective, they can also engage in *linguistic distancing* to increase psychological distancing merely by reducing use of first-person singular pronouns and present-tense verbs.

In fact, recent research demonstrates that cognitive reappraisal and linguistic distancing share a bidirectional relationship (Nook, Schleider, & Somerville, 2017). When adults regulate their emotions by cognitively reappraising the meaning of negative images, they spontaneously distance their language, and participants who more strongly distance their language when reappraising are more successful at reducing their negative affect. Likewise, instructing participants to distance their language by writing about aversive images as if they are physically far away (physical distancing), without using the word "I" (social distancing), or without using present-tense verbs (temporal distancing) spontaneously reduces negative affect. These findings converge with other work on psychological distancing showing that subtle shifts in distancing one's language can reduce distress and even facilitate coping with stressful or traumatic experiences (Kaplow et al., 2018; Kross et al., 2014; Moser et al., 2017; Orvell, Kross, & Gelman, 2017).

From a developmental perspective, might the ability to regulate one's emotions vary across age? Indeed, evidence from several studies demonstrates that broad emotion regulation abilities improve with age (Campos, Campos, & Barrett, 1989; Cole, Martin, & Dennis, 2004; Eisenberg, 2000; Gullone, Hughes, King, & Tonge, 2010; Tottenham, Hare, & Casey, 2011). Additionally, cognitive reappraisal success increases from childhood to young adulthood, especially when these images contain social scenes involving negative interactions between people (McRae, Gross, et al., 2012; Silvers et al., 2012, 2017a; Silvers, Shu, Hubbard, Weber, & Ochsner, 2015). Furthermore, fMRI data demonstrate that developments in the regulatory roles of ventrolateral and ventromedial prefrontal cortex activity explain age-related differences in cognitive reappraisal ability across this age window (Silvers et al., 2017a). These findings converge with neurodevelopmental evidence that these prefrontal regions undergo protracted development through this age window (Ahmed, Bittencourt-Hewitt, & Sebastian, 2015; Gogtay et al., 2004; Shaw et al., 2008). However, not all studies have found age-related improvements in cognitive reappraisal success across childhood and adolescence, either when down-regulating negative affect in response to aversive images (Ahmed et al., 2018; Van Cauwenberge, Van Leeuwen, Hoppenbrouwers, & Wiersema, 2017) or when down-regulating craving in response to appetizing foods (Giuliani & Pfeifer, 2015; Silvers et al., 2014). Instead, these studies found no relations between reappraisal success and age.

However, the potential role of linguistic distancing in the development of emotion regulation remains unexplored. Studies have shown age-related differences from childhood to young adulthood in the ability to "project" oneself into past or future autobiographical scenes (Abram, Picard, Navarro, & Piolino, 2014; Gott & Lah, 2014). To the extent that this psychological skill overlaps with psychological distancing, these data support the notion that increased spontaneous psychological distancing might underlie developmental differences in emotion regulation success. Thus we hypothesized that the tendency to spontaneously distance one's language during cognitive reappraisal would mediate increased emotion regulation success from childhood to young adulthood (see https://osf.io/vcnyr/ for preregistration of methods, hypotheses, and analysis plan). We administered a classic cognitive reappraisal paradigm that included a verbal assessment of participants' thoughts during reappraisal to participants aged 10 to 23. As such, this task assessed participants' reappraisal success and linguistic distancing. We hypothesized that both reappraisal success and linguistic distancing would increase across this age window and that increased linguistic distancing during reappraisal would mediate increased reappraisal success.

In addition to changes in emotion regulation success, the *strategies* that people use to reappraise a stimulus may also change across development. Emotion regulation is an umbrella term for several techniques that people can use to change how they feel, and developmental researchers have found that regulatory habits shift from more behaviorally-focused strategies (e.g., escaping a situation) to more cognitive-focused strategies (e.g., distracting oneself; Altshuler, Genevaro, Ruble, & Bonstein, 1995; Brown, Covell, & Abramovitch, 1991) across childhood. However, scholars have proposed that there is a taxonomy of strategies *within* cognitive reappraisal that differ from each other in important ways (Aldao & Nolen-Hoeksema, 2013; McRae, Ciesielski, & Gross, 2012; Sheppes et al., 2014). For example, people can reappraise the meaning of an aversive stimulus by pretending it is fake (*challenging reality*) or by reinterpreting the details of the stimulus to make it less negative (*changing circumstances*; McRae, Ciesielski, et al., 2012). Few studies have assessed use of different reappraisal strategies in developmental samples, and these studies tend to ask participants to retrospectively report which strategies they tend to use rather than assessing their actual strategy use in experimental tasks (Cracco, Goossens, & Braet, 2017; Zimmermann & Iwanski, 2014; though see Lennarz, Hollenstein, Lichtwarck-Aschoff, Kuntsche, & Granic, 2018 who took an experience-sampling approach). As such, age-related differences in reappraisal strategy use remain unclear.

To address the scientific gaps outlined above, this study investigated three research questions using a classic cognitive reappraisal task in which participants' thoughts and feelings were audio recorded, transcribed, and coded. First, do relations between linguistic distancing and cognitive reappraisal found in adults replicate in a developmental sample? Second, do indices of reappraisal success and/or linguistic distancing change from childhood to young adulthood? Third, are there age-related differences in the strategies people use when reappraising their emotions? This study was originally designed to address the first two of these questions (as noted in the preregistration, https://osf.io/vcnyr/). The decision to investigate the third question concerning age-related differences in reappraisal strategy use was added after data collection was complete. Hence, analyses concerning reappraisal strategy use should be considered as exploratory both because the analyses were defined following preregistration and because the study design was not optimized to address this question. In particular, the instructions used in this study mention specific reappraisal strategies as examples and thus may have biased participants' strategy choices (see **Supplemental Materials** for task instructions). Thus even though patterns observed in this study can provide initial insight into how reappraisal strategy choice might differ across age, these methodological limitations should be kept in mind. Nonetheless, advancing understanding of the three research questions targeted by this study provides greater insight into age-related variation in the cognitive processes underlying cognitive reappraisal, a critical affective skill.

Methods and Materials

Participants

One hundred twenty-four participants aged 10-23 recruited from our laboratory's participant database completed the study. Adult participants and guardians of minor participants provided informed consent prior to participation, and minor participants assented to participation. We excluded three participants due to missing or unintelligible audio recordings, eight participants who failed to meet an *a priori* compliance threshold (i.e., ≥ two-thirds of all reappraisal trials must have been verified as using reappraisal instructions), and one participant who failed to understand task instructions. Thus, 112 participants were included in final analyses (50.89% male, one did not disclose sex; 65.18% Caucasian, 14.29% Black, 9.82% Asian, 10.71% Other; 8.93% Hispanic; age range = 10.02-23.87, M_{age} =17.07, SD_{age} = 3.95). Age was not a significant predictor of sex (logistic regression β =-.01, p =.974) nor of any of the race or ethnicity markers (*p*s > .05), suggesting that the sex and race distributions of the sample were not systematically related to age. The Committee for Use of Human Subjects at Harvard University approved all methods for this study (IRB15-4030: "Developmental brain predictors of subsequent emotion change"). Participants received $20 for their time. Although this study adapted methods from Nook et al. (2017), the current study reports on a non-overlapping sample.

Preregistration for this study was filed on Open Science Framework following the completion of a pilot phase with 53 participants (https://osf.io/vcnyr/). As described in the preregistration, we used a power analysis to select a target sample size that would allow us to test three hypothesized relations between (a) age and linguistic distancing, (b) linguistic distancing and reappraisal success, and (c) age and reappraisal success. To our knowledge, there were no previous studies examining age-related effects in the relationship between linguistic distancing and reappraisal success (i.e., path a). Prior work suggested that the effect size for the b path (i.e., a correlation between linguistic distancing and reappraisal success, $r = .28$; Nook et al., 2017) was smaller than the effect size for the c path (i.e., the increase in reappraisal success across age, $\beta = .446$; McRae, Gross, et al., 2012). To ensure we had sufficient power to detect the smaller of these effects, we conducted a power analysis based on the weakest hypothesized relationship (i.e., path b: a correlation between linguistic distancing and emotion regulation success. This power analysis indicated that we required at least 98 participants to reproduce at 80% power. We increased the target sample size to 112 to provide additional power to detect smaller effects and to allow us to collect an even number of participants (i.e., 8, allowing for a target of 4 girls and 4 boys of each age) across the 14 ages in the 10-23 age window. This final target sample size was preregistered and subsequently collected.

Stimuli and Procedure

The paradigm for this study was an abbreviated version of Study 1 reported in Nook et al. (2017). On each trial, participants saw the cue word "LOOK" or the cue word "CHANGE" above an image for 30 seconds (**Figure 1**). Participants were instructed that the cue word "LOOK" meant that they should "just look at the picture and let yourself feel whatever that image makes you feel." The cue word "CHANGE" indicated that they should regulate their emotions by reappraising the meaning of the image (see **Supplemental Materials** for task instructions). Participants were instructed to reinterpret the meaning of the image to make it less negative (e.g., imagine that the objects are fake or that something good is about to happen; Gross, 1998, 2015). Piloting revealed that children were slower at typing than adults; thus to avoid this potential confound, participants were asked to say out loud (rather than type) what they were thinking and feeling about each image, and their answers were audio recorded. The image automatically advanced after 30 seconds. Participants were instructed not to advance the screen before the requisite time had elapsed, and compliance with this instruction was near perfect (99.8% of total trials). After responding to each image according to trial instructions, participants rated how they were feeling on a 7-point scale (1 = *Not bad at all* to 7 = *Extremely bad*). Negative affect ratings were self-paced.

Trials were divided into three conditions: (i) look negative, (ii) reappraise negative, and (iii) look neutral. Participants completed 12 trials of each condition. We assembled three lists of 12 child-friendly images from the Open Affective Standardized Image Set (OASIS; Kurdi, Lozano, & Banaji, 2017). These image lists were subsets of those used in Nook et al., (2017; see **Table S1** for stimuli details). One list included only neutral images (e.g., paper clips, mugs, rocks; normed valence ratings between 4 and 5 on a 1–9 scale where lower scores are more negative; valence: $M = 4.40$, $SD = 0.26$; arousal: $M = 2.44$, $SD = 0.33$). Neutral images were always paired with the "LOOK" instruction. The other two lists both included negative images only, and they were matched for valence (List A: $M = 2.39$, $SD = 0.49$; List B: $M = 2.42$, $SD = 0.41$; comparison between lists: $t(22) = 0.13$, $p = .899$) and arousal (List A: $M = 4.39$, $SD = 0.51$; List B: $M = 4.32$, $SD = 0.53$; comparison between lists: $t(22) = 0.32$, $p = .750$). Negative images included a wide variety of emotional scenes (e.g. a baby crying, frightening animals, a woman at a cemetery, natural disasters, polluted beaches, abandoned animals, people expressing anger), and the two lists were well matched on image content (see **Table S1**). Mapping of each negative image list to look negative or reappraise negative conditions was counterbalanced across participants to ensure that differences between the look negative and reappraise negative conditions were not due to stimulus differences. Participants reported their date of birth, sex, and race at the beginning of the survey. We produced unrounded measures of participants' age by calculating the number of days between their date of birth and the date they completed the study and dividing this number by 365.25. This ensured that all statistical analyses and figures used a continuous measure of age (e.g., 15.091 rather than 15).

Data Processing

Following data collection, audio recordings of participants' thoughts and feelings during each trial—amounting to a total of 45 hours of recordings—were transcribed into text files by trained research assistants. Transcribing each participants' audio data required approximately one hour, meaning transcriptions required about 123 hours in total. Transcribers were instructed to mark any segments where they were uncertain of what was said by the participant, and these segments were checked by at least one other transcriber. If the segment remained unintelligible after a final check by the first author, it was excluded from linguistic analyses. Of the 1275 trials included in final analyses, 17 trials (i.e., 1%) contained unintelligible segments, suggesting that almost all vocalizations were readily understood and transcribed. In addition to the cross-checking of unintelligible segments among the transcribers, transcriptions were spot-checked for quality by the first author.

To ensure that participants complied with task instructions, three trained coders reviewed participants' transcribed responses to all reappraisal trials and coded each of them for compliance (i.e., that they did indeed use a cognitive reappraisal strategy when instructed to do so). Coders also coded which reappraisal strategy or strategies participants used on each trial. The third author acted as the master coder (i.e., she coded all reappraisal trials) and the other two coders provided second codings for approximately half of the reappraisal trials each. In this initial coding process, discrepancies between coders on strategies used for each trial were rare (93% agreement in initial codings) across all trials included in final analyses. These discrepancies were resolved through discussion, and coders came to full (i.e., 100%) agreement for all codings.

Across all subjects who understood task instructions and had usable audio responses (N = 120), 11.46% of all trials were found to be non-compliant. Participants who failed to meet the *a priori* compliance threshold [i.e., over one third of reappraisal trials ($\geq$ 5 trials) were non-compliant] were excluded from all analyses. Non-compliant trials from included participants (i.e., 7.81% of trials) were also excluded from analyses to ensure dependent measures only included compliant trials. Although the mean age of participants excluded due to non-compliance (14.18 years) was slightly lower than the full sample's mean age robust regressions revealed no significant relations between age and a participant's number of non-compliant trials neither in the full dataset of 120 participants who provided usable data, β =-.06, p =.327, nor the final dataset of 112 participants after excluding those who failed to meet the compliance threshold, β =-.02, p =.843. Additionally, significance of results does not change when including all usable data including non-compliant participants and trials (with three minor exceptions noted in the **Supplemental Materials**).

Following prior research (McRae, Gross, et al., 2012; Nook, Schleider, et al., 2017; Silvers et al., 2012; Wager et al., 2008), we computed each participant's average negative affect rating for trials in each condition (look negative, reappraise negative, and look neutral). We then created measures of (i) *emotional reactivity* (i.e., average look negative affect rating – average look neutral affect rating) and (ii) *reappraisal success* (i.e., average look negative affect rating – average reappraise negative affect rating) for each participant. In addition to this self-report measure of affect, we used Pennebaker's Linguistic Inquiry and Word Count (LIWC) program to produce a set of linguistic measures from participants' verbal responses to each trial type (Pennebaker, Chung, Ireland, Gonzales, & Booth, 2007). LIWC computes the percentage of words that fall within grammatical categories (e.g., verbs, first-person singular pronouns) and content categories (e.g., body-related words, affect related words). Qualitative and empirical investigations have related these categories to psychological phenomena of interest, such as affective state, temporal focus, and certain cognitive processes (Doré, Ort, Braverman, & Ochsner, 2015; Nook, Schleider, et al., 2017; Pennebaker et al., 2007; Tackman et al., 2018).

We focused linguistic analyses on (i) negative affect words (e.g., "hurt," "nasty," "worried," "sad," "crying," "annoyed"), (ii) positive affect words (e.g., "love," "nice," "sweet," "happy," "laughing," "cute"), and (iii) a composite linguistic measure of psychological distancing (following Mehl, Robbins, & Holleran, 2013). This composite measure combined use of first-person singular pronouns (e.g., "I," "me," "my"), present-tense verbs, articles ("the," "a," "an"), discrepancy words (e.g., "would," "could," "should"), and words of more than six letters across trials (see Mehl et al., 2013 and Nook et al., 2017 for more detailed descriptions of how this composite measure was computed). We averaged this measure of linguistic distancing across trials within each condition for each participant. Low linguistic distancing scores indicated that participants used language that was personal, experiential, and focused on the here-and-now, whereas high linguistic distancing scores indicated that language was impersonal, abstract, and not focused on the here-and-now.

Analogous to the measure of reappraisal success, we then computed measures of how much each participant modulated their affective and distancing language when regulating their emotions by subtracting each participant's average frequency of negative affect words, positive affect words, and linguistic distancing words in the look negative condition from their average use in the reappraise negative condition. More positive values for these variables indicated that participants showed a larger increase in their use of each word type when reappraising relative to responding naturally.

The trained coders also coded the use of eight strategies used in each reappraisal trial, following the system developed by McRae and colleagues (McRae, Ciesielski, et al., 2012). They coded each reappraisal as fitting one or more of these strategies (mean number of strategies used per trial = 1.31, *SD* = 0.21): (i) *changing circumstances* (i.e., reinterpreting the current circumstances of the event so that the event is less negative than initially thought; e.g., "the boy is crying out of happiness"[1]), (ii) *challenging reality* (i.e., the event might not be real; e.g., "it's from a movie" or "it's just a photo"), (iii) *changing consequences* (i.e., the future outcome of the

[1] Example reappraisals provided here are taken from participants' actual responses to the task.

negative event will be less negative than initially thought; e.g., “someone will see this stray dog and feel sorry for him, so they will adopt him and he will have a much better life”), (iv) *acceptance* (i.e., accepting or simply “being ok with” the negative situation; e.g., “it’s alright because death is part of the circle of life, that is just how nature works”), (v) *introducing agency* (i.e., someone with necessary skills will be able to change the negative event; e.g., “the firefighters will come and stop the fire”), (vi) *making positive* (i.e., reinterpreting the situation to make it better than if the negative event had never happened; e.g., “he seems very sad and frustrated like he just broke up with his girlfriend, but perhaps it was a very toxic relationship and it is good he got out of it”), (vii) *separating oneself*[2] (i.e., the reappraisal invokes a sense of physical or psychological distance from the negative event; e.g., “the snake is at the zoo, behind glass, and it cannot get to me”), and (viii) *problem-solving* (i.e., specific steps can be taken to improve or solve the negative event; e.g., “the neighbors can get organized in groups and clean all the litter on the beach so that the sea is not polluted”). See McRae, Ciesielski, et al. (2012) for further details of this coding system. We also included *other* as a category to capture reappraisals that did not clearly fall under any of the categories outlined above.

Analyses

Replicating cognitive reappraisal and linguistic distancing effects in a developmental sample. Our first research question concerned whether the results we found in a previous adult sample (Nook, Schleider, et al., 2017) would replicate in a developmental sample of children, adolescents and adults. We evaluated how cognitive emotion regulation affected (i) negative

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[2] The *separating oneself* strategy is typically referred to simply as *distancing* (see McRae, Ciesielski, et al., 2012). However, we decided to rename it throughout this paper to avoid it being confused with *psychological distancing* or *linguistic distancing.*

affect ratings, (ii), affect word use, and (iii) linguistic signatures of psychological distance. Repeated-measures analyses of variance (ANOVAs) tested for significant differences across the three conditions in four dependent variables (i.e., negative affect ratings, negative affect word use, positive affect word use, and linguistic distancing). When significant main effects emerged, follow-up paired-samples *t*-tests assessed for differences between the reappraise negative condition and the other two conditions. We hypothesized that regulating negative emotions would be associated with reduced negative affect (i.e., reduced self-reported negative affect ratings, reduced use of negative affect words, and increased use of positive affect words) and increased linguistic distancing. To confirm that emotion regulation was associated with increases in specific aspects of social and temporal distancing, we present analyses of each subcomponent of the linguistic distancing measure in the **Supplemental Materials**. Note that 90% confidence intervals (CIs) are reported for ANOVA statistics because the ANOVA *F*-test is technically a one-sided test (Lakens, 2013).

We then investigated whether the tendency to use more psychologically distant language when regulating was associated with more successful emotion regulation. We used simple robust regressions to test the hypothesis that higher reappraisal success scores would be associated with stronger reductions in use of negative affect words when regulating, stronger increases in use of positive affect words when regulating, and increased linguistic distancing when regulating.

Relations between cognitive reappraisal, linguistic distancing, and age. Our second research question concerned how age was related to reappraisal success, linguistic distancing, emotion reactivity, raw negative affect ratings in each condition, and changes in negative and positive affect word use when regulating. Following prior work (McRae, Gross, et al., 2012;

Silvers et al., 2012, 2017a), we hypothesized that emotion reactivity would remain constant across age but reappraisal success would increase across age. Because some previous work has found that emotion regulation success increases linearly with age but others report both linear and quadratic effects (McRae, Gross, et al., 2012; Silvers et al., 2012), we tested both linear and non-linear age models. We also hypothesized that linguistic distancing when regulating emotions would increase with age. To ensure that age-related differences in *overall* affect ratings (i.e., even to neutral images; Silvers et al., 2017b) did not mask developmental differences in other dependent variables, we also subjected raw average negative affect ratings in each condition to these analyses. To provide a linguistic measure of affect, we also tested whether age was related to changes in the use of negative and positive affect words when regulating.

To allow for the possibility of non-linear relationships between age and these dependent variables, we followed recent methods (Nook et al., 2018; Rodman, Powers, & Somerville, 2017) and subjected each dependent variable to a set of robust regression models that tested for both linear and non-linear age trajectories. Adjudicating between different age-related patterns is important to accurately characterize the shape of relations between age and dependent variables, as simple linear regressions may miss more complex curvilinear trajectories. For instance, a quadratic relationship with age would suggest that the middle of the age range (i.e., late adolescence) differed from other ages. A cubic relationship with age would suggest a more complex non-linear pattern such that the dependent variable rose, fell, and rose again (or vice versa) across the age range of the sample.

Thus three robust regression models were tested for each dependent variable, corresponding to (i) linear, (ii) quadratic, or (iii) cubic relationships with age. Quadratic and cubic age models included the respective lower order polynomial transformations of age as regressors within the model (i.e., the quadratic age model also included a linear term for age, and the cubic age model also included linear and quadratic terms for age). We compared these three models to each other, as well as to a simple null model. The best fitting age model was the model that had (i) the lowest Akaike's information criterion (AIC, a common metric for model fit), and (ii) a significant p-value (i.e., $p < .05$, indicating a significant improvement over the null model). When the null model provided the lowest AIC or when no model produced a significant fit, it was concluded that no age effect existed for that dependent variable. However, when the linear model provided the best fit as determined by lowest AIC and a significant linear effect (i.e., $p < .05$), we tested whether this model provided a significantly better fit relative to the null model using a likelihood ratio chi square test. When a non-linear model (i.e., a cubic or quadratic model) produced the lowest AIC and had a significant cubic or quadratic regressor (i.e., $p < .05$), we used likelihood ratio tests (LRTs) to compare it to the model with the second-lowest AIC to ensure it provided a significantly better fit than all other models.

Reappraisal strategy use across age. Our third research question concerned potential differences in what reappraisal strategies participants used across age. Following pre-registration, we determined the importance of verifying that participants complied with reappraisal instructions during reappraisal trials, and therefore we added methods to code reappraisal compliance as well as the strategies participants used in each reappraisal. These extra analyses are thus exploratory in nature. We present them as descriptive characterizations of age-related differences in spontaneous use of reappraisal strategies that may prompt questions for future research. Additionally, it is important to note that task instructions included example reappraisal strategies that fell within three of the categories we coded (i.e., *changing* *circumstances, changing consequences, and challenging reality*, see **Supplemental Materials**), and this may have affected participants' reappraisal strategy choices.

The use of each reappraisal strategy category for each subject was quantified as the proportion of compliant reappraisal trials in which they employed each reappraisal category. To investigate whether the average number of reappraisal strategies used in each trial varied across age, and how the frequency of use of each reappraisal strategy varied across age, the same three age models outlined in the previous section (i.e., linear, quadratic, and cubic) as well as a simple null model were fit to the average number of strategies used per trial and to the use of each reappraisal strategy. We used the same criteria to determine the best fitting model as described in the previous section [i.e., lowest AIC, significant age regressor, and (when needed) a significant LRT confirming it provided a significantly better fit than less complicated models].

Linguistic complexity control analyses. Finally, we conducted a set of *post hoc* analyses testing whether age-related variation in linguistic complexity (i.e., the sophistication with which an individual can express information via language; Lust, Foley, & Dye, 2009; Pallotti, 2015; Ravid, 2005) could explain age-related differences in the cognitive reappraisal strategies verbalized in this task. Although the study did not include independent measures of verbal ability or verbal fluency, prior research has used measures ascertained by LIWC to assess linguistic complexity (Pennebaker & King, 1999; Saslow et al., 2014). This approach hinges on the notion that more complex language involves expressing information with more nuance (i.e., making more distinctions and qualifications). As such, linguistic complexity scores can be formed by combining the LIWC categories of exclusive words (e.g. "but," "except," "however," "unless"), tentative words (e.g. "maybe," "perhaps," "guess"), negations (e.g. "neither," "never," "cannot"), discrepancies (e.g. "should," "would"), and the reverse-scored use of inclusive words (e.g. “with,” “also,” “plus”). We report details of these analyses and their results in the **Supplemental Materials**.

Analytic software and data availability. All analyses were conducted in RStudio (RStudio Team, 2016). We conducted polynomial age analyses using the *poly* function in the core *stats* package (R Core Team, 2018), robust regressions using the *rlm* function in the *MASS* package (Venables & Ripley, 2002), and likelihood ratio tests using the *lrtest* function in the *lmtest* package (Zeileis & Hothorn, 2002). Data for this study can be downloaded from https://osf.io/ex5gy/.

Results

Replicating Cognitive Reappraisal and Linguistic Distancing Effects in a Developmental Sample

All results reported in Study 1 of Nook et al. (2017) replicated in this developmental sample. Details of these results are reported below.

Self-reported negative affect ratings. Self-reported negative affect ratings differed significantly across conditions, $F(2, 222) = 401.06$, $p < .001$, $\eta_p^2 = .78$, 90% CI = [.74, .81] (**Figure 2A**). Participants reported feeling less negative affect in response to images in the reappraise negative condition ($M = 2.90$, $SD = .99$) than in response to images in the look negative condition ($M = 3.72$, $SD = 1.05$), $t(111) = 11.52$, $p < .001$, 95% CI of mean difference [0.68, 0.96], Cohen’s $d = 1.09$. Unsurprisingly, ratings for images in the reappraise negative condition were higher than ratings for images in the look neutral condition ($M = 1.52$, $SD = 0.55$), $t(111) = 17.38$, $p < .001$, 95% CI = [1.23, 1.54], $d = 1.64$.

Affect words. Reappraisal affected the use of negative and positive affect words. The prevalence of negative affect words differed significantly across conditions, $F(2, 222) = 273.62$, $p < .001$, $\eta_p^2 = .71$, 90% CI = [.66, .75]. Participants used fewer negative affect words in the reappraise negative condition ($M = 3.19\%$, $SD = 1.06$) than in the look negative condition ($M = 5.51\%$, $SD = 1.84$), $t(111) = 13.66$, $p < .001$, 95% CI = [1.98, 2.65], $d = 1.29$. Participants used more negative affect words in the reappraise negative condition than the look neutral condition ($M = 1.63\%$, $SD = 1.12$, $t(111) = 11.38$, $p < .001$, 95% CI = [1.28, 1.82], $d = 1.08$. Similarly, the frequency of positive affect words differed significantly across conditions, $F(2, 222) = 60.01$, $p < .001$, $\eta_p^2 = .35$, 90% CI = [.27, .42]. Participants used more positive affect words in the reappraise negative condition ($M = 3.44\%$, $SD = 1.29$) than the look negative condition ($M = 2.94\%$, $SD = 1.37$), $t(111) = 3.71$, $p < .001$, 95% CI = [0.24, 0.77], $d = 0.35$. Participants used fewer positive affect words in the reappraise negative condition than the look neutral condition ($M = 4.77\%$, $SD = 2.15$), $t(111) = 6.82$, $p < .001$, 95% CI = [0.94, 1.71], $d = 0.64$.

Linguistic distancing. Critically, participants spontaneously increased their use of words coding psychological distance when regulating their emotional responses to negative images. The composite measure of linguistic distance differed significantly across conditions, $F(2, 222) = 24.73$, $p < .001$, $\eta_p^2 =. 18$, 90% CI = [.11, .25] (**Figure 2B**). Participants' verbal responses were more distanced in the reappraise negative condition ($M = 0.11$, $SD = 0.27$) than in the look negative condition ($M = -0.08$, $SD = 0.31$), $t(111) = 6.03$, $p < .001$, 95% CI = [0.13, 0.26], $d = 0.57$. Additionally, verbal responses were more distanced in the reappraise negative condition than in the look neutral condition ($M = 0.02$, $SD = 0.28$), $t(111) = 3.39$, $p < .001$, 95% CI = [0.04, 0.14], $d = 0.32$. This pattern existed for all components of the linguistic distancing variable except for words of more than six letters (**Table S2**).

Relations between linguistic measures and reappraisal success. As in the adult sample, a robust regression showed that participants in this developmental sample who more strongly distanced their language when regulating were more successful at regulating their emotions, β = .24, p = .010 (**Figure 2C**). Significant regressions emerged between reappraisal success and two components of the linguistic distancing measure (i.e., first-person singular pronouns and present-tense verbs), but this relationship was not significant for discrepancy words, articles, or words of greater than six letters (**Table S3**). Greater reappraisal success was also associated with reduced use of negative affect words when regulating as compared with when responding naturally, β = -.23, p = .011, and it was also associated with increased use of positive affect words when regulating, β = .26, p = .003.

Relations Between Cognitive Reappraisal, Linguistic Distancing, and Age

Comparisons between null, linear, quadratic, and cubic age models were used to assess whether behavior in the cognitive reappraisal task differed across age. Contrary to hypotheses, age was not significantly related to any of the emotion regulation variables of interest, as the null model produced the best fit for each dependent variable (**Table S4**). We did not find any significant age-related differences in emotional reactivity, reappraisal success, or linguistic distancing when regulating. To ensure that this lack of effect was not due to overall differences in emotional responding, we analyzed raw negative affect ratings in each condition and confirmed that age was not significantly related to reported affect in the reappraise negative, look negative, or look neutral conditions (**Figure 3**). Similarly, there were no significant age-related differences in how strongly participants changed their use of negative or positive affect words when reappraising. In the preregistration of this project (https://osf.io/vcnyr/) we also planned to conduct a robust mediation testing whether increased linguistic distancing when regulating mediated increased reappraisal success across age. However, because we found no relations between age and reappraisal success or linguistic distancing (the *a* and *b* paths of the mediation model), there was no justification for a mediation analysis.

Reappraisal Strategy Use Across Age

Overall use of each strategy. The overall use of each of the nine reappraisal strategies was first calculated at the subject level (as the percentage of usable trials that used each strategy). These participant-level proportions were then averaged across the sample (see **Figure 4**). Overall use of each of the nine reappraisal strategies differed significantly, $F(8,888) = 269.15$, $p < .001$, $\eta_p^2 = .71$, 90% CI = [.68, .73]. *Changing circumstances* was the most frequently used strategy (M = 69.39%, SD = 19.96), followed by *challenging reality* (M = 25.18%, SD = 24.99) and *changing consequences* (M = 8.74%, SD = 13.52). These were followed by *acceptance* (M = 7.78%, SD = 11.99), *introducing agency* (M = 7.13%, SD = 10.37), *making positive*, M = 5.14%, SD = 8.98), *separating oneself* (M = 3.88%, SD = 6.78), and *problem-solving* (M = 3.36%, SD = 6.56). The *other* category was needed for only one trial (0.08%) across all subjects. On this trial, the subject reminded himself he has already overcome a similar situation and used this personal experience to keep negative feelings in perspective.

Reappraisal strategy use across age. We again used model comparisons to assess whether the number of reappraisal strategies used per trial and the average use of each reappraisal strategy were best explained by a null, linear, quadratic, or cubic age model (**Table 1**). We did not find significant age-related differences in the number of strategies used for each reappraisal trial. **Figure 5** shows the best fitting models of age for the five reappraisal strategies for which age was a significant predictor of strategy use. Model comparisons revealed that the linear age model was the best fit for *changing circumstances* (**Figure 5A**, LRT comparing linear and null models: chi square (X^2) = 4.86, degrees of freedom (*DF*) = 1, $p = .027$); the cubic age model was the best fit for *challenging reality* (**Figure 5B**, LRT comparison to null model, the next best fitting model: $X^2 = 7.98$, $DF = 3$, $p = .046$); the linear age model was the best fit for *changing consequences* (**Figure 5C**, LRT comparing linear and null models: $X^2 = 6.65$, $DF = 1$, $p = .010$); the null model was the best fit for the use of *acceptance*, for *introducing agency*, and for *making positive*; the linear age model was the best fit for *separating oneself* (**Figure 5D**, LRT comparing linear and null models: $X^2 = 28.05$, $DF = 1$, $p < .001$); and the cubic age model was the best fit for *problem-solving* (**Figure 5E**, LRT comparison to linear model, the next best fitting model: $X^2 = 25.11$, $DF = 2$, $p < .001$). Note that relations between age and use of *changing circumstances, challenging reality,* and *problem-solving* strategies were reduced to statistical trends when including non-compliant participants and trials (**Supplemental Materials**).

Linguistic complexity control analyses. Analyses revealed no significant linear, quadratic, or cubic relations between age and the linguistic complexity measure produced by LIWC (see Pennebaker & King, 1999; Saslow et al., 2014; see **Supplemental Materials**). Null models were the best fit both for overall average linguistic complexity scores and also the extent to which participants increased their linguistic complexity while regulating. Although this was a *post hoc* analysis using a somewhat crude measure of linguistic complexity, this result provides initial evidence that age-related differences in linguistic complexity could not mediate or confound age-related differences in other dependent variables.

Discussion

This study investigated age-related differences in cognitive reappraisal from childhood to young adulthood. Participants' verbally expressed thoughts and feelings were recorded during a classic cognitive reappraisal task and analyzed to test how linguistic distancing and the use of reappraisal strategies differed across age. Consistent with hypotheses and prior work, we found that participants reduced their negative affect when reappraising negative images and spontaneously increased their linguistic distance when reappraising. Additionally, stronger linguistic distancing during reappraisal was associated with more successful down-regulation of negative affect, an effect that was evident in both self-report and linguistic measures. Contrary to hypotheses, we found no age-related differences in reappraisal success, linguistic distancing, or any other affective or linguistic measure from this task. However, analyses of participants' use of five reappraisal strategies showed significant relations with age. Participants' tendency to reappraise images by changing circumstances or psychologically distancing themselves showed linear increases across age, their tendency to change the consequences of the situation decreased linearly with age, and their tendency to challenge reality or problem solve showed non-linear relations with age. However, reappraisal strategy results should be interpreted with caution given that task instructions likely primed participants to use a specific subset of strategies. Nonetheless, together these findings extend understanding of the psychological and linguistic processes underlying the development of successful emotion regulation.

In addition to replicating prior work showing that adults distance their language when regulating their emotions and that stronger linguistic distancing is associated with more successful regulation (Nook, Schleider, et al., 2017), we also found that participants' tendency to spontaneously distance their language when regulating emotions remained stable across this developmental window. This result suggests that by late childhood, people subtly increase psychological and linguistic distance from aversive stimuli during emotion regulation. This reveals an unexplored feature of children and adolescents' emotion regulation abilities. Additionally, because linguistic distancing tracked successful reappraisal for children and adolescents (as well as adults), it is possible that encouraging children and adolescents to "take a step back" and distance their language during cognitive reappraisal could increase the efficacy of this regulatory strategy. This implies that future research should investigate the clinical utility of linguistic distancing in childhood, adolescent, and adult samples.

However, based on evidence that the ability to project into past or future autobiographical scenes becomes more rich (Gott & Lah, 2014) and more specific (Abram et al., 2014) from childhood to young adulthood, we initially hypothesized that linguistic distancing might increase across this developmental window. Thus, finding that linguistic distancing did not vary across age was unexpected. Nonetheless, this result converges with prior work showing no age differences in the efficacy of emotion regulation when participants were specifically instructed to engage in temporal distancing (Ahmed et al., 2018), as well as recent work showing that children much younger than our age range (i.e., 4-6 years of age) are able to improve their performance on cognitively demanding and frustrating tasks through psychological distancing (Grenell et al., 2018; White et al., 2017; White & Carlson, 2016). Thus when taken together with prior work, the current results suggest that relations between the developmental trajectories of (i) emotion regulation via distancing and (ii) at least some psychological projection abilities (at least as measured by Abram et al., 2014 and Gott & Lah, 2014) may not be as straightforward as one might assume. These patterns raise several questions that could be investigated in future work, including (i) what facets of psychological distancing undergo development, (ii) what facets of psychological distancing are important to emotion regulation, and (iii) whether children might only experience difficulty performing difficult projection/distancing tasks but show adult levels on easier tasks. Understanding the nuanced relationships between developments in the ability to project oneself beyond the here-and-now and emotion regulation could provide much needed insight into how the basic processes underlying emotion regulation vary across age.

Similarly, the lack of developmental differences in reappraisal success in this study is inconsistent with some prior studies (McRae, Gross, et al., 2012; Silvers et al., 2012, 2017a, 2015) and consistent with others (Ahmed et al., 2018; Van Cauwenberge et al., 2017). These discrepancies suggest that there may be important conceptual factors that moderate whether or not a study will find developmental differences in reappraisal success. One potential moderating variable is the type of reappraisal strategy under investigation. Lack of developmental effects have been found when reinterpretations were provided by the task and when participants were instructed to project themselves temporally into the future (Ahmed et al., 2018; Van Cauwenberge et al., 2017), and increased cognitive reappraisal success across age has been found when participants were instructed to psychologically distance themselves from the content of images (Silvers et al., 2012, 2017a, 2015). However, two studies found increased reappraisal success across age when participants were given general instructions to reinterpret the meaning of aversive images, similar to the prompt used in this study (McRae, Gross, et al., 2012; Silvers et al., 2012). Thus if reappraisal type does indeed moderate developmental effects, the differences in instructions that produce these effects must be subtle.

The target of reappraisal (i.e., the types of situations and stimuli that generate emotions participants must regulate) could also moderate developmental differences in reappraisal success. Specifically, one study found age differences in reappraisal success only for images that included social (i.e., interpersonal) content (Silvers et al., 2012). The current study included a mix of social and non-social stimuli, but fewer social stimuli were used than non-social stimuli, potentially clouding age differences. Emerging research also indicates that both the intensity of negative affect induced by a stimulus (Lennarz et al., 2018; Sheppes et al., 2014) and its reappraisal "affordances" (i.e., how easy it is for participants to generate alternative appraisals; Suri et al., 2017) both affect what regulatory strategies people choose to implement. Given that we found age differences in participants' spontaneous use of regulatory strategies, these factors could likewise moderate relations between age and reappraisal success. Future research could specifically manipulate reappraisal affordances and image intensity to examine whether these factors do indeed impact reappraisal success differently for children and adolescents compared to adults, as these factors could also explain divergent results across studies. As a broader point, the current study included too few trials to examine how image-level variables (e.g., intensity, emotional content, social content, etc.) impacted reappraisal success and strategy choice. Future research should intentionally manipulate these variables to investigate how these factors influence regulation.

A final potential moderator relevant to the current study involves the fact that participants were asked to say aloud the content of their reappraisals. This design feature could have impacted any number of psychological processes (e.g., depth of elaboration or sense of interpersonal support; Schacter & Graf, 1986; Zaki & Williams, 2013) that might have affected participants' regulatory success. Thus, the context of reappraisal—a facet of emotion regulation that has gained increased interest in recent years (Aldao, 2013; Schirda, Valentine, Aldao, & Prakash, 2016)—could also have an important impact on developmental differences in emotion regulation. In particular, Park, Ayduk, & Kross (2016) found that an intervention in which participants verbalized their thoughts and feelings through writing—but not silently thought about them—increased psychological distance and reduced negative reactivity in response to an emotional challenge months after the intervention. Although there is not an obvious reason why this effect would be stronger at younger ages, it is nonetheless possible that having participants specifically verbalize their approach to regulating their emotions may contribute to discrepancies between the current results and prior work. We encourage future researchers to specifically examine which of the factors listed above (or others) moderate measures of cognitive reappraisal across development. Meta-analytic approaches might be especially helpful in clarifying the relative influence of these contextual factors on reappraisal success across age.

As an advance beyond prior work, the current study ensured that participants did indeed engage in cognitive reappraisal on trials when they were instructed to do so. This verification provided several points of additional insight. First, it ensured that any age-related differences in reappraisal success were not driven by (or masked by) age-related differences in compliance. Indeed, we found no relationships between age and compliance, and all results (except for age trajectories for the use of 3 reappraisal strategies) remained significant regardless of whether noncompliant trials and participants were excluded. Second, we were able to estimate the number of non-compliant trials across a developmental sample of participants. Across all 120 participants for whom we had usable behavioral and audio data, we found that approximately 10% of trials did not involve a reappraisal. Although full compliance would be ideal, the fact that most results do not differ when non-compliant participants and trials are included suggests that this proportion of noncompliant trials does not significantly interfere with estimates of reappraisal success. This result implies that developmental results in other studies are not likely due to differential compliance across age, but given that our methods differed, this is an empirical question that should be verified in future work.

Our third research question concerned age differences in the reappraisal strategies people use to regulate their affect. Although reappraisal strategy use has been of great interest to both basic (McRae, Ciesielski, et al., 2012; Sheppes et al., 2014) and applied (Aldao et al., 2010) researchers, standard methods of assessing reappraisal do not permit insight into what strategies participants use at the trial level. We found that the vast majority of reappraisal trials involved either *changing circumstances* or *challenging reality*, and each of the other strategies were used on fewer than 10% of trials on average. Again, the generalizability of this pattern should be considered in light of the fact that the study's instructions provided example reappraisal strategies that fell within these categories (see **Supplemental Materials**). Hence, participants may have been "primed" to use these strategies when reappraising images. Interestingly, however, patterns of average strategy use observed in the current study are similar to the rates reported by McRae and colleagues in an adult sample (McRae, Ciesielski, et al., 2012), although results from the current study show less use of the *making positive* and *changing consequences* strategies. This consistency with prior work might imply that participants' predilection for changing circumstances and challenging reality may reflect their general behavior in cognitive reappraisal tasks, but future studies that use more neutral instructions should replicate this finding before taking it as definitive.

Although prior researchers have found that adolescents report that they would use a smaller set of reappraisal strategies in emotional situations compared to children and adults (Zimmermann & Iwanski, 2014), we found that the average number of reappraisal strategies participants used on each trial did not vary across age. Thus, when adolescents are faced with the challenge of reappraising images, they tend to use just as many strategies concurrently as children and young adults. By contrast, the types of strategies participants used differed across age, with use of five strategies showing linear or cubic relations with age. However, the facts that (i) there was a large imbalance in overall strategy use, (ii) analyses of strategy use were not preregistered, and (iii) the instructions introduced example strategies that may have biased participants' behavior in the task should be kept in mind when interpreting these results. Thus, we present these results as exploratory characterizations of participants' spontaneous reappraisal strategies that could generate future questions for research. That said, three key patterns can be observed in these data.

First, use of the *changing circumstances* strategy (the most frequently used strategy) increased linearly across age. Several processes could produce this result. For example, adults may select this strategy because they believe it is easier or more effective than other strategies, whereas its perceived ease or effectiveness may vary for other ages. Hence, this result calls for future work on age-related differences in perceptions of reappraisal strategies and how these perceptions relate to reappraisal strategy selection (see Troy, Shallcross, Brunner, Friedman, & Jones, 2018 for an example study in adults). Second, the two cubic patterns we observed were inverses of each other: Adolescents showed elevated *challenging reality* use and reduced *problem solving* use compared to other ages. A similar trend appeared at the highest end of our age window. Although denying reality may be a helpful strategy for down-regulating negative affect in many situations, it can also be problematic, as merely pretending stressors aren't real will not solve underlying problems causing those stressors. As such, these results converge with prior work showing that adolescents self-report a general shift away from optimal regulatory strategies and towards potentially maladaptive strategies compared to children and adults

(Cracco et al., 2017). Future research could examine whether adolescents do indeed tend to "avoid" real-world stressors by denying their reality and whether this has negative downstream consequences. However, an assumption of this interpretation is that emotion regulation strategies may differ in their impact across time (e.g., *challenging reality* might reduce distress in the short term but increase distress in the long term). Because the current study used a paradigm that tightly constrains the time window in which participants select and deploy emotion regulation strategies, it is not an ideal method for testing this question. Hence, although the current study provides a close analysis of how people choose to regulate their emotions in short timespans, future research could benefit from methods that examine more long-term consequences of these regulatory strategies.

Third, we found that participants' tendency to change the consequences of stimuli decreased with age, whereas their use of the separating oneself (i.e., psychological distancing) strategy increased with age. This pattern might shed light on why overall linguistic distancing is stable across age. Reappraising by changing the consequences of a stimulus requires reimagining how the scene will play out in the future, and psychological distancing involves reimagining the scene so that its contents are separated from oneself. Thus there may be a developmental shift in *how* participants distance themselves from aversive stimuli as they age: Whereas children might tell themselves a new story about how the event will play out, young adults instead take a more general psychologically distanced perspective. Adolescence, then, may be a period of crossover between these tendencies. Future work should seek to replicate and extend these patterns to further investigate if and why styles of psychological distancing vary across development.

Although the current study addresses the three research questions discussed above, limitations of the study's design merit discussion and should be addressed through future research. First, although we found that spontaneous linguistic distancing in cognitive reappraisal was stable from age 10 to 23, it is possible that this capacity emerges at earlier ages. Hence, future research on these phenomena could recruit younger ages to assess whether age-related differences in spontaneous linguistic distancing arise earlier in development. Second, the current work adopts a cross-sectional design, which prevents any causal conclusions regarding development. Use of longitudinal methods would provide greater certainty about the age-related differences observed here. Third, asking participants to verbalize their regulatory approach may have influenced participants' psychological distance and regulatory success (Park et al., 2016). It's also possible that participants may have been using several reappraisal strategies but only verbally describing some of them. Although linguistic measures require that participants verbalize their thoughts through speaking or writing, future research could manipulate whether or not reappraisals are verbalized to see if this manipulation affects reappraisal success. Participants could then be thoroughly questioned about their use of reappraisal strategies after each trial to ensure that the measure of reappraisal strategy isn't biased by which strategies are easiest to describe.

Fourth, although analyses of a linguistic complexity measure provided by LIWC provided initial evidence that linguistic complexity did not significantly differ across age (and thus did not confound primary results), the current study could have more specifically investigated how general verbal and linguistic development might relate to developments in linguistic distancing, reappraisal success, and/or the reappraisal strategies that participants verbalized. The general ability to represent and communicate about emotional and nonemotional information changes across age (Baron-Cohen, Golan, Wheelwright, Granader, & Hill, 2010; Farkas & Beron, 2004; Nook et al., 2018), and these developments could relate in very interesting ways to the phenomena central to the current study. For example, prior work shows that increased verbal knowledge mediates the development of multidimensional emotion concepts, which could be related to one's ability to regulate emotions (Nook, Sasse, Lambert, McLaughlin, & Somerville, 2017). Thus future research on the development of emotion regulation—and linguistic components of emotion regulation, in particular—should i) include gold-standard measures of general verbal ability (e.g., Wechsler, 1991) and ii) examine more sophisticated measures of linguistic complexity (Pallotti, 2015; Ravid, 2005) to test for relations between these constructs. Targeting these constructs in future studies is important given the possibility that children may have used complex reappraisal strategies cognitively but struggled to express them through language.

Fifth, because the current study examined spontaneous reappraisal strategy use when instructed to reappraise aversive images—which could differ from people's regulatory choices in real-world settings where reappraisal is not explicitly instructed—future work should examine participants' reappraisal strategy use outside of controlled laboratory environments. For example, experience-sampling methods that have been used to examine how broad emotion regulation strategies and other aspects of emotion dynamics relate to adolescent well-being (e.g., Lennarz et al., 2018; Lennarz, Lichtwarck-Aschoff, Timmerman, & Granic, 2017) could be adapted to investigate how these phenomena vary across development. Sixth and finally, because use of each strategy differed greatly across participants, this study was not well designed to test how effectively each reappraisal strategy down-regulated negative affect. A more controlled study in which participants are instructed to use different strategies could more successfully assess the efficacy of each strategy across age (e.g., Troy et al., 2018). A combination of these final two future directions could contribute to the notion that there may be gaps between developmental patterns in people's *capacity* and their *tendency* to regulate their emotions (Silvers & Guassi Moreira, 2017). In other words, researchers could both explore what strategies people of different ages select to regulate their emotions in naturalistic settings as well as how effective those strategies are.

In all, this study revealed that children and adolescents spontaneously distance their language when regulating emotions to the same extent as adults and that greater linguistic distancing is associated with more successful cognitive reappraisal regardless of one's age. This result suggests that increasing linguistic distancing tracks—and might even facilitate—successful emotion regulation even in childhood and adolescence. Additionally, the results provide initial evidence that the strategies people spontaneously use to reappraise stimuli vary across development. Specifically, the tendency to change the circumstances of a situation increases with age, adolescents may be more likely to deny reality and avoid problem solving than other ages, and there may be a cross-over in how people distance their perspective on aversive stimuli across age. These results provide greater insight into the cognitive and linguistic underpinnings of successful emotion regulation across development and generate new research questions on how the tendency and efficacy of different reappraisal strategies might vary from childhood to adulthood.

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Author contributions

ECN and LHS developed the study design. ECN programmed the computer task. CMVB and HYC collected data. HYC oversaw reappraisal-coding process. CMVB and ECN analyzed data. Authors collaboratively interpreted results. ECN and CMVB drafted the manuscript, and all other authors provided critical revisions. All authors approved the final version of the manuscript for submission.

Related publications

Portions of these results have been shared via posters at conferences of the Social and Affective Neuroscience Society (2018) and the Society for Research in Psychopathology (2018).

Conflicts of interest

Authors declare no conflicts of interest.

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TABLES

Table 1. Results of polynomial models for the use of each reappraisal strategy.

Reappraisal strategy	Model	β	p	AIC
Average number of strategies used	**Null**			**321.53**
	Linear	-.11	.268	321.68
	Quadratic	.02	.517	323.72
	Cubic	.04	.693	325.56
Changing circumstances	Null			320.95
	Linear	**.20**	**.040***	**318.09**
	Quadratic	-.06	.100	319.79
	Cubic	.05	.190	321.29
Challenging reality	Null			320.88
	Linear	-.10	.301	321.37
	Quadratic	.009	.586	323.35
	Cubic	**.26**	**.040***	**318.90**
Changing consequences	Null			324.31
	Linear	**-.15**	**.010***	**319.67**
	Quadratic	.04	.040*	322.26
	Cubic	-.08	.024*	320.54
Acceptance	**Null**			**323.51**
	Linear	.01	.831	325.77
	Quadratic	.04	.813	328.06
	Cubic	.04	.889	329.72
Introducing agency	**Null**			**324.72**
	Linear	.05	.452	327.38
	Quadratic	-.02	.740	328.91
	Cubic	-.14	.194	326.65
Making positive	**Null**			**325.25**
	Linear	-.07	.291	323.70
	Quadratic	.03	.521	325.28
	Cubic	.05	.605	327.50
Separating oneself	Null			344.72
	Linear	**.15**	**.034***	**318.67**
	Quadratic	-.08	.048*	318.94
	Cubic	-.03	.099	320.04
Problem-solving	Null			347.05
	Linear	.01	.110	346.97
	Quadratic	.001	.255	350.57
	Cubic	**-.14**	**.038***	**325.86**

Note: Bold text indicates best fitting model for each dependent variable, as determined by AIC, p-value, and LRT. β = standardized beta, AIC = Akaike Information Criterion; * $p < .05$. Note that the *separating oneself* strategy is typically referred to as *distancing* (see McRae, Ciesielski, et al., 2012), and was renamed in this paper to avoid confusion with the broader concept of *psychological distancing* or the measure of *linguistic distancing*.

FIGURES

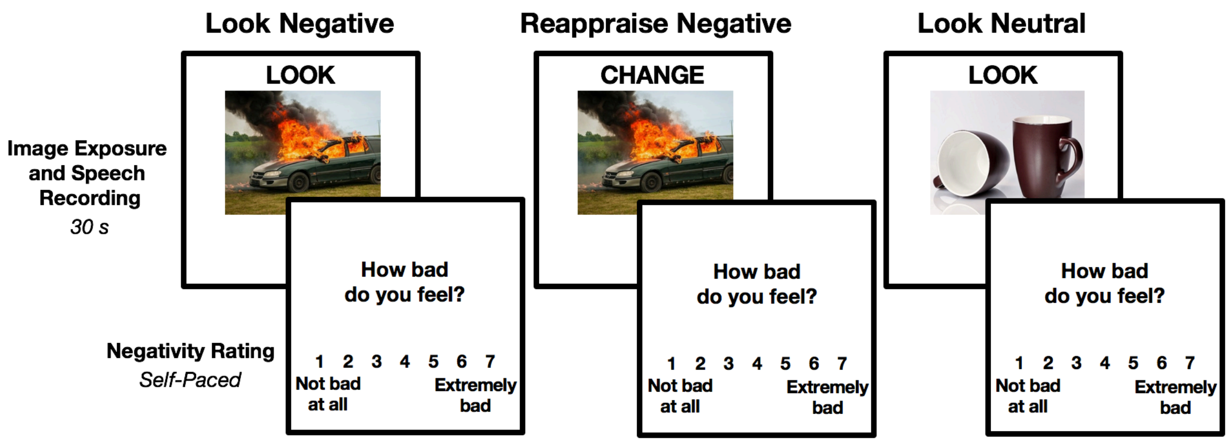

Figure 1. Task schematic. Participants said aloud their thoughts and feelings about an image for 30 second before rating how bad they felt. "LOOK," or "CHANGE" cues were presented above images to sort trials into look negative, reappraise negative, and look neutral conditions. In look negative and look neutral trials, participants said aloud their natural thoughts and feelings in response to negative and neutral images, respectively. In reappraise negative trials, participants talked about their thoughts and feelings while reappraising the meaning of the image to make it less negative.

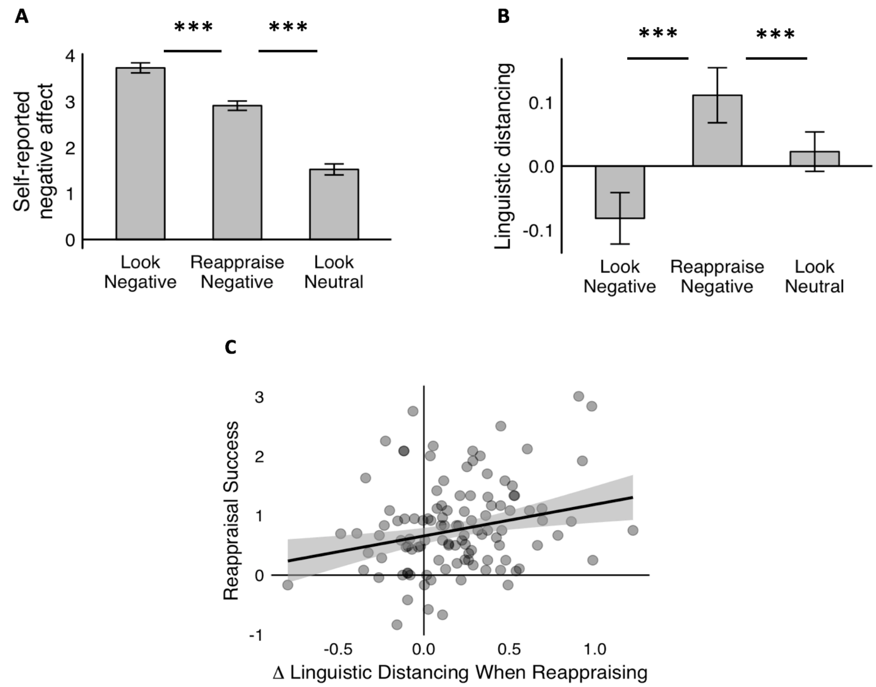

Figure 2. Linguistic distancing results. (A) Average negative affect ratings for each condition. Participants reported feeling less negative affect in response to images after regulating their emotions relative to when they passively looked at them. (B) Average linguistic distancing (mean *z*-scored frequencies of word types tracking psychological distance) in each condition. Participants used significantly more distant language in the reappraise negative condition than the other conditions. (C) Scatterplot showing the relation between reappraisal success (the extent to which participants reduced their negative affect when regulating their emotions) and the extent to which participants increased their use of words encoding psychological distance when regulating. Participants who showed stronger linguistic distancing when regulating were more successful at regulating their emotions. Panels A and B error bars are 95% confidence intervals adjusted for within-subjects comparisons following Morey (2008). The black line in panel C shows a robust linear regression fit, and the grey shading represents 95% confidence interval of the linear regression. $^{***}p < .001$.

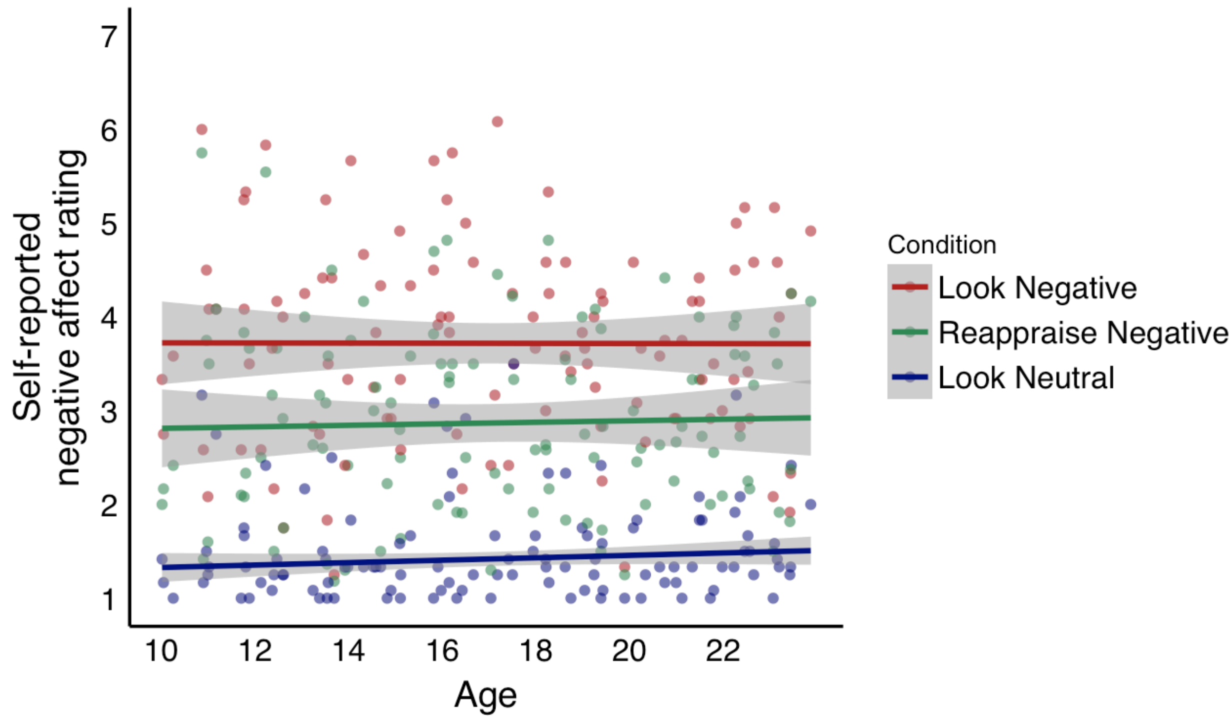

Figure 3. Robust linear regressions of mean self-reported negative affect ratings in each condition suggest no age-related differences in negative affect when participants regulated their emotions, nor when they passively looked at negative images or at neutral images. Lines display robust linear regression fits, and grey shaded regions represent 95% CIs.

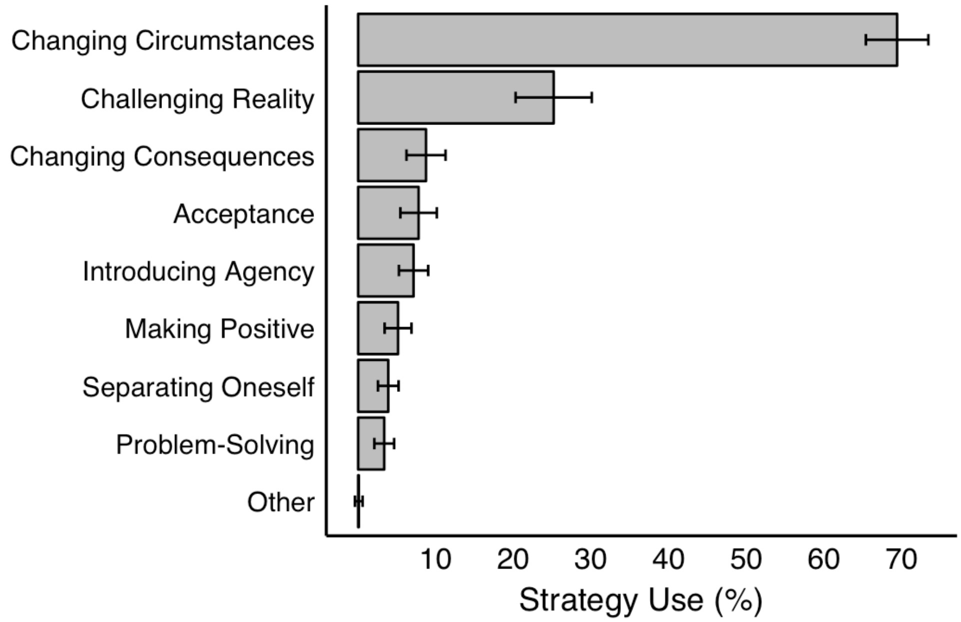

Figure 4. Average use of each reappraisal strategy. The percentage of compliant trials that used each reappraisal strategy was first computed for each participant, and then averaged across all subjects for each reappraisal strategy._Error bars represent 95% CIs. Note that the *separating oneself* strategy is typically referred to as *distancing* (see McRae, Ciesielski, et al., 2012), and was renamed in this paper to avoid confusion with the broader concept of *psychological distancing* or the measure of *linguistic distancing*..

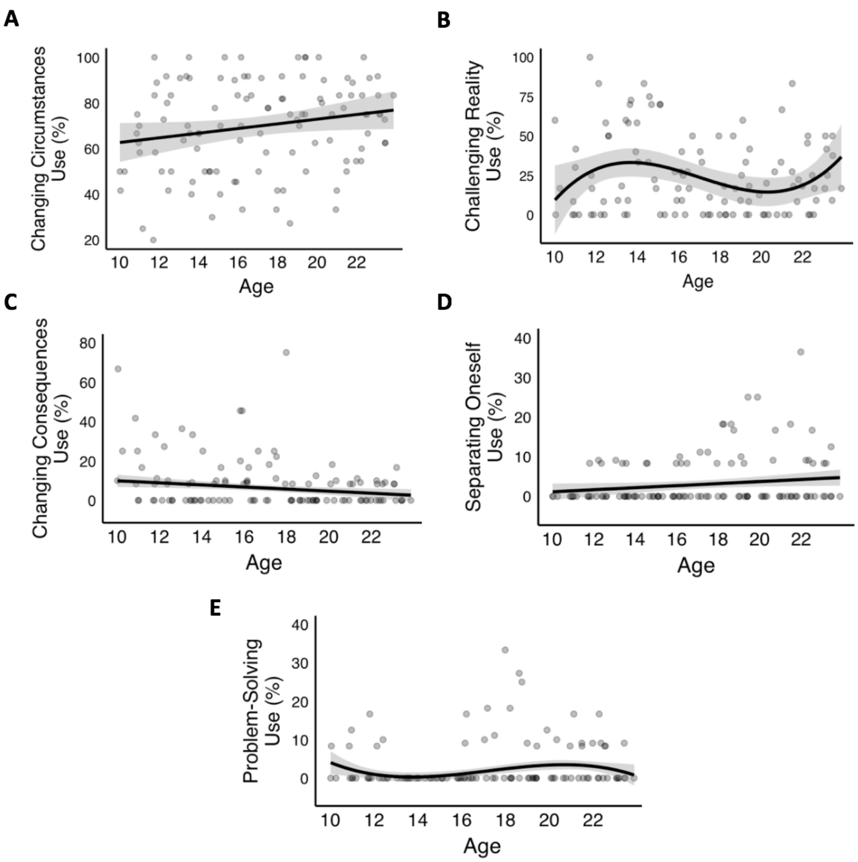

Figure 5. Reappraisal strategy use by age. Best fitting models of age for the five reappraisal strategies for which age was a significant predictor of strategy use. The y-axis represents the percentage of usable reappraise negative trials for which each strategy was used. (A) *Changing circumstances* was best described by a linear age effect. (B) *Challenging reality* was best described by a cubic age effect. (C) *Changing consequences* was best described by a linear age effect. (D) *Separating oneself* was best described by a linear age effect. (E) *Problem-solving* was best described by a cubic age effect. The black lines show robust linear regression fits, and the grey shaded regions represent 95% CIs. Note that the *separating oneself* strategy is typically referred to as *distancing* (see McRae, Ciesielski, et al., 2012), and was renamed in this paper to avoid confusion with the broader concept of *psychological distancing* or the measure of *linguistic distancing.*

Supplemental Materials

To accompany

Use of linguistic distancing and cognitive reappraisal strategies

during emotion regulation in children, adolescents, and young adults

Nook*, Vidal Bustamante*, Cho, & Somerville

* Indicates equal contribution

Contents

1. Task Instructions

Next is the Talking about Pictures Game! First you will see the word LOOK or the word CHANGE above a picture. Some of these pictures might make you feel bad.

If you see the word LOOK, then you should just look at the picture and let yourself feel whatever that picture makes you feel. Don't try to change your feelings at all. Just let yourself feel whatever you would normally feel.

If you see the word CHANGE, then you should try to make yourself feel better about the picture by thinking about it differently. Try to think about the picture in a new way that makes you feel better about it. For example, you might tell yourself that the picture is fake: no one is hurt, it's just a scene from a movie, or something like that. You could also think about how the picture is part of a story that has a happy ending: Something good will happen in the picture, or there's something happening outside the picture that helps you feel better about it.

The picture will be on the screen for 30 seconds. We want to know what you're thinking and feeling while it is on the screen. So, make sure you LOOK or CHANGE your feelings about the picture the whole time it's on the screen and say out loud what you're thinking and feeling while you follow those instructions. We will record your answers. Make sure you speak loud enough that we can hear you! After the picture, you will pick a number to rate how you feel.

2. OASIS image details

Table S1. Details of OASIS image stimuli used in this study.

OASIS ID	Image Name	Category	Valence Norm	Arousal Norm	Image List
I120	Car crash 1	Scene	1.85	4.55	Negative List A
I380	Garbage dump 2	Scene	1.60	3.78	Negative List A
I370	Funeral 1	Scene	2.92	4.24	Negative List A
I328	Fire 11	Scene	1.75	5.32	Negative List A
I848	Tornado 1	Scene	2.10	5.06	Negative List A
I215	Depressed pose 3	Person	2.66	4.01	Negative List A
I366	Frustrated pose 5	Person	2.46	3.74	Negative List A
I38	Baby 7	Person	2.97	4.25	Negative List A
I167	Cockroach 2	Animal	2.26	4.11	Negative List A
I273	Dog 23	Animal	2.68	4.82	Negative List A
I770	Snake 4	Animal	2.37	4.80	Negative List A
I793	Spider 1	Animal	3.07	4.02	Negative List A
I117	Car accident 2	Object	1.97	4.09	Negative List B
I645	Pollution 1	Scene	2.48	3.62	Negative List B
I150	Cemetery 5	Scene	2.51	4.70	Negative List B
I324	Fire 7	Scene	1.74	4.60	Negative List B
I851	Tornado 4	Scene	2.70	5.14	Negative List B
I213	Depressed pose 1	Person	2.69	3.45	Negative List B
I696	Sad face 9	Person	2.31	4.26	Negative List B
I20	Angry pose 1	Person	2.81	3.62	Negative List B
I166	Cockroach 1	Animal	2.06	4.35	Negative List B
I274	Dog 24	Animal	1.89	4.77	Negative List B
I769	Snake 3	Animal	2.91	4.57	Negative List B
I794	Spider 2	Animal	2.90	4.70	Negative List B
I55	Barrels 1	Object	4.21	2.47	Neutral List
I84	Boat 1	Object	4.57	2.80	Neutral List
I172	Cold 2	Object	4.73	2.59	Neutral List
I195	Cups 1	Object	4.28	2.03	Neutral List
I450	Keys 1	Object	4.03	2.37	Neutral List
I588	Office supplies 3	Object	4.24	2.72	Neutral List
I594	Paintbrush 1	Object	4.06	2.11	Neutral List
I601	Paperclips 2	Object	4.58	2.34	Neutral List
I632	Pinecone 1	Object	4.64	2.07	Neutral List
I668	Rocks 1	Object	4.68	2.42	Neutral List
I760	Skyscraper 1	Scene	4.13	2.25	Neutral List
I804	Street 2	Scene	4.61	3.16	Neutral List

Note: OASIS ID, image name, category, valence norm, and arousal norm taken from OASIS dataset norms (Kurdi, Lozano, & Banaji, 2017). Assignment of Negative List A and Negative List B images to the look negative and reappraise negative conditions was counterbalanced across participants.

3. Control Analyses Including Non-Compliant Participants and Trials

To ensure that excluding non-compliant participants and trials did not bias results, we report analyses of the dataset after including these participants and trials. Analyses below include all data from the 120 participants who provided usable behavioral and audio data.

Replicating Cognitive Reappraisal and Linguistic Distancing Effects in a Developmental Sample

The significance of results in this section did not change when including non-compliant participants and trials. Statistics are presented for completeness.

Self-reported negative affect ratings. Participants reported less negative affect after reappraising negative images. Self-reported negative affect ratings differed significantly across conditions, $F(2, 238) = 420.09$, $p < .001$, $\eta_p^2 = .78$, 90% CI = [.74, .81]. Participants reported feeling less negative affect in response to images in the reappraise negative condition ($M = 3.02$, $SD = .99$) than in response to images in the look negative condition ($M = 3.73$, $SD = 1.04$), $t(119) = 10.05$, $p < .001$, 95% CI = [0.57, 0.85], $d = .92$. Unsurprisingly, ratings for images in the reappraise negative condition were higher than ratings for images in the look neutral condition ($M = 1.53$, $SD = 0.55$), $t(119) = 18.97$, $p < .001$, 95% CI = [1.33, 1.64], $d = 1.73$.

Affect words. The prevalence of negative affect words differed significantly across conditions, $F(2, 238) = 268.98$, $p < .001$, $\eta_p^2 = .69$, 90% CI = [.64, .73]. Participants used fewer negative affect words in the reappraise negative condition ($M = 3.44\%$, $SD = 1.28$) than in the look negative condition ($M = 5.57\%$, $SD = 1.86$), $t(119) = 12.51$, $p < .001$, 95% CI = [1.80, 2.47], $d = 1.14$. Participants used more negative affect words in the reappraise negative condition than the look neutral condition ($M = 1.66\%$, $SD = 1.13$, $t(119) = 12.31$, $p < .001$, 95%

CI = [1.49, 2.06], *d* = 1.12. The frequency of positive affect words also differed significantly across conditions, $F(2, 238) = 65.19$, $p < .001$, $\eta_p^2 = .35$, 90% CI = [.27, .42]. Participants used more positive affect words in the reappraise negative condition (*M* = 3.31%, *SD* = 1.33) than the look negative condition (*M* = 2.86%, *SD* = 1.39), $t(119) = 3.43$, $p < .001$, 95% CI = [0.19, 0.72], *d* = 0.31. Participants used fewer positive affect words in the reappraise negative condition than the look neutral condition (*M* = 4.69%, *SD* = 2.18), $t(119) = 7.25$, $p < .001$, 95% CI = [1.00, 1.75], *d* = 0.66.

Linguistic distancing. The composite measure of linguistic distance differed significantly across conditions, $F(2, 238) = 17.26$, $p <.001$, $\eta_p^2 =. 13$, 90% CI = [.06, .19]. Participants' verbal responses were more distanced in the reappraise negative condition (*M* = 0.08, *SD* = 0.28) than in the look negative condition (*M* = -0.08, *SD* = 0.31), $t(119) = 5.04$, $p < .001$, 95% CI = [0.10, 0.22], *d* = 0.46. Additionally, verbal responses were more distanced in the reappraise negative condition than in the look neutral condition (*M* = 0.01, *SD* = 0.30), $t(119) = 2.93$, $p = .004$, 95% CI = [0.02, 0.13], *d* = 0.27. This pattern existed for all components of the linguistic distancing variable except for words of more than six letters.

Relations between linguistic measures and reappraisal success. Participants who more strongly distanced their language when regulating were more successful at regulating their emotions, $\beta = 0.25$, $p = .004$. Significant regressions emerged between reappraisal success and two components of the linguistic distancing measure (i.e., first-person singular pronouns and present-tense verbs), but this relationship was not significant for discrepancy words, articles, or words of greater than six letters. Greater reappraisal success was also associated with reduced use of negative affect words when regulating as compared with when responding naturally, $\beta = -.29$, $p < .001$, and it was also associated with increased use of positive affect words when regulating, β = .29, p < .001.

Relations Between Cognitive Reappraisal, Linguistic Distancing, and Age

As stated in the main text, the null age model provided the best fit to dependent variables from the task even when all non-compliant participants and trials were included. Hence, we found no age-related differences in emotional reactivity; reappraisal success; linguistic distancing when regulating; raw negative affect ratings in the reappraise negative, look negative, and look neutral conditions; or change in use of negative or positive affect words when reappraising. These null results suggest that lack of compliance would not have produced age-related effects in this study.

Reappraisal Strategy Use Across Age

Overall use of each strategy. Use of each of the nine reappraisal strategies differed significantly, $F(8,952) = 255.48$, $p < .001$, $\eta_p^2 = .68$, 90% CI = [.66, .70]. The order of frequency with which the strategies were used (from most frequently to least frequently used) remained the same when including the full sample. *Changing circumstances* was the most frequently used strategy (M = 68.99%, SD = 22.09), followed by *challenging reality* (M = 24.57%, SD = 25.65) and *changing consequences* (M = 8.15%, SD = 13.24). These were followed by *acceptance* (M = 8.04%, SD = 12.74), *introducing agency* (M = 7.07%, SD = 10.90), *making positive*, M = 5.03%, SD = 9.02), *separating oneself* (M = 4.04%, SD = 7.85), and *problem-solving* (M = 3.55%, SD = 7.68). Only one trial across all subjects required a designation of *other*.

Reappraisal strategy use across age. We tested how including all usable trials and all participants affected the best model selected in the final sample described in the main text. Most results were unaffected: Linear age remained a significant predictor for *changing consequences* use, $ß = -.11$, $p = .045$, and *separating oneself* use, $ß = .12$, $p = .046$*,* and the null model of age remained the best fit for the use of *acceptance, introducing agency, and making positive* strategies*.* However, including usable trials for all previously-excluded participants reduced age effects to statistical trends for three strategies: *changing circumstances* (linear age model $ß = .18$, $p = .060$), *changing reality* (cubic age model $ß = .09$, $p = .094$), and *problem-solving* (cubic age model $ß = -.008$, $p = .051$).

4. Analyses of Linguistic Distancing Subcomponents

To ensure that emotion regulation shifted the frequencies of words encoding social and temporal distance within the linguistic distancing composite measure, we used t-tests to assess whether use of each component of this variable (i.e., first-person singular pronouns, present-tense verbs, discrepancy words, articles, and words of more than six letters) changed during reappraisal, and we used robust regressions to test whether greater increases in use of each word category while regulating was associated with greater reappraisal success (see Methods for further details). Results from these analyses are presented in **Tables S2** and **S3**.

Participants reduced their use of first-person singular pronouns (e.g., "I," "me," "my") when regulating their emotions, and participants who showed greater decreases in first-person pronoun use when regulating were more successful regulators, suggesting that emotion regulation is associated with spontaneous *social* distancing. Participants also used fewer present-tense verbs when regulating, and there was a significant relationship between increased temporal distancing and better reappraisal success, implying that increased *temporal* distance is also associated with successful emotion regulation. The use of discrepancy words (e.g., "could," "should," "would") was reduced when regulating, but there was no relationship between changes in discrepancy word and reappraisal success. Similarly, article use increased when participants were regulating their emotions, but there was no relationship between changes in discrepancy word and reappraisal success. The frequency of words greater than 6 letters in length did not vary significantly across conditions, and it did not correlate with reappraisal success.

Table S2. T-tests comparing frequencies of psychological distance words in *Look Negative* and *Reappraise Negative* conditions.

	t	*p*	*d*	*Look Neg.* Mean (*SD*)	*Reapp. Neg.* Mean (*SD*)
First-person singular pronouns	9.72	**< .001*****	.92	5.66% (2.54)	3.56% (2.06)
Present-tense verbs	9.66	**< .001*****	.91	14.16% (2.32)	11.71% (2.32)
Articles	-3.41	**< .001*****	-.32	6.17% (1.81)	6.76% (1.72)
Discrepancy words	-2.96	**.004****	-.28	1.57% (0.96)	1.93% (1.04)
Words > 6 letters	.73	.464	.07	12.11% (2.24)	11.96% (2.25)

Notes: ** $p < .01$, *** $p < .001$

Table S3. Robust regressions between reappraisal success and changes in the frequency of psychological distance words.

	β	*p*
First-person singular pronouns	-.24	**.008****
Present-tense verbs	-.21	**.018***
Discrepancy words	-.11	.232
Articles	.13	.154
Words > 6 letters	.02	.812

Notes: ** $p < .01$, * $p < .05$

5. Table of Age-Related Regression Analyses for Emotion Regulation Variables

Table S4. Results of polynomial age models for emotion regulation and linguistic dependent variables.

Dependent variable	Model	β	p	AIC
Reappraise negative ratings	**Null**			**320.97**
	Linear	.03	.743	323.12
	Quadratic	-.001	.948	325.12
	Cubic	.10	.789	326.40
Look negative ratings	**Null**			**320.84**
	Linear	-.003	.980	322.83
	Quadratic	-.05	.870	324.56
	Cubic	.09	.816	326.22
Look neutral ratings	**Null**			**325.10**
	Linear	.09	.177	326.47
	Quadratic	.03	.387	328.16
	Cubic	.03	.561	330.03
Reactivity	**Null**			**320.85**
	Linear	-.05	.599	322.56
	Quadratic	-.07	.651	324.13
	Cubic	.06	.749	325.72
Reappraisal success	**Null**			**321.59**
	Linear	.03	.716	323.84
	Quadratic	-.07	.739	324.64
	Cubic	-.07	.733	327.17
Δ Negative affect word use when regulating	**Null**			**321.42**
	Linear	.11	.246	322.44
	Quadratic	.07	.391	323.61
	Cubic	.03	.561	330.03
Δ Positive affect word use when regulating	**Null**			**320.87**
	Linear	.15	.147	320.43
	Quadratic	.07	.295	322.32
	Cubic	-.02	.492	324.36
Δ Linguistic distancing when regulating	**Null**			**320.98**
	Linear	.05	.622	322.51
	Quadratic	.09	.541	322.93
	Cubic	.11	.408	323.09

Note: Bold text indicates best fitting model for each dependent variable, as determined by p-values and AIC. β = standardized beta, AIC = Akaike Information Criterion.

6. Linguistic Complexity Control Analyses

It is possible that age-related differences in linguistic complexity (i.e., the sophistication with which an individual can express information via language; Lust, Foley, & Dye, 2009; Pallotti, 2015; Ravid, 2005) could influence what cognitive reappraisal strategies participants used or verbalized in this task. Although this study did not include independent measures of verbal ability or verbal fluency, prior research has used measures ascertained by LIWC to assess linguistic complexity (Pennebaker & King, 1999; Saslow et al., 2014). This approach hinges on the notion that more complex language involves expressing information with more nuance (i.e., making more distinctions and qualifications). As such, linguistic complexity can be measured by computing trial-level means of z-scores of the LIWC categories of exclusive words (e.g. "but," "except," "however," "unless"), tentative words (e.g. "maybe," "perhaps," "guess"), negations (e.g. "neither," "never," "cannot"), discrepancies (e.g. "should," "would"), and the reverse-*z*-score of inclusive words (e.g. "with," "also," "plus").

We computed this measure of linguistic complexity averaged across all trials for each participant and tested whether it varied across age using the three robust regression age models used throughout the paper (i.e. linear, quadratic, and cubic age models). We also tested whether age was related to how strongly participants shifted their linguistic complexity when regulating their emotions (i.e., we computed a "Δ linguistic complexity when regulating" variable that paralleled the "Δ linguistic distancing when regulating" variable by subtracting participants' linguistic complexity in the look negative condition from their linguistic complexity in the reappraise negative condition). We found that none of the age models provided a significant fit for either overall linguistic complexity or Δ linguistic distancing when regulating (see **Table S5** below). Thus, we found no evidence of age-related variation in this measure of linguistic complexity. We concluded that it could not be considered a mediator or confound of age-related differences in other dependent variables.

Table S5. Results of polynomial age models for LIWC linguistic complexity variables.

Reappraisal strategy	Model	*β*	*p*	AIC
Mean linguistic complexity across all trials	**Null**			**320.84**
	Linear	.07	.481	322.42
	Quadratic	.007	.778	324.43
	Cubic	.07	.802	326.01
Δ linguistic complexity when regulating	**Null**			**320.94**
	Linear	.001	.987	322.93
	Quadratic	-.07	.727	324.37
	Cubic	.13	.456	324.97

Note: Bold text indicates best fitting model for each dependent variable, as determined by *p*-values and AIC. *β* = standardized beta, AIC = Akaike Information Criterion.

There are several possible reasons for this null effect. The first is that the age range of the current sample (10-23 years of age) might be too constrained to detect age-related variation in linguistic complexity relevant to the LIWC measure. It is possible that the use of terms relevant to the LIWC linguistic complexity measure undergo developmental shifts at ages younger than 10 years old (the lower bound of our sample). A second possibility for this null effect is that the linguistic complexity measure used was computed using participants' utterances within an emotion regulation task, which might provide only limited insight into participants' overall linguistic complexity. A LIWC assessment of text gathered from other contexts (e.g., during social conversations) might give a more accurate assessment of participants' verbal abilities. Finally, it is possible—if not likely—that this measure of linguistic complexity is not as precise or powerful as other potential measures. This is especially true given that this linguistic score was made for adult (not developmental) samples. Unfortunately, because we did not acquire any gold-standard assessments of age-related differences in verbal ability or linguistic complexity in the present study due to time constraints, we cannot test this possibility empirically. However, addressing the role of linguistic complexity in cognitive reappraisal strategy use across age is a very important topic for future research.