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Meta-Analysis of the Age-Related Positivity Effect: Age Differences in Preferences for Positive Over Negative Information

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In contrast to long-held axioms of old age as a time of "doom and gloom," mounting evidence indicates an age-related positivity effect in attention and memory. However, several studies report inconsistent findings that raise critical questions about the effect's reliability, robustness, and potential moderators. To address these questions, we conducted a systematic meta-analysis of 100 empirical studies of the positivity effect (N = 7,129). Results indicate that the positivity effect is reliable and moderated by theoretically implicated methodological and sample characteristics. The positivity effect is larger in studies that do not constrain (vs. constrain) cognitive processing—reflecting older adults' natural information processing preferences—and in studies incorporating wider (vs. narrower) age comparisons. Analyses indicated that older adults show a significant information processing bias toward positive versus negative information, whereas younger adults show the opposite pattern. We discuss implications of these findings for theoretical perspectives on emotion–cognition interactions across the adult life span and suggest future research directions.

Keywords: aging, positivity effect, meta-analysis, emotion, information processing

Through much of modern history psychologists espoused views on aging that were less than kind. "Doom and gloom" perspectives characterizing later life as a time of profound physical, cognitive, and emotional losses prevailed well into the 20th century (for a discussion see Carstensen, Pasupathi, Mayr, & Nesselroade, 2000). Yet recent empirical and theoretical work challenges long-held axioms by illustrating the "bright side" of aging, from improved psychological well-being and emotional self-regulation to an age-related positivity effect (for a review see Charles & Carstensen, 2010). Researchers have devoted particular attention to the positivity effect, which has been the subject of numerous empirical studies in the decade since it was initially observed and conceptualized by Carstensen and colleagues (Charles, Mather, & Carstensen, 2003; Mather & Carstensen, 2003). The term "positivity effect" refers to an observed age-related increase in the preference for positive over negative information in attention and memory (Carstensen & Mikels, 2005; Mather & Carstensen, 2005). Among the many replications of the positivity effect, however, are a handful of empirical studies that challenged the consistency, size, and reliability of the effect (for a review, see Reed & Carstensen, 2012). Inconsistencies in the patterns reported raise important questions for future research in this area: Is the positivity effect reliable and, if so, how large is the effect and what factors moderate it? The present meta-analysis was designed to address these questions.

Age-related differences in the processing of emotionally valenced information (i.e., a preferential shift toward the positive) were first considered within the context of socioemotional selectivity theory (SST; Carstensen, 2006), a life span theory of motivation. According to SST, motivational priorities shift across the life span as a function of future time horizons. When individuals perceive their futures as relatively open-ended and nebulous, as in early adulthood, they tend to prioritize future-oriented goals such as acquiring information, meeting new people, and generally expanding their horizons. However, when individuals increasingly appreciate the fragility of life and future time horizons narrow, as is typical in later life, they prioritize present-focused goals related to emotional meaning and satisfaction. These systematic age differences in goal priorities consequently should alter information processing by shifting attention and memory toward goal-congruent and away from goal-incongruent material. Because older adults are especially motivated by goals related to emotional satisfaction, SST predicts an information processing shift toward positive information in later life. This life-span perspective stands in contrast to extensive research on the well-documented *negativity bias*, which captures how negative information and emotions are substantially more impactful than positive (Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001; Rozin & Royzman, 2001). SST therefore conceptualizes the *positivity effect* in terms of the *relative* age difference between younger and older adults in the processing of positive versus negative information: Older adults attend to and remember positive versus negative information to

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a greater extent than younger adults[1] (Carstensen & Mikels, 2005; Mather & Carstensen, 2005). Based on this conceptualization, the critical contrast for the positivity effect is between positive and negative information. This perspective on the positivity effect converges with the theoretical basis of the negativity bias as “bad is stronger than good” (Baumeister et al., 2001) and affords comparisons between the two literatures (for a discussion see Carstensen & Mikels, 2005; Mikels, Reed, Hardy, & Löckenhoff, in press).

Initial research on age differences in the processing of emotional information consistently supported the positivity effect. In one of the earliest illustrations of the positivity effect, Mather and Carstensen (2003) used a dot-probe visual attention paradigm to demonstrate that compared with younger adults, older adults preferentially look toward positive (i.e., happy) and away from negative (i.e., angry or sad) faces. Subsequent studies replicated the positivity effect in visual attention using eye-tracking methods (Isaacowitz, Wadlinger, Goren, & Wilson, 2006a, 2006b). Early studies also found support for the positivity effect in memory. Compared with younger adults, older adults better remembered positive versus negative information across paradigms ranging from autobiographical and long-term memory (Charles et al., 2003; Kennedy, Mather, & Carstensen, 2004) to working memory (Mikels, Larkin, Reuter-Lorenz, & Carstensen, 2005). The positivity effect is also evident in decision making. Older versus younger adults show relatively greater attention and memory for positive versus negative attributes when choosing among health-related and everyday options (Löckenhoff & Carstensen, 2007, 2008; Mather, Knight, & McCaffrey, 2005).

In the years following these early studies, the positivity effect has been documented across a wide range of experimental paradigms, tasks, and stimuli. Researchers have found evidence for the positivity effect in visual stimuli, such as emotional faces and photographs (Leigland, Schulz, & Janowsky, 2004; Spaniol, Voss, & Grady, 2008) and lexical stimuli such as word lists and health messages (Piguet, Connally, Krendl, Huot, & Corkin, 2008; Shamaskin, Mikels, & Reed, 2010), suggesting that the effect generalizes across different types of materials. At the same time, the variety of paradigms used to demonstrate the positivity effect—from rapid visual attention (Mickley Steinmetz, Muscatell, & Kensinger, 2010) to autobiographical memory (Kennedy et al., 2004) to decision making (Löckenhoff & Carstensen, 2007)—suggests that the effect is not constrained to specific domains of information processing.[2]

Although empirical support for the positivity effect is wide-ranging, more than a few studies have found minimal or no age differences in the processing of positive versus negative information (for a review, see Reed & Carstensen, 2012). Indeed, studies have failed to observe the positivity effect in memory for words (e.g., Grühn, Smith, & Baltes, 2005; Majerus & D'Argembeau, 2011), images (e.g., Gallo, Foster, & Johnson, 2009) and advertisements (e.g., Williams & Drolet, 2005). At first glance these findings appear to challenge the reliability of the positivity effect. However, when the experimental designs of these studies are compared with studies finding the effect, a pattern emerges suggesting a key moderator: Studies that do not observe a positivity effect typically impose experimental constraints on information processing by altering individuals' goals, attention and/or resources. For instance, age differences in emotional information processing fail to appear when participants are instructed to remember all information either explicitly (Grühn et al., 2005; Majerus & D'Argembeau, 2011) or implicitly (Gallo et al., 2009) or when they are required to make explicit judgments about experimental stimuli at encoding (e.g., Kensinger, Brierley, Medford, Growdon, & Corkin, 2002). By contrast, studies that afford and encourage naturalistic and unconstrained processing of stimuli (e.g., instructing participants to view images as they would a TV) observe the positivity effect (Charles et al., 2003; Isaacowitz et al., 2006b; Kwon, Scheibe, Samanez-Larkin, Tsai, & Carstensen, 2009).

Empirical observations of the positivity effect when information processing is unconstrained versus constrained are entirely consistent with the motivational account offered by SST (for discussions, see Mather & Carstensen, 2005; Reed & Carstensen, 2012). According to SST, age differences in the processing of emotional information are driven in a top-down manner by chronically activated goals. Pursuing such goals requires sufficient cognitive control and an absence of superseding situation-specific goals. Thus, SST would *not* predict a positivity effect when individuals are imbued with goals that conflict with their chronically activated goals and/or when their cognitive resources are limited, and empirical work supports these predictions. Across a series of experiments Mather and colleagues demonstrated the positivity effect in memory and attention among older individuals with high levels of cognitive control and also those in a full versus divided attention condition (Knight et al., 2007; Mather & Knight, 2005). Löckenhoff and Carstensen (2007) illustrated the moderating role of goals when they eliminated the positivity effect in decision making by activating information-seeking goals in younger and older adults via experimental instructions. These studies illustrate how manipulations of experimental instructions and task characteristics engender versus suppress the positivity effect.

In recent years alternative theoretical accounts of the age-related positivity effect have been offered based on age-related cognitive or neural deficits (for a discussion, see Reed & Carstensen, 2012). Labouvie-Vief and colleagues (Labouvie-Vief et al., 2010; Wurm, 2011) posited in Dynamic Integration Theory that age-related cognitive declines lead older adults to automatically and preferentially process positive information because it is easier to process (i.e., less complex) than negative information. The aging-brain model proposed by Cacioppo, Berntson, Bechara, Tranel, and Hawkley (2011) attribute the positivity effect to age-related degeneration of the amygdala inhibiting neural and affective responses to negative (though not positive) information. However, these perspectives are inconsistent with key empirical findings

[1] Unfortunately, the literature now includes a number of related terms that are too often used interchangeably with the positivity effect and obfuscate the issues (see, e.g., Murphy & Isaacowitz, 2008). For instance, older adults are often referred to as demonstrating a *positivity bias*, whereby positive information is attended to and remembered more than negative information. Yet, despite the fact that in some studies findings are driven by a preference for positive among older adults (i.e., a positivity bias; Mather et al., 2004; Mikels et al., 2005), the positivity effect can just as easily reflect a reduced preference for negative. Relatedly, the positivity effect has been confused with a *positivity preference* whereby positive material is more *impactful* than neutral material.

[2] Empirical evidence of the positivity effect also extends beyond behavioral findings to age-related patterns of neural activity (for a review, see Samanez-Larkin & Carstensen, 2011). For instance, compared with younger adults, older adults recruit subcortical regions such as the amygdala to a greater extent when processing positive versus negative information (Mather et al., 2004).

reviewed above. For instance, although both explanations predict that the positivity effect would be strongest among individuals with the greatest age-related cognitive or neural impairments, evidence supports the opposite prediction: The positivity effect is most evident when comparing younger and older individuals with greater versus poorer cognitive control (Mather & Knight, 2005). Additionally, neither Dynamic Integration Theory nor the aging-brain model can account for evidence that the positivity effect can be modulated by experimental manipulations of goals or processing resources (e.g., Löckenhoff & Carstensen, 2007; Knight et al., 2007). However, these findings *are* consistent with the motivational perspective of SST.

Present Study

To address open questions surrounding the positivity effect and to test theoretically derived moderators, we conducted a systematic meta-analysis of studies of attention and memory. All studies included in the present meta-analysis met strict inclusion criteria based on the operational definition of the positivity effect as an interaction between age and valence: Older relative to younger adults show greater attention and memory for positive versus negative information.

A recent meta-analysis by Murphy and Isaacowitz (2008) likewise examined age differences in the processing of emotionally valenced information, but with goals and methods that are distinct from the present study in important ways.[3] The goals of the prior meta-analysis were to examine age differences in the emotion salience effect, positivity preference, and negativity preference. This engendered broad inclusion criteria that extended beyond direct tests of the positivity effect. As a result, most of the included studies (roughly 85%) had experimental designs that precluded testing for the interaction between age and positive-versus-negative valence (i.e., the age-related positivity effect). In addition, the analyses by Murphy and Isaacowitz focused on contrasts between neutral and positive or negative stimuli, rather than the positive–negative contrast of the positivity effect. As acknowledged by the researchers (Murphy & Isaacowitz, 2008, p. 265), their findings speak to questions regarding age differences in positivity and negativity preferences but do not directly address the positivity effect.

By contrast, the present meta-analysis was specifically designed as a direct test of the positivity effect and consequently only included studies that incorporated comparisons across age (i.e., older vs. younger) and valence (i.e., positive vs. negative). Our hypotheses were grounded principally in the theoretical perspective offered by SST (for a review, see Reed & Carstensen, 2012). Overall, we predicted that the positivity effect would be reliable. However, we remained agnostic about the global size of the effect because we predicted that it would be moderated by two key theoretically implicated factors. First and foremost, we hypothesized that the size of the positivity effect would be moderated by *experimental constraints* on goals, attention, and/or cognitive resources. Specifically, we predicted that the effect size would be strongest among studies that did not constrain information processing through instructional manipulations and/or task-related restrictions and weakest among studies with such constraints. Second, because the positivity effect is theoretically linked to a gradual change in motivational priorities across adulthood, we also predicted that the effect size would be moderated by the *mean age difference* between the younger and older samples. Studies with greater age discrepancies between the two subsamples were expected to yield larger effect sizes.

Method

Literature Search

We conducted an extensive search for empirical studies relevant to the positivity effect in peer-reviewed journal articles published as of June 2011. Article databases PsycINFO and Web of Knowledge were searched using the following global keyword combinations: *Positivity effect*, *aging* and *valence, aging* and *emotion*. In addition to the global keywords, nested search terms were used.[4] Additional articles were located via ancestor and descendent searches of highly cited empirical articles (e.g., Charles et al., 2003; Kensinger et al., 2002; Mather & Carstensen, 2003), early theoretical articles (Carstensen & Mikels, 2005; Mather & Carstensen, 2005), and recent review articles (Charles & Carstensen, 2010; Reed & Carstensen, 2012; Scheibe & Carstensen, 2010). Finally, supplementary articles (both published and in press) were obtained directly from their authors in response to data requests.

Inclusion Criteria

Our inclusion criteria were grounded in an operational definition of the positivity effect centered on the interaction between age and valence: Older relative to younger adults show greater attention and memory for positive versus negative information. Consequently, all studies were required to meet the following criteria for inclusion in the meta-analysis:

1. Included studies needed to have incorporated at least one age comparison (e.g., younger vs. older adults). Studies with only one age group were excluded. Studies with continuous age analyses were included if categorical age data could be obtained from the authors (e.g., Li, Fung, & Isaacowitz, 2011). Age groups were coded based on the original definitions and cutoffs provided by included studies. Consequently, "younger" and "older" samples were entered based on the authors' original categorizations when available. In addition, because the positivity effect concerns normal aging, older adult samples identified as having severe cognitive impairments (e.g., Alz-

[3] It is especially instructive to consider these differences given the frequency with which the Murphy and Isaacowitz meta-analysis has been misinterpreted in the literature as a test of the positivity effect (e.g., Broster et al., 2012; Ebner et al., 2012; Goeleven, De Raedt, & Dierckx, 2010; Johnson & Whiting, 2013; Leclerc & Kensinger, 2011; Wurm, 2011).

[4] Nested search terms were as follows: (attention OR cognition OR "dot probe" OR "eye tracking" OR fixation OR memory OR reaction OR recall OR recognition OR recollection OR remember OR "visual scanning") AND (anger OR bias OR contentment OR disgust OR elation OR emotion OR "facial expression" OR fear OR happy OR joy OR negative OR negativity OR neutral OR positive OR positivity OR sad OR surprise) AND (aging OR ageing OR elderly OR "older adult" OR retired OR elder).

heimer's disease patients) were excluded from the analysis.[5]

2. Studies needed to have assessed information processing for positively *and* negatively valenced material to be included. Studies with only positive or negative stimuli were excluded.

3. All included studies needed to have direct measures of attention and/or memory for emotionally valenced information. Studies that examined age differences in the evaluation of positive versus negative stimuli without direct measures of attention or memory were excluded (e.g., Grühn & Scheibe, 2008).

Following these criteria, only studies that included full factorial designs with respect to age and valence were included in the meta-analysis. Some eligible articles could not be included in the meta-analysis because critical data were not reported and the original data sets were no longer available (e.g., Rahhal, May, & Hasher, 2002; Thompson, Aidinejad, & Ponte, 2001). This led to the inclusion of 100 independent studies with 115 comparisons (several studies had multiple conditions or subgroups) and a total *N* of 7,129. Methodological and sample characteristics for all included studies are detailed in Table 1.

Data Entry

All available study data were entered into a database and subsequently double-checked for accuracy. Authors were contacted if effect size data (i.e., sample sizes, means, and standard deviations) could not be directly recorded, calculated, or measured (i.e., from a graph) based on the published article.

Coding

All included studies were coded for experimental constraints on goals, resources, and/or attention using the following scheme: Studies that were coded as "constrained" instructed participants (explicitly or implicitly) to either focus on or away from valenced material, required participants to rate or judge stimuli, and/or explicitly mentioned an upcoming memory test prior to the encoding or study phase. Studies that were coded as "unconstrained" afforded and/or encouraged passive or naturalistic viewing of valenced materials (e.g., viewing a series of images as you would a TV), incorporated incidental memory tests, and/or allowed participants to attend to versus ignore whichever information they pleased (either explicitly or implicitly). Two independent raters (AR and LC) coded all studies (92.7% agreement rate) and disagreements were resolved via discussion.

Data Analytic Approach

Because the moderator analyses require establishing independence between effect sizes across studies, for each study we selected a single outcome using the following rubric:

For each study with multiple operationalizations of a single outcome (e.g., d', CR, and hits for recognition memory) we selected the most precise and comprehensive measure of accuracy (for memory) or amount (for attention). For memory studies we used the following priority list: d', CR (or corrected recall), hits (or proportion/percent recall). This was done to avoid combining outcomes that are confounded (e.g., hits and CR) or conceptually incongruent (e.g., hits and false alarms). For attention studies we selected dependent measures that best encapsulate the sheer amount of attention, such as fixation ratios and fixation duration, over measures of attentional shifts (e.g., fixation counts and saccades).

For studies with multiple measurement points, we selected the earliest outcome measures (e.g., the shortest delay between study and test phase). Thus, for memory studies with both recall and recognition measures, we selected the recall measures if they were administered first.

Studies with multiple between-subjects experimental conditions or subgroups were entered and coded separately by condition or subgroup in the meta-analysis (see Table 1).

All effect size data were subjected to a meta-analysis in which the primary outcome variable was the interaction between age (older vs. younger) and valence (positive vs. negative). Consistent with the operational definition of the positivity effect as the relative age difference in attention and memory for positive versus negative information, positivity effect sizes were calculated based on recommendations for independent groups repeated-measures designs (Becker, 1988; Morris & DeShon, 2002). First, we computed effect sizes for positivity *bias* scores (d_{bias}) within each age group and study (or study subgroup) as the paired standardized mean difference between positive and negative scores (see Borenstein, 2009):

$$d_{bias} = \left(\frac{M_{Pos} - M_{Neg}}{SD_{Dif}}\right) \sqrt{2(1 - r)}$$

$$SD_{Dif} = \sqrt{(SD_{Neg}^2 + SD_{Pos}^2 - 2r * SD_{Neg} * SD_{Pos})}$$

$$v_{bias} = \left(\frac{1}{n} + \frac{d_{bias}^2}{2n}\right)2(1 - r)$$

In the above formulas M_{Pos} and M_{Neg} refer to mean positive and negative scores within each age group, SD_{Pos} and SD_{Neg} refer to corresponding standard deviations, SD_{Dif} refers to the standard deviation of the positive-minus-negative difference, v_{bias} refers to the variance of the bias score effect size, n refers to the sample size within each age group, and r refers to the correlation between positive and negative scores. We used a conservative positive-to-negative correlation of $r = .4$ derived from the Charles et al. (2003) data set.[6]

After calculating positivity bias scores within each age group, we then computed the positivity effect size (d_{PE}) for each study (or subgroup) as the difference in positivity bias effect sizes between older (d_{biasO}) and younger (d_{biasY}) samples (following Becker, 1988):

$$d_{PE} = d_{biasO} - d_{biasY}$$

[5] Healthy older adult samples from the same studies were included in the analysis (e.g., Fleming et al., 2003; Kensinger et al., 2002).

[6] Analyses were replicated using correlations of $r = .2$ and $r = .6$, and the results were not significantly different from those reported below.

Variance for the positivity effect size (v_{PE}) was calculated as the sum of the variance for younger and older adults' bias scores (v_{biasY} and v_{biasO}, respectively; see Morris & DeShon, 2002):

$$v_{PE} = v_{biasO} + v_{biasY}$$

Finally, we corrected the positivity effect scores for small sample bias (following Morris & DeShon, 2002). Corrected effect sizes were used for the overall meta-analysis as well as the moderator and meta-regression analyses. Effect sizes based on Cohen's d can be categorized as small ($d = .2$), medium ($d = .5$), and large ($d = .8$; Cohen, 1988).

We chose this effect size metric for two reasons: First, it best reflected our operational definition of the positivity effect as an interaction between age and valence. Using this approach yielded effect sizes that were signed and scaled in relation to the relative strength of the positivity effect. Larger and more positive effect sizes indicated a strong positivity effect, whereas smaller or negative effect sizes indicated a weaker positivity effect or a negativity effect,[7] respectively. The second reason for using this effect size metric is that it afforded and facilitated the use of moderator and meta-regression analyses.

Following guidelines by Konstantopoulos and Hedges (2009) we conducted a meta-regression analysis via a weighted least-squares linear regression. The positivity effect estimate (d_{PE}) was entered as the dependent variable, the within-study mean age difference (squared) was the independent variable, and the reciprocal of the sampling variance ($1/v_{PE}$ above) was used as the weight. We entered a fixed regression intercept of zero to reflect the fact that the positivity effect theoretically cannot exist when comparing samples of equal age (i.e., no mean age difference). A corrected standard error (S_j) was computed by dividing the standard error (SE_j) of the regression estimate by the square root of the residual mean square (MS_{RMS}) from the regression analysis of variance:

$$S_j = SE_j / \sqrt{MS_{RMS}}$$

The corrected standard error was used to calculate a 95% confidence interval (CI) for the regression estimate (b_j) as follows: 95% CI $= b_j \pm 1.96\ S_j$.

Because we anticipated multiple moderators of the positivity effect size, we used a random effects model for the main analysis. Effect sizes were calculated from reported means and standard deviations when available and from inferential statistics when means and/or standard deviations were unavailable.[8] CIs were computed based on the standard deviations of the effect sizes and assessed in our moderator analysis. Bias score effect sizes were calculated in Comprehensive Meta-Analysis software (Biostat, Inc.). Positivity effect sizes were computed from bias scores in SPSS, which was used to conduct the meta-regression. All effect sizes were meta-analyzed in Comprehensive Meta-Analysis software.

Results

As predicted, we observed a reliable positivity effect overall, indicated by a significant and positive effect size across all studies, $d_{PE} = .257$, 95% CI [.165, .349], $Z = 5.48$, $p < .001$. Examination of the positivity bias scores within each age group revealed that older adults showed a small but significant positive bias overall, $d_{bias} = .128$, 95% CI [.042, .214], $Z = 2.92$, $p < .01$, whereas younger adults showed a significant negative bias ($d_{bias} = -.123$, 95% CI [−.203, −.043], $Z = -3.01$, $p < .01$). Effect sizes for individual studies are depicted in Table 2.

We tested for publication bias using the tandem method (Ferguson & Brannick, 2012): First, we calculated a fail-safe N of 2,913 ($\alpha = .05$), $Z = 10.06$, $p < .001$. This indicates that the number of additional (i.e., unpublished, missing or new) studies needed to reduce the overall effect size to nonsignificance ($\alpha >$ .05) is more than 25 times the number of included studies. We then computed Egger's regression (Egger et al., 1997), which yielded a nonsignificant bias intercept, $\beta = -.14$, $t(113) = .19$, $p = .85$. Finally, we conducted the Duval and Tweedie (2000) trim-and-fill procedure, which yielded an imputed point estimate of $d = .43$, 95% CI [.39, .48]. This indicates that missing or unpublished studies would actually increase, rather than decrease, the overall effect size. Thus, combined results from the tandem method suggest that the likelihood of publication bias is minimal.

To test whether processing constraint moderated the size of the positivity effect, we computed 95% CIs for effect sizes among constrained versus unconstrained studies (see Table 3). Consistent with our hypothesis, when examining the positivity effect nonoverlapping CIs indicated a significantly larger effect size among unconstrained studies, which yielded a medium average effect size, $d = .482$, 95% CI [.323, .640], $Z = 5.95$, $p < .001$), versus constrained studies, which yielded a small average effect size, $d = .134$, 95% CI [.033, .235], $Z = 2.61$, $p < .01$. Subsequent examination of bias scores indicated that older adults showed a significant positive bias when their processing was unconstrained, $d = .280$, 95% CI [.123, .436], $Z = 3.50$, $p < .001$, but no bias under constrained conditions, $d = .048$, 95% CI [−.048, .144], $Z = .97$, $p = .33$. By contrast, younger adults' negative bias did not differ significantly based on processing constraint, as indicated by a nonsignificant between-groups heterogeneity test, $Q_b(1) = 1.61$, $p = .21$. Younger adults displayed a significant negative bias both when their processing was not constrained, $d = -.197$, 95% CI [−.340, −.054], $p < .01$, and under constrained processing conditions, $d = -.085$, 95% CI [−.182, .011], $p < .05$ one-tailed.

To test whether the mean age difference between older and younger samples moderates the size of the positivity effect across studies, we conducted a meta-regression (see above for details).[9] As indicated in Figure 1, our hypothesis was supported in the overall data set: There was a significant association between the magnitude of the age discrepancy (squared) and the size of the positivity effect across studies, $b = .0001$, $SE = .000018$, 95% CI

[7] By negativity effect we mean a greater focus on negative versus positive among older versus younger adults.

[8] Means and standard deviations for positive and negative scores were available for all but the following studies: Kennedy et al. (2004); Löckenhoff & Carstensen (2007, 2008), and McKay-Nesbitt et al. (2011). The first three studies reported means and standard deviations for composite measures of positive-versus-negative attention and memory, and the latter study reported test statistics for the positive-versus-negative t test comparison. For these studies the standardized paired difference effect sizes were calculated based on formulas provided by Borenstein (2009).

[9] Effect size data from Kennedy et al. (2004) were excluded from the meta-regression because the mean age difference could not be calculated due to missing age data.

Table 1
Methodological and Sample Characteristics of Studies Included in the Meta-Analysis

					Sample size		Mean age		Mean age difference
Study	Condition	Paradigm	Stimuli	Constraint	Older	Younger	Older	Younger	
Allard & Isaacowitz, 2008	Full attention	EYE	IMG	N	20	20	70.5	21.6	48.9
Bannerman et al., 2011		BNR	FAC	N	30	30	70.6	21.8	48.8
Brassen et al., 2011		DIS	FAC	Y	21	22	65.8	25.2	40.6
Charles et al., 2003, Study 1		LTM	IMG	N	48	48	71.0	24.6	46.4
Charles et al., 2003, Study 2		LTM	IMG	N	32	32	74.1	23.5	50.5
Chung, 2010		LTM	IMG	N	80	43	74.1	21.2	52.8
Comblain et al., 2004		LTM	IMG	Y	20	20	67.5	22.5	45.0
D'Argembeau & Van der Linden, 2004		LTM	FAC	Y	32	32	67.0	24.0	43.0
Ebner & Johnson, 2009, Study 1		LTM	FAC	Y	24	32	74.8	19.3	55.5
Ebner & Johnson, 2010, Study 2		DIS	FAC	Y	20	32	74.1	19.3	54.8
Emery & Hess, 2008, Study 1	Rating	LTM	IMG	Y	27.5	29	74.1	18.5	55.6
Emery & Hess, 2008, Study 1	Watching	LTM	IMG	N	27.5	29	74.1	18.5	55.6
Emery & Hess, 2008, Study 2	Rating	LTM	IMG	Y	21	23	72.7	20.7	52.0
Emery & Hess, 2008, Study 2	Watching	LTM	IMG	N	21	23	72.7	20.7	52.0
Emery & Hess, 2011		LTM	IMG	Y	53	48	70.9	19.5	51.4
Feng et al., 2011		LTM	IMG	N	40	45	74.7	20.0	54.7
Fernandes et al., 2008		LTM, ABM	IMG, WOR, ABM	Y	48	49	72.3	19.0	53.3
Fleming et al., 2003		LTM	WRD	Y	19	27	70.1	23.8	46.3
Fung et al., 2008		EYE	FAC (SYN)	N	57	46	69.0	19.7	49.3
Fung et al., 2010, Study 1		LTM	IMG	N	103	114	76.5	21.2	55.3
Gallo et al., 2009		LTM	IMG	Y	24	24	77.7	21.3	56.4
Goeleven et al., 2010		DIS	FAC	Y	27	27	74.3	32.3	42.0
Grady et al., 2007		LTM	FAC	Y	30	40	70.0	21.8	48.2
Grühn et al., 2005		LTM	WRD	Y	72	72	69.3	24.3	45.0
Grühn et al., 2007		LTM	IMG	Y	48	48	69.8	25.3	44.4
Hahn et al., 2006, Study 1		VIS	FAC (SCH)	Y	20	20	67.7	21.2	46.5
Hahn et al., 2006, Study 2		VIS	FAC (SCH)	Y	14	14	65.2	22.7	42.5
Hahn et al., 2006, Study 3		VIS	FAC (SCH)	Y	15	15	64.5	22.4	42.1
Isaacowitz et al., 2006a		EYE	FAC (SYN)	N	27	37	68.2	18.4	49.8
Isaacowitz et al., 2006b		EYE	FAC (SYN)	N	28	32	71.4	19.8	51.6
Isaacowitz et al., 2008		EYE	FAC (SYN)	N	52	72	71.4	19.6	51.7
Kapucu et al., 2008		LTM	WRD	Y	23	22	71.9	19.6	52.3
Kennedy et al., 2004		ABM	ABM	N	28	28	—	—	—
Kensinger & Schacter, 2008		LTM	IMG	Y	17	17	73.3	21.6	51.7
Kensinger et al., 2002		LTM	IMG	Y	20	20	73.3	20.5	52.8
Kensinger et al., 2007, Study 1		LTM	IMG, WRD	Y	30	30	74.5	21.5	53.0
Kensinger et al., 2007, Study 2		LTM	WRD	Y	30	30	69.7	20.6	49.1
Kensinger, 2008, Study 1		LTM	WRD	Y	30	30	73.5	26.1	47.4
Kensinger, 2008, Study 2		LTM	WRD	Y	30	30	72.3	24.6	47.7
Knight et al., 2002	Neutral mood	LTM	WRD	N	33	64	76.5	21.4	55.1
Knight et al., 2002	Sad mood	LTM	WRD	Y	45	55	76.9	20.4	56.5
Knight et al., 2007	Divided attention	EYE	IMG	Y	13.5	16.5	75.0	19.9	55.2
Knight et al., 2007	Full attention	EYE	IMG	N	13.5	16.5	75.0	19.9	55.2
Ko et al., 2011	American sample	LTM	IMG	Y	26	29	72.3	21.7	50.6
Ko et al., 2011	Korean sample	LTM	IMG	Y	26	29	70.4	21.9	48.5
Kwon et al., 2009		LTM	IMG	N	52	52	70.8	25.1	45.7
Langeslag & Van Strien, 2008		STM	IMG	Y	20	20	68.5	19.8	48.7
Langeslag & Van Strien, 2009		LTM	IMG	Y	19	19	71.3	21.2	50.1
Leclerc & Kensinger, 2008		VIS	IMG	Y	24	24	76.1	19.5	56.6
Leclerc & Kensinger, 2010, Study 1		EYE	IMG	Y	18	18	72.2	21.5	50.7

Table 1 (*continued*)

Study	Condition	Paradigm	Stimuli	Constraint	Sample size		Mean age		Mean age difference
					Older	Younger	Older	Younger	
Leclerc & Kensinger, 2010, Study 2		EYE	IMG	Y	24	24	73.7	23.9	49.8
Leclerc & Kensinger, 2011		LTM	IMG	Y	19	20	71.7	23.4	48.3
Leigland et al., 2004		LTM	FAC, WRD	Y	36	25	72.3	23.9	48.4
Li et al., 2011		EYE	VID	N	24	24	68.2	20.8	47.5
Löckenhoff & Carstensen, 2007	Control	DEC	ATR	N	20	20	79.8	27.3	52.5
Löckenhoff & Carstensen, 2007	Emotion-focus	DEC	ATR	Y	20	20	79.8	27.3	52.5
Löckenhoff & Carstensen, 2007	Information-focus	DEC	ATR	Y	20	20	79.8	27.3	52.5
Löckenhoff & Carstensen, 2008	Different Age	DEC	ATR	Y	23.66	23.66	78.1	19.9	58.2
Löckenhoff & Carstensen, 2008	Same Age	DEC	ATR	Y	23.66	23.66	78.1	19.9	58.2
Löckenhoff & Carstensen, 2008	Self (control)	DEC	ATR	N	23.66	23.66	78.1	19.9	58.2
Majerus & D'Argembeau, 2011, Study 2		STM	WRD	Y	15	15	70.7	26.0	44.7
Majerus & D'Argembeau, 2011, Study 3		STM	WRD	Y	15	15	69.5	25.0	44.5
Mather & Carstensen, 2003, Study 1		DOT	FAC	N	52	52	74.0	25.8	48.2
Mather & Carstensen, 2003, Study 2		DOT	FAC	N	44	44	71.5	25.4	46.1
Mather & Knight, 2005, Study 1		LTM	IMG	N	48	48	72.7	19.7	53.0
Mather & Knight, 2005, Study 2		LTM	IMG	N	31	25	73.6	21.7	51.9
Mather & Knight, 2005, Study 3	Divided attention	LTM	IMG	Y	16	16	73.8	22.8	51.0
Mather & Knight, 2005, Study 3	Full attention	LTM	IMG	N	16	16	73.8	22.8	51.0
Mather & Knight, 2006		VIS	FAC (SCH)	Y	35	33	72.5	20.3	52.2
Mather et al., 2005, Study 3		LTM	STA	N	40	40	72.5	23.7	48.9
Mather et al., 2005, Study 4b		DEC	ATR	N	48	44	72.6	21.3	51.3
McKay-Nesbitt et al., 2011		LTM	ADS	N	124	151	70.0	20.0	50.0
Mickley & Kensinger, 2009, Study 1		LTM	IMG	Y	26	26	78.2	19.2	59.0
Mickley & Kensinger, 2009, Study 2		LTM	IMG	Y	24	25	75.6	19.6	56.0
Mickley Steinmetz et al., 2010		RVD	WRD	Y	22	25	74.7	20.6	53.9
Mienaltowski et al., 2011		DIS	FAC	Y	15	16	69.5	19.9	49.6
Mikels et al., 2005		WM	IMG	Y	20	20	72.5	22.4	50.2
Nashiro & Mather, 2011a, Study 1		LTM	IMG	Y	18	18	72.7	20.7	52.0
Nashiro & Mather, 2011a, Study 2		LTM	IMG	Y	24	24	74.9	19.2	55.7
Nashiro & Mather, 2011b		LTM	IMG	Y	24	24	77.1	20.2	56.9
Nashiro et al., 2011, Study 1		RL	FAC	Y	17	18	72.7	20.7	52.0
Nashiro et al., 2011, Study 2		RL	FAC	Y	20	20	81.1	19.6	61.5
Nikitin & Freund, 2011		EYE	FAC	N	79	89	70.5	25.5	45.0
Noh & Isaacowitz, 2011		CUE	FAC	Y	44	42	74.1	20.4	53.7
Orgeta, 2011, Study 1		DOT	FAC	N	40	40	69.8	20.1	49.8
Orgeta, 2011, Study 2		DOT	FAC (SCH)	N	40	40	69.7	22.4	47.4
Piguet et al., 2008		LTM	WRD	Y	36	36	72.2	21.4	50.8
Pruis et al., 2009		LTM	IMG, STO	Y	26	25	72.7	29.4	43.3
Ready et al., 2007, Study 1		ABM	ABM	N	28	21	71.6	24.6	47.0
Ready et al., 2007 Study 2		ABM	ABM	N	17	53	68.7	22.9	45.8
Rendell et al., 2011		PM	IMG, TSK	Y	30	30	75.0	21.9	53.1
Ritchey et al., 2011		LTM	IMG	Y	16	20	66.7	23.2	43.5

(*table continues*)

Table 1 (*continued*)

Study	Condition	Paradigm	Stimuli	Constraint	Sample size Older	Sample size Younger	Mean age Older	Mean age Younger	Mean age difference
Rösler et al., 2005		EYE	IMG	N	12	12	64.4	26.5	37.9
Samanez-Larkin et al., 2009		DIS	WRD	Y	12	12	73.3	22.2	51.1
Savaskan et al., 2007		LTM	FAC	Y	15	15	76.7	26.9	49.9
Shamaskin et al., 2010		LTM	HRM	Y	25	24	74.5	20.4	54.1
Spaniol et al., 2008, Study 1		LTM	FAC, IMG, WOR	Y	24	24	67.5	22.5	45.0
Spaniol et al., 2008, Study 2		LTM	FAC, IMG, WOR	N	23	24	71.8	22.3	49.4
St. Jacques et al., 2010		LTM	IMG	Y	15	15	70.2	24.8	45.4
Thapar & Rouder, 2009		LTM	WRD	Y	30	30	67.7	19.9	47.9
Thomas & Hasher, 2006		DIS	WRD	Y	48	48	67.6	21.4	46.2
Tomaszczyk et al., 2008	Active processing	LTM	IMG	Y	36	36	72.3	19.7	52.7
Tomaszczyk et al., 2008	Passive processing	LTM	IMG	N	36	36	72.3	19.7	52.7
Van Gerven & Murphy, 2010		DIS	WRD	Y	48	48	68.1	21.9	46.2
Waring & Kensinger, 2009		LTM	IMG	Y	24	24	72.8	19.6	53.2
Werheid et al., 2010, Study 1		LTM	FAC	Y	20	20	66.2	24.4	41.8
Werheid et al., 2010, Study 2		LTM	FAC	Y	20	20	66.4	24.5	41.9
Werheid et al., 2010, Study 4		LTM	FAC	Y	12	12	65.2	26.6	38.6
Williams & Drolet, 2005, Study 2	Control	LTM	ADS	Y	40.33	41.66	70.0	20.0	50.0
Williams & Drolet, 2005, Study 2	Expansive time	LTM	ADS	Y	40.33	41.66	70.0	20.0	50.0
Williams & Drolet, 2005, Study 2	Limited time	LTM	ADS	Y	40.33	41.66	70.0	20.0	50.0
Yang & Hasher, 2011		SEM	WRD	N	51	55	67.94	19.13	48.81
Yang & Ornstein, 2011	Control	LTM	IMG	N	12	12	68.5	21.92	46.58
Yang & Ornstein, 2011	Emotion-focused	LTM	IMG	Y	20	19	71.3	19.95	51.35
Yang & Ornstein, 2011	Information-focused	LTM	IMG	Y	12	12	69.33	20.25	49.08

Note. Study Type: ATT = attention; MEM = memory. Paradigm: EYE = eye-tracking; BNR = binocular rivalry; DIS = distraction; LTM = long-term memory; ABM = autobiographical memory; VIS = visual search task; STM = short-term memory; DEC = decision grid; DOT = dot-probe task; WM = working memory; RL = reversal learning; CUE = spatial cueing; PM = prospective memory; RVD = rapid visual detection; SEM = semantic memory. Stimuli: ABM = autobiographical memories; ADS = advertisements; ATR = attributes; FAC = faces; FAC (SCH) = schematic faces; FAC (SYN) = synthetic faces; HRM = health-related messages; IMG = images; WRD = words; VID = videos; STA = statements; STO = stories; TSK = tasks; g_{PE} = Positivity effect size; — = data unavailable.

[.000083, .000121], $Z = 10.32$, $p < .001$. Age discrepancy was a stronger predictor of the size of the positivity effect in studies without processing constraints, $b = .00019$, $SE = .00003$, 95% CI [.00016, .00022], $Z = 12.23$, $p < .001$, versus studies with processing constraints, $b = .00004$, $SE = .00002$, 95% CI [.00002, .00007], $Z = 3.46$, $p < .001$.

Discussion

The present study was designed to address open questions regarding the reliability, size, and moderators of the positivity effect. Using a meta-analytic approach with strict inclusion criteria and an expansive set of studies, we found evidence for the positivity effect overall. Converging analyses indicated a minimal likelihood of publication bias. Critically, however, the positivity effect appears to be moderated by experimental constraints on information processing and the magnitude of the age difference between younger and older subsamples, supporting the motivational perspective on the positivity effect offered by SST.

According to SST, the positivity effect results from chronically activated goals shifting across the adult life span: Whereas younger people tend to pursue goals concerning knowledge acquisition and expanding horizons, older people prioritize goals related to emotional meaning and satisfaction. Because these age-related goals and their corresponding information processing patterns reflect top-down motivational processes and not fixed declines in cognitive or neural capacity, they are malleable and require cognitive resources to pursue (e.g., Mather & Knight, 2006; Löckenhoff & Carstensen, 2007). Based on this theoretical framework, we compared experiments that constrained the goals and/or resources of research participants (either intentionally or inadvertently) versus experiments that afforded the unfettered expression and pursuit of chronically activated goals. Results of this comparison indicated that the positivity effect is strongest (medium-sized) among studies that do not constrain information processing (i.e., via goals, attention and/or resources) and weakest (small) among studies that do impose experimental constraints. The size of the positivity effect appears to scale with the magnitude of the age difference within studies, supporting the view that the effect may reflect a gradual life span shift in information processing. Examination of bias scores within each age group revealed that older adults attend to and better remember positive more than negative information, whereas the opposite pattern was observed among younger adults. As with the positivity effect, positivity and negativity biases were moderated by processing constraints: Older adults appear to preferentially

Table 2
Effect Size Data for Individual Studies Included in the Meta-Analysis

Study	Condition	Constraint	*N*	Positivity bias (d_{bias})		Positivity effect		
				Older	Younger	d_{PE} [95% CI]	*Z*	*p*
Allard & Isaacowitz, 2008	Full attention	N	40	0.55	0.49	0.06 [−0.59, 0.71]	0.18	0.86
Bannerman et al., 2011		N	60	0.65	−0.03	0.67 [0.15, 1.18]	2.53	0.01
Brassen et al., 2011		Y	43	0.22	0.11	0.11 [−0.47, 0.69]	0.37	0.71
Charles et al., 2003, Study 1		N	96	0.95	−0.01	0.95 [0.51, 1.38]	4.25	<.001
Charles et al., 2003, Study 2		N	64	−0.14	−0.55	0.41 [−0.1, 0.92]	1.55	0.12
Chung, 2010		N	123	0.34	−1.00	1.33 [0.89, 1.76]	5.95	<.001
Comblain et al., 2004		Y	40	−0.43	−0.44	0 [−0.65, 0.65]	0.00	1.00
D'Argembeau & Van der Linden, 2004		Y	64	0.06	0.32	−0.26 [−0.74, 0.22]	−1.06	0.29
Ebner & Johnson, 2009, Study 1		Y	56	0.43	0.31	0.12 [−0.43, 0.67]	0.42	0.67
Ebner & Johnson, 2010, Study 2		Y	52	0.16	0.01	0.15 [−0.4, 0.7]	0.53	0.60
Emery & Hess, 2008, Study 1	Rating	Y	56.5	−0.08	−0.34	0.25 [−0.26, 0.76]	0.94	0.34
Emery & Hess, 2008, Study 1	Watching	N	56.5	0.00	−0.19	0.19 [−0.32, 0.7]	0.72	0.47
Emery & Hess, 2008, Study 2	Rating	Y	44	0.31	−0.18	0.48 [−0.1, 1.06]	1.60	0.11
Emery & Hess, 2008, Study 2	Watching	N	44	−0.23	−0.08	−0.15 [−0.73, 0.43]	−0.50	0.62
Emery & Hess, 2011		Y	101	−0.38	−0.56	0.18 [−0.21, 0.57]	0.90	0.37
Feng et al., 2011		N	85	−0.44	−0.85	0.41 [−0.07, 0.89]	1.67	0.09
Fernandes et al., 2008		Y	97	0.08	0.28	−0.2 [−0.59, 0.19]	−1.00	0.32
Fleming et al., 2003		Y	46	−0.19	0.03	−0.22 [−0.8, 0.36]	−0.73	0.46
Fung et al., 2008		N	103	−0.19	−0.20	0.02 [−0.37, 0.41]	0.10	0.92
Fung et al., 2010, Study 1		N	217	1.60	−0.29	1.87 [1.53, 2.2]	10.80	<.001
Gallo et al., 2009		Y	48	−0.25	−0.41	0.15 [−0.43, 0.73]	0.50	0.62
Goeleven et al., 2010		Y	54	0.77	0.29	0.47 [−0.08, 1.02]	1.66	0.10
Grady et al., 2007		Y	70	−0.36	−0.78	0.42 [−0.09, 0.93]	1.59	0.11
Grühn et al., 2005		Y	144	−0.04	0.55	−0.59 [−0.92, −0.25]	−3.41	<.001
Grühn et al., 2007		Y	96	0.02	−0.42	0.44 [0.04, 0.83]	2.20	0.03
Hahn et al., 2006, Study 1		Y	40	−0.31	−0.26	−0.05 [−0.66, 0.56]	−0.16	0.87
Hahn et al., 2006, Study 2		Y	28	−0.09	−0.10	0 [−0.73, 0.73]	0.00	1.00
Hahn et al., 2006, Study 3		Y	30	−0.30	−0.21	−0.09 [−0.79, 0.61]	−0.25	0.80
Isaacowitz et al., 2006a		N	64	0.54	−0.13	0.66 [0.14, 1.17]	2.49	0.01
Isaacowitz et al., 2006b		N	60	0.85	0.22	0.62 [0.06, 1.17]	2.19	0.03
Isaacowitz et al., 2008		N	124	0.45	0.12	0.32 [−0.01, 0.65]	1.85	0.06
Kapucu et al., 2008		Y	45	−0.31	−0.74	0.42 [−0.19, 1.03]	1.33	0.18
Kennedy et al., 2004		N	56	0.51	−0.25	0.75 [0.19, 1.3]	2.65	0.01
Kensinger & Schacter, 2008		Y	34	−0.57	−0.57	0 [−0.7, 0.7]	0.00	1.00
Kensinger et al., 2002		Y	40	−0.05	0.07	−0.12 [−0.73, 0.49]	−0.38	0.70
Kensinger et al., 2007, Study 1		Y	60	−0.09	−0.48	0.38 [−0.13, 0.89]	1.44	0.15
Kensinger et al., 2007, Study 2		Y	60	0.03	−0.50	0.53 [0.01, 1.04]	2.00	0.05
Kensinger, 2008, Study 1		Y	60	0.42	−0.50	0.9 [0.38, 1.41]	3.40	<.001
Kensinger, 2008, Study 2		Y	60	0.41	−0.23	0.63 [0.11, 1.14]	2.38	0.02
Knight et al., 2002	Neutral mood	N	97	0.31	0.02	0.28 [−0.15, 0.71]	1.25	0.21
Knight et al., 2002	Sad mood	Y	100	0.13	0.30	−0.17 [−0.56, 0.22]	−0.85	0.40
Knight et al., 2007	Divided attention	Y	30	−0.17	0.27	−0.43 [−1.13, 0.27]	−1.19	0.23
Knight et al., 2007	Full attention	N	30	0.22	−0.21	0.41 [−0.29, 1.11]	1.14	0.26
Ko et al., 2011	American sample	Y	55	−0.04	−0.95	0.89 [0.3, 1.47]	2.97	0.00
Ko et al., 2011	Korean sample	Y	55	−0.14	−0.59	0.45 [−0.1, 1]	1.59	0.11
Kwon et al., 2009		N	104	0.12	−0.28	0.4 [0, 0.79]	2.00	0.05
Langeslag & Van Strien, 2008		Y	40	−0.13	−0.16	0.03 [−0.58, 0.64]	0.09	0.92
Langeslag & Van Strien, 2009		Y	38	0.15	−0.25	0.39 [−0.22, 1]	1.23	0.22
Leclerc & Kensinger, 2008		Y	48	−0.01	0.17	−0.18 [−0.73, 0.37]	−0.64	0.52
Leclerc & Kensinger, 2010, Study 1		Y	36	−0.36	−0.03	−0.32 [−0.97, 0.33]	−0.96	0.33
Leclerc & Kensinger, 2010, Study 2		Y	48	0.04	0.04	0 [−0.55, 0.55]	0.00	1.00
Leclerc & Kensinger, 2011		Y	39	0.11	−0.24	0.35 [−0.26, 0.96]	1.11	0.27
Leigland et al., 2004		Y	61	1.16	0.75	0.41 [−0.24, 1.06]	1.24	0.22
Li et al., 2011		N	62	−0.78	−1.23	0.44 [−0.17, 1.05]	1.39	0.16
Löckenhoff & Carstensen, 2007	Control	N	40	0.82	0.13	0.67 [0, 1.34]	1.93	0.05
Löckenhoff & Carstensen, 2007	Emotion-focus	Y	40	0.67	0.30	0.36 [−0.29, 1.01]	1.09	0.28
Löckenhoff & Carstensen, 2007	Information-focus	Y	40	0.34	0.04	0.29 [−0.36, 0.94]	0.87	0.38
Löckenhoff & Carstensen, 2008	Different Age	Y	47.32	0.53	0.14	0.38 [−0.2, 0.96]	1.27	0.21
Löckenhoff & Carstensen, 2008	Same Age	Y	47.32	0.89	−0.08	0.95 [0.33, 1.56]	3.00	0.00
Löckenhoff & Carstensen, 2008	Self (control)	N	47.32	0.89	0.03	0.84 [0.22, 1.45]	2.66	0.01
Majerus & D'Argembeau, 2011, Study 2		Y	30	0.19	0.20	−0.01 [−0.71, 0.69]	−0.03	0.98

(*table continues*)

Table 2 (*continued*)

Study	Condition	Constraint	N	Positivity bias (d_{bias}) Older	Positivity bias (d_{bias}) Younger	Positivity effect d_{PE} [95% CI]	Positivity effect Z	Positivity effect p
Majerus & D'Argembeau, 2011, Study 3		Y	30	0.34	−0.03	0.36 [−0.34, 1.06]	1.00	0.32
Mather & Carstensen, 2003, Study 1		N	104	0.17	0.12	0.05 [−0.34, 0.44]	0.25	0.80
Mather & Carstensen, 2003, Study 2		N	88	0.14	0.07	0.07 [−0.36, 0.5]	0.31	0.75
Mather & Knight, 2005, Study 1		N	96	0.15	−0.31	0.46 [0.06, 0.85]	2.30	0.02
Mather & Knight, 2005, Study 2		N	56	−0.32	−1.34	1.01 [0.35, 1.66]	3.05	0.00
Mather & Knight, 2005, Study 3	Divided attention	Y	32	−0.79	−0.43	−0.35 [−1.08, 0.38]	−0.94	0.35
Mather & Knight, 2005, Study 3	Full attention	N	32	0.15	−0.25	0.39 [−0.28, 1.06]	1.13	0.26
Mather & Knight, 2006		Y	68	−0.16	−0.25	0.09 [−0.39, 0.57]	0.37	0.71
Mather et al., 2005, Study 3		N	80	0.31	−0.07	0.38 [−0.05, 0.81]	1.70	0.09
Mather et al., 2005, Study 4b		N	92	1.13	0.76	0.37 [−0.11, 0.85]	1.51	0.13
McKay-Nesbitt et al., 2011		N	259	0.00	−0.25	0.25 [−0.02, 0.52]	1.77	0.08
Mickley & Kensinger, 2009, Study 1		Y	52	−0.24	0.18	−0.42 [−0.97, 0.13]	−1.48	0.14
Mickley & Kensinger, 2009, Study 2		Y	49	−0.50	0.03	−0.52 [−1.07, 0.03]	−1.84	0.07
Mickley Steinmetz et al., 2010		Y	47	−0.10	−0.28	0.18 [−0.4, 0.76]	0.60	0.55
Mienaltowski et al., 2011		Y	31	−0.01	0.01	−0.03 [−0.7, 0.64]	−0.09	0.93
Mikels et al., 2005		Y	40	0.55	−0.43	0.96 [0.3, 1.61]	2.89	0.00
Nashiro & Mather, 2011a, Study 1		Y	36	0.48	0.11	0.37 [−0.28, 1.02]	1.12	0.26
Nashiro & Mather, 2011a, Study 2		Y	48	0.04	0.30	−0.26 [−0.81, 0.29]	−0.92	0.36
Nashiro & Mather, 2011b		Y	48	0.09	−0.47	0.55 [−0.03, 1.13]	1.83	0.07
Nashiro et al., 2011, Study 1		Y	35	0.79	0.04	0.73 [0.02, 1.43]	2.02	0.04
Nashiro et al., 2011, Study 2		Y	40	0.67	−0.07	0.73 [0.07, 1.38]	2.20	0.03
Nikitin & Freund, 2011		N	168	1.02	1.18	−0.16 [−0.55, 0.23]	−0.80	0.42
Noh & Isaacowitz, 2011		Y	86	−0.05	0.03	−0.08 [−0.51, 0.35]	−0.36	0.72
Orgeta, 2011, Study 1		N	80	0.00	−0.02	0.02 [−0.41, 0.45]	0.09	0.93
Orgeta, 2011, Study 2		N	80	0.08	0.00	0.08 [−0.35, 0.51]	0.36	0.72
Piguet et al., 2008		Y	72	−0.05	0.04	−0.09 [−0.52, 0.34]	−0.40	0.69
Pruis et al., 2009		Y	51	−0.32	−0.92	0.59 [0, 1.17]	1.97	0.05
Ready et al., 2007, Study 1		N	49	0.28	−0.34	0.61 [0.05, 1.16]	2.16	0.03
Ready et al., 2007, Study 2		N	34	1.08	−1.00	2.04 [1.23, 2.84]	4.95	<.001
Rendell et al., 2011		Y	60	0.58	0.32	0.25 [−0.3, 0.8]	0.88	0.38
Ritchey et al., 2011		Y	36	−0.46	−0.69	0.23 [−0.47, 0.93]	0.64	0.52
Rösler et al., 2005		N	24	0.06	−0.30	0.35 [−0.43, 1.13]	0.88	0.38
Samanez-Larkin et al., 2009		Y	24	−0.18	0.14	−0.31 [−1.09, 0.47]	−0.78	0.44
Savaskan et al., 2007		Y	45	0.29	0.56	−0.26 [−0.91, 0.39]	−0.78	0.43
Shamaskin et al., 2010		Y	49	2.41	1.14	1.25 [0.33, 2.16]	2.67	0.01
Spaniol et al., 2008, Study 1		Y	48	−0.65	−0.52	−0.13 [−0.78, 0.52]	−0.39	0.70
Spaniol et al., 2008, Study 2		N	47	−0.53	−0.68	0.15 [−0.46, 0.76]	0.47	0.64
St Jacques et al., 2009		Y	30	−0.17	−0.20	0.02 [−0.68, 0.72]	0.06	0.96
Thapar & Rouder, 2009		Y	60	0.22	0.03	0.19 [−0.32, 0.7]	0.72	0.47
Thomas & Hasher, 2006		Y	96	0.25	−0.25	0.49 [0.09, 0.88]	2.45	0.01
Tomaszczyk et al., 2008	Active processing	Y	72	0.23	−0.16	0.39 [−0.09, 0.87]	1.59	0.11
Tomaszczyk et al., 2008	Passive processing	N	72	0.14	−0.32	0.45 [−0.03, 0.93]	1.84	0.07
Van Gerven & Murphy, 2010		Y	96	0.06	−0.18	0.23 [−0.16, 0.62]	1.15	0.25
Waring & Kensinger, 2009		Y	48	−0.10	−0.06	−0.04 [−0.59, 0.51]	−0.14	0.89
Werheid et al., 2010, Study 1		Y	40	−0.35	−0.46	0.1 [−0.51, 0.71]	0.32	0.75
Werheid et al., 2010, Study 2		Y	40	−0.12	−0.21	0.09 [−0.52, 0.7]	0.28	0.78
Werheid et al., 2010, Study 4		Y	24	0.45	0.00	0.44 [−0.34, 1.22]	1.10	0.27
Williams & Drolet, 2005, Study 2	Control	Y	82	−0.92	0.96	−1.87 [−2.38, −1.35]	−7.07	<.001
Williams & Drolet, 2005, Study 2	Expansive time	Y	82	1.33	1.39	−0.06 [−0.64, 0.52]	−0.20	0.84
Williams & Drolet, 2005, Study 2	Limited time	Y	82	−1.14	−0.83	−0.31 [−0.82, 0.2]	−1.17	0.24
Yang & Hasher, 2011		N	106	0.13	−0.60	0.72 [0.32, 1.11]	3.60	<.001
Yang & Ornstein, 2011	Control	N	24	−0.31	−0.63	0.31 [−0.49, 1.11]	0.75	0.45
Yang & Ornstein, 2011	Emotion-focused	Y	39	−0.38	−0.13	−0.24 [−0.85, 0.37]	−0.76	0.45
Yang & Ornstein, 2011	Information-focused	Y	24	−0.09	−0.57	0.47 [−0.33, 1.27]	1.14	0.25

Note. Sample size (N) represents total sample (older + younger) within each study.

process positive (vs. negative) information when their processing is unconstrained but process positive and negative information equally when constraints are present. By contrast, younger adults preferentially process negative (vs. positive) information under constrained *and* unconstrained processing conditions.

The present study represents to our knowledge the first systematic meta-analysis of the age-related positivity effect and supports key theoretically based predictions from a precise operational definition. These predictions were previously supported by some, but not all, published studies. For instance, although Löckenhoff and Carstensen (2007) demonstrated that experimental constraints on goals eliminate positivity in decision making, Emery and Hess (2008) found minimal evidence for the influence of goal manipulations on emotional memory. Studies that explicitly constrain

Table 3
Positivity Effect and Positivity Bias Effect Sizes by Processing Constraint and Age Group

Processing constraint	k	Positivity bias (d_{bias}) Older	Positivity bias (d_{bias}) Younger	Positivity effect (d_{PE})
Unconstrained	38	.280 [.123, .436]	−.197 [−.340, −.054]	.482 [.323, .640]
Constrained	77	.048 [−.048, .144]	−.085 [−.182, .011]	.134 [.033, .235]
Total	115	.128 [.042, .214]	−.123 [−.203, −.043]	.257 [.165, .349]

Note. 95% confidence intervals are in brackets.

processing to test the resulting effects on positivity are few and far between in the research literature, yet studies that inadvertently constrained processing are relatively common. Using a meta-analytic approach circumvents this issue because it ensures that the latter category of studies is evaluated in the appropriate context. This is a key contribution of the present study because ignoring differences in task constraint across experiments leads one to significantly underestimate the size of the positivity effect. Not only was the positivity effect significantly mitigated in studies with information processing constraints, but older adults' preferential processing of positive information (over negative) was completely eliminated under these conditions. Thus, the inclusion of experimental constraints on processing not only skew age differences but also provide a misleading portrait of information processing tendencies within each age group.

Our finding that the size of the positivity effect scales with the magnitude of age differences is also theoretically consistent despite scant empirical support from individual studies. Research by Fung and colleagues using adult life span samples found a linear association between age and positivity in visual attention (Li et al., 2011) as well as age differences in positivity between older and younger—but not middle-aged—adults (Fung, Isaacowitz, Lu, & Li, 2010), suggesting a gradual age trend. Critically, though the present analysis focuses primarily on comparisons between young and older adults, the positivity effect theoretically reflects *relative* age comparisons. As a consequence one could observe a positivity effect among a sample comprised entirely of older adults if it contained a sufficiently wide age range (e.g., 60 to 100). Of course, the vast majority of studies on the positivity effect neither include a broad life span sample nor a comparison of younger, middle-aged and older adults, thus complicating efforts to identify the developmental trajectory of positivity. Applying a meta-analytic perspective partially remedies this problem by allowing between-study comparisons of variable age differences to compensate for limited within-study age comparisons. However, the cross-sectional nature of the studies included in the meta-analysis limits the ability to draw conclusions regarding developmental changes. Longitudinal or sequential studies are therefore needed to directly test whether the positivity effect is indeed a developmental trend.

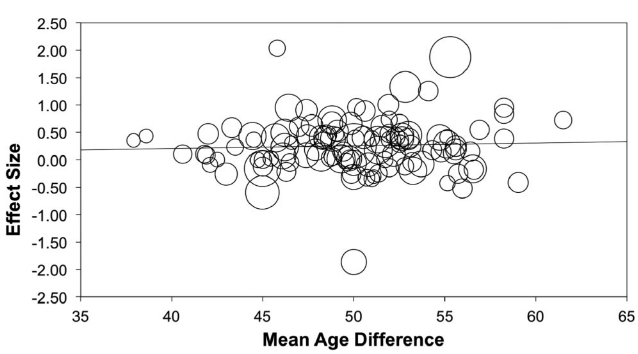

Figure 1. Meta-regression of mean age difference on positivity effect size. Each circle represents a single study sample. Circle sizes are proportional to the sample size. Regression fit line $\beta = .005$, $t(113) = 5.69$, $p < .001$.

Although our meta-analysis was intended to examine the reliability, size and moderators of the positivity effect, our approach precluded addressing questions about underlying mechanisms, such as whether the effect is driven by age differences in increased positive and/or decreased negative processing. In contrast to the prior meta-analysis by Murphy and Isaacowitz (2008), we included studies that lacked measures of neutral information processing (e.g., Kennedy et al., 2004; Shamaskin et al., 2011) that would serve as necessary controls for separately comparing positive versus negative information processing across age groups. Our results therefore leave open questions concerning the mechanisms underlying the positivity effect. For instance, is the positivity effect driven by discrete changes in the processing of positive and negative information and, if so, what factors moderate whether age differences are manifest for one valence versus the other? These questions represent fertile ground for future meta-analyses, and the dramatic expansion of the empirical literature in the years since Murphy and Isaacowitz's (2008) study renders a systematic replication of the latter particularly useful.

Although the present meta-analysis is not able to directly address specific mechanisms underlying the positivity effect, it does provide novel insights into the overall pattern. Consistent with previous reviews (see, e.g., Baumeister et al., 2001), the present analysis provides additional evidence of a *negativity bias* in youth. As discussed earlier, the positivity effect captures an age-related shift in favor of positive versus negative information. Until now, though, it was unclear whether the shift is a reduced negativity bias (or no negativity bias) or a full-blown positivity bias. Our overall findings support the latter: Collapsing across all studies, older adults showed a *positivity bias* on average. However, in studies that constrained information processing they showed neither a positivity bias nor a negativity bias, whereas younger adults showed a negativity bias. Thus, the exact configuration of the age-related positivity effect—whether a shift from negativity in youth to positivity in later life or an elimination of negativity in later life—may hinge on outside influences on information processing. This result places a significant life span qualification on the pervasiveness of the negativity bias; although in youth "bad is stronger than good" (Baumeister et al., 2001), in later life good is just as strong as bad—if not stronger.

Results of our meta-analysis have prescriptive value for future research on the positivity effect. Because of the disproportionate impact of processing constraints on positivity, it is imperative to recognize and assess the consequences of often-unintended methodological alterations in this area of study. As illustrated by the present meta-analysis, merely notifying participants that their memory will be tested before presenting stimuli significantly reduces age differences in preferential processing, in large part by eliminating older adults' natural prioritization of positive over negative information. Studies that intend to examine normative age differences in the processing of emotional information would therefore benefit from encouraging and enabling participants to process information in whichever way they prefer and removing all potential constraints or barriers.

The present findings bring needed clarity to an increasingly crowded and complex literature and reinforce the utility of meta-analysis for summarizing extant work. However, future empirical studies are needed to address critical questions regarding alternative influences on the positivity effect. For instance, while individual studies have shown that the positivity effect depends on sufficient cognitive control resources (Knight et al., 2007; Mather & Knight, 2005), the present meta-analysis could not examine this moderator. This was due to a lack of consistent selection and reporting of background cognitive ability measures across studies. Future studies incorporating common measures of cognitive control resources[10] would afford testing this key tenet of the motivational perspective on positivity effect. Another limitation of the present meta-analysis is that it could not examine cross-cultural differences in positivity because of the relatively few number of studies with non-Western samples. Understanding the influence of culture on positivity from a meta-research perspective is especially important given the inconsistent results stemming from individual studies (e.g., Fung et al., 2008, 2010; Kwon et al., 2009). Though cultural comparisons and perspectives are becoming increasingly common in this area, more work is needed to understand how the positivity effect is manifest (or not) across cultures and the underlying mechanisms therein. Another limitation of the current meta-analysis is that it could not address the context sensitivity of the positivity effect beyond experimental constraints. Although the motivational perspective proposes that age differences in emotional information processing will be mitigated in high-stakes versus low-stakes situations (i.e., deciding on a life-saving medical procedure vs. choosing a hypothetical car; for a discussion, see Reed & Carstensen, 2012), the vast majority of extant studies use tasks with minimal significance to participants. Future research with relatively consequential information processing contexts could trace the conditions under which older and younger adults differ in their emotional memory and attention.

In sum, the present meta-analysis brings some measure of clarity to a domain that has produced a remarkable quantity of research—and no shortage of debate—in the mere decade since its inception. Although evaluating studies in a serial manner might indeed lend the impression of disorder in the literature and raise doubts over the validity of the positivity effect, using a meta-analytic perspective paints a different picture: Discrepant results observed across tests of the positivity effect become both meaningful and relatively predictable, reflecting theoretically implicated moderators. When these factors are taken into consideration, empirical findings coalesce to reveal a positivity effect that is both reliable and robust.

[10] For example, the Attentional Network Task by Fan and colleagues (Fan, McCandliss, Sommer, Raz, & Posner, 2002).

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