

## CHAPTER 3

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# THE BROADEN-AND-BUILD THEORY OF POSITIVE EMOTIONS: FORM, FUNCTION, AND MECHANISMS

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MANY of the most wonderful moments in life are infused with positive emotions. We may feel joy playing with children; love sharing with family members; and awe in the presence of natural beauty. During these moments, we feel a subjective sense of pleasure. Positive emotions feel good. But, beyond just feeling good, do positive emotions serve any function for us in either the short or long term?

Across the past decade, questions such as these have led to an explosion of research and significant advances in our understanding of positive emotions. In this chapter, we present the broaden-and-build theory of positive emotions (Fredrickson, 1998, 2001, 2004) as a framework for addressing these questions and understanding the nature, origins, and consequences of positive emotions. Next, we review evidence supporting the first part of the theory—the broaden effect—with a particular focus on attention and cognitive flexibility. Then we review evidence supporting the second part of the theory—the build effect—which has implications for lifespan development. Taken together, this work underscores the role of positive emotions in generating long-term resources such as well-being and resilience. We consider possible mechanisms underlying the broaden and build effects and provide evidence for the undo effect of positive emotions. Finally, we conclude with directions for future research.

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### BROADEN-AND-BUILD THEORY OF POSITIVE EMOTIONS

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The broaden-and-build theory of positive emotions was proposed to account for the unique effects of positive versus negative emotions that could not be explained by existing theories of emotions. For example, according to numerous theories (Frijda, 1986; Lazarus, 1991; Levenson, 1994), emotions were viewed as engendering specific behavioral action tendencies. Fear fueled the urge to escape, whereas anger sparked attack, and so on. From an evolutionary perspective, the specific action tendencies paired with discrete emotions functioned to ensure human ancestors' survival. Each discrete emotion had a specific action tendency, and consequently, served an adaptive function. Yet, unlike negative emotions such as fear and anger, the specific action tendencies of positive emotions were less specified. Compared to the action urges generated by negative emotions, those generated by positive

emotions are considerably less clear and specific and in some cases, may call forth the action of “not acting.” For example, joy and contentment appear to generate aimless activation and inactivity, respectively (Frijda, 1986). Such vagueness and lack of specificity led to the proposal that positive emotions may, in fact, serve functions quite distinct from negative emotions. But if not to act to enhance immediate survival, what, if any, function do positive emotions serve?

According to the broaden-and-build theory, rather than fueling specific action tendencies, positive emotions appear to spark broadened and expansive thought–action tendencies. They affect our thoughts and attention, and by leading to broadened and expansive attention, positive emotions fuel flexible and creative thinking and problem-solving approaches, which accumulate and build long-term psychological, physical, and social resources (Fredrickson, 1998, 2001, 2004). These new resources, in turn, would have increased the odds that human ancestors survived subsequent threats to life and limb.

In the following sections, we describe these two central effects of the broaden-and-build theory—the broaden effect and the build effect—and provide supporting evidence across a variety of domains. Toward that end, we first address the following questions: (1) What is a broadened thought–action repertoire? and (2) What evidence exists to support the claim that positive emotions broaden thought–action repertoires?

## **The broaden effect**

The broaden effect is a primary claim in the broaden-and-build theory. Rather than directly fueling specific physical actions, positive emotions appear to generate non-specific, broadened cognitive changes, which may lead to behavioral changes (Fredrickson, 1998). Positive emotions spark broad alterations in “thought–action” tendencies. One form in which positive emotions impact cognitive change is a broadened and expansive scope of attention.

### ***Attention***

Within this widened scope of attention, individuals experience and attend to a larger distribution that includes more features of the surround that may have otherwise been excluded. This broaden effect is in direct contrast to the well-known narrowing effect of negative emotions on attention.

For example, a considerable body of research has documented that under conditions of negative affect and threat, individuals engage in significantly more narrowed and focused attention and selectively attend to negative information. Fear and anxiety have been reported to narrow an individual’s attentional focus (Derryberry & Tucker, 1994; Mogg, Millar, & Bradley, 2000; Mogg et al., 2000). Likewise, significant attention to threat has been demonstrated for anxious versus non-anxious individuals (for review see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & IJzendoorn, 2007). Anxious individuals show faster attention and automatic engagement with threat-related versus neutral stimuli and slower time to disengage (Fox, Russo, Bowles, & Dutton, 2001), reflecting effects at multiple stages of information processing.

Like negative emotions, positive emotions also impact our attention and thought–action

repertoires, only they broaden rather than narrow them. Whereas negative emotions may occur in threatening situations and constrict our attention to facilitate a quick response, positive emotions generally occur in safe contexts and stimulate expansive attention, and increase openness and receptivity to a range of experiences. To illustrate the unique effect of positive emotions and broadened attention, we present a series of studies showing the broadened attention effect. These include studies of visual attention utilizing global–local processing, executive attention, and emotional information processing tasks.

Global–local processing tasks assess the extent to which participants attend to global and holistic versus local and detailed features of a stimulus. One example includes an image with two geometric figures: (1) a large letter “T” composed of five smaller letter “Ls,” and (2) a large letter “L” composed of five smaller letter “Ts.” Participants are asked to find the letter “T” as quickly as possible requiring them to make a decision about a figure based on holistic (global) or elemental (local) features.

Utilizing a measure like this, research supports the effect of positive emotions widening attentional scope. In one experiment, participants were induced to feel positive, negative, or neutral states by watching film clips (Fredrickson & Branigan, 2005). Participants who viewed the positive emotion films were more likely to show a global preference compared to the other conditions. In another experiment, participants who frequently smiled were faster at recognizing global targets relative to local targets (Johnson, Waugh, & Fredrickson, 2010). Frequent smiling improved the ability to process information holistically.

Positive emotions have also been found to impact attention on traditional executive attention tasks. In a study conducted by Rowe, Hirsh, and Anderson (2007), broadened attention following positive emotion was assessed with the Eriksen flanker task (Eriksen & Eriksen, 1974). Participants were presented with a screen with a central target flanked by congruent (e.g., “NNNNN”) or incongruent (e.g., “EENEE”) adjacent stimuli. Response slowing is typically observed when the central target is flanked by incompatible stimuli. Target/distractor distance was also manipulated (“E E N E E”) and results revealed a significant effect of positive affect on attentional breadth. Compared to sad and neutral conditions, the positive affect condition showed significantly greater reaction time to incongruent versus congruent stimuli. This response slowing was also demonstrated for trials with the greatest target/distractor distance providing evidence for increased attentional scope, facilitating inclusion of peripheral information.

Additional evidence supporting the broadened attentional effect of positive emotions derives from studies of affective picture processing. Utilizing eye-tracking technology, participants’ eye movements (in response to affective pictures) were assessed following positive mood induction (Wadlinger & Isaacowitz, 2006). Results revealed that those who were induced to experience positive mood demonstrated greater attention breadth while viewing pictures. This included longer fixation to peripheral aspects of images. Interestingly, fixation and broadened attention were longer for positive versus negative and neutral images. This evidence for attentional expansion following positive affect, coupled with elaborate processing of positive stimuli, suggests potentially important directions for future studies of mechanisms underlying thought–action tendencies, such as a possible motivation or incentive to maintain an even greater expansion of attention. We elaborate on this proposal in later

sections. Next, however, we describe the broaden effects on cognition.

## **Cognition**

Another form that positive emotions take involves the broadened influence on cognition, or more specifically, increased cognitive flexibility and creativity. As with expanding attention, positive emotions also broaden and expand one's thinking to allow for greater flexibility, creativity, and the generation of unusual and innovative problem solving. Positive emotions motivate individuals to pursue novel, creative, and unscripted paths of thought and action (Fredrickson, 1998) and "give[s] rise to an enlarged cognitive context" (Isen, 1987, p. 222).

Classic research by Isen and colleagues provides striking evidence for positive emotions' effects on flexible and innovative thinking. Those experiencing positive affect have named more unusual associations to neutral words, used more inclusive categories, and generated novel problem solving strategies (Ashby, Isen, & Turken, 1999). In one experiment, participants were induced to feel positive or neutral emotions and then completed Mednick's Remote Associates Test, which requires individuals to generate a word that relates to three other words (Isen, Daubman, & Nowicki, 1987). In this experiment, participants induced to feel positive emotions generated more correct answers than those induced to feel neutral emotions, demonstrating a broadened scope of cognitive flexibility.

Positive emotions also broaden cognition as demonstrated by generating creative and novel uses for everyday objects. When given a problem to solve using a candle, a box of thumbtacks, and a book of matches, Isen and colleagues (1987) found that 75% of the participants who were induced to feel positive emotions were able to solve the problem, compared to 20% of the neutral and 13% of the negative groups. Likewise, positive emotions broadened cognition by facilitating problem solving in studies in which participants were asked to generate unusual uses for everyday objects (Ziv, 1976).

Positive emotions also appear to influence participants' thoughts about actions in which they would like to engage. Specifically, Fredrickson and Branigan (2005) reported that compared to those in negative and neutral conditions, participants induced to experience positive emotions generated a large and varied list of behaviors in which they wanted to engage. This study provides intriguing findings on the effect of positive emotions on broadened cognition and desired behavior and possible influences on thought–action repertoires. Could an additional feature of positive emotions be to spark reward-seeking behavior following broadened cognition? We address this question later. Next, however, we address another important effect of positive emotions—how we view and understand others.

## **Social cognition**

The broadened effect on social cognition refers to an expansion of how we view ourselves in relation to others. As with attention and cognition, positive emotions widen and expand our interpersonal scope and promote flexible and creative ways of processing social information. One of these areas includes how one views the self and the broadened effect of self-expansion.

Self-expansion refers to incorporating aspects of another person's character as one's own (Aron, Aron, & Smollen, 1992). It represents the degree of perceived similarity, overlap, and

interconnectedness between the self and another. Findings reveal that positive emotions are key predictors of changes in social cognition and spark self-expansive views in relationships. Indeed, individuals who report frequent experiences of positive emotions were more likely to report significant overlap between self and other (Waugh & Fredrickson, 2006). This has been demonstrated in first-year university students reporting on new roommate relations within the first week of the semester and again at 1 month.

Results also indicate that positive emotions broaden our perception of self and other with respect to racial categories. Specifically, in a series of experiments conducted by Johnson and Fredrickson (2005), participants induced to experience positive emotions, compared to those in negative or neutral conditions, showed significant improvement in their ability to recognize people of a different race reducing an effect called the “own-race bias” in face recognition. Positive emotions appeared to eliminate the robust “own-race bias” in facial recognition through broadened and expanded views of self and others such that perceived similarities across social categories were broadened and perceived differences between social groups became diminished.

Overall, the form positive emotions take in the short term is one of broadened attention and cognition. We experience increased breadth and expansion of our attentional scope, thoughts, and problem-solving approaches, and views of self in relation to others. These broadened effects, in turn, spark decision-making (and possibly action), that over time lead to the second effect of the broaden-and-build theory—the build effect.

### **Evidence for the build effect**

According to the broaden-and-build theory, positive emotions spark broadened and expansive cognitive changes that lead to altered patterns of decision-making and actions that reflect investment in intellectual, personal, and social domains (Fredrickson, 1998). Over time, these consequential patterns of thoughts and actions accumulate, and build long-term psychological, physical, and social resources (Fredrickson, 1998, 2001, 2004). These may “add up” over time, leading to quantitative changes across development (e.g., increased levels of well-being), yet they may also lead to qualitatively new changes, such as when a child begins to think abstractly. Perhaps it was Piaget (1962) who illustrated this best when he described how children’s play and engagement with the environment afforded the opportunity to develop qualitatively new knowledge and stages of cognitive thought.

Evidence suggesting that positive emotions build intellectual resources can be found in studies such as anticipatory smiling, joint attention, secure attachment, and cognition. For example, studies have assessed relations between infant positive affect and joint attention, which reflects a form of broadened attention involving the triadic coordination of attention between self, others, and a third object (Tomasello, 1995). Infants high on positive affect demonstrate significantly higher levels of initiating joint attention with another, presumably because engaging in shared attention is rewarding (Nichols, Martin, & Fox, 2005). Likewise, 6-month-old infants who engage in more smiling behavior demonstrated more anticipatory smiling (smiling at a toy object and then at an adult) during a joint attention task at 9 months (Parlade et al., 2008), and higher levels of social competence at 30 months (Parlade et al.,

2008). Higher levels of joint attention at 12 months were also associated with higher levels of: (1) expressive language and cognitive ability at 24 months, and (2) social competence at 30 months.

More direct evidence can also be found in a recent intervention designed to enhance the developmental outcomes of socially deprived children from Romanian orphanages. Young children from the institution were randomly assigned to a foster care intervention or to remain in the institution at approximately 21 months of age. Compared to children who remained in the institution and a community-based comparison group, children in the foster care intervention demonstrated significantly higher levels of positive affect and attention at 42 months (Ghera et al., 2009). These children also evidenced significant growth in cognitive abilities from 30 and 42 months to 54 months as assessed by the Bayley Scales of Infant Development (BSID-II; Bayley, 1993) and the Wechsler Preschool Primary Scale of Intelligence—Revised (WPPSI-R; Wechsler, 1989) compared to the institutionalized group (Nelson et al., 2007). Interestingly, caregiver quality, as assessed by increased positive affect and sensitive responding, was enhanced in the intervention group, providing support that early environmental experiences infused with positive affect build long-term resources.

Significant effects of maternal positive affect on additional long-term outcomes have also been demonstrated. Maternal positive expressions during mother–infant free play have been found to be associated with: (1) a reduction in infant crying across the first year of life (Conway, McDonough, Clark, & Smith, 2001), and (2) attentional flexibility and behavioral competence at 33 months (Conway, 2002; Conway, McDonough, & Sameroff, 2002). Likewise, parent–infant interactions characterized by shared positive affect predict secure attachment, compliance, the internalization of values and goals, the development of conscience, and positive emotional expression with peers (Ainsworth, Behlar, Waters, & Wall, 1978; Denham, Mitchell-Copeland, Strandberg, Auerbach, & Blair, 1997; Kochanska, 1997; Kochanska & Aksan, 1995; Kochanska & Murray, 2000; Kochanska, Murray, & Coy, 1997). Links between parental positive emotional expression and children’s emotion regulation and social competence have also been reported with school-age children (Boyum & Parke, 1995; Eisenberg et al., 2001).

These findings suggest that cumulative exposure to maternal positive affect and individual and relational experiences of positive affect may, over time, build long-term attentional, cognitive, and social resources in childhood. Yet, these effects are also evident during adulthood. Next, we review emerging findings demonstrating the powerful build effects of positive emotions on adults’ well-being and resilience.

## ***Well-being***

One of the central tenets of the broaden-and-build theory is the importance of positive emotions for individuals’ trajectories towards growth and well-being (Fredrickson, 1998). In the last few years, research has begun to show how positive emotions may be key ingredients on the path towards a satisfying and fulfilling life. In a direct test of the build effect, adults were randomized to a skills based intervention or wait list control. The purpose of the 7-week skills-based intervention was to teach participants to self-generate positive emotions through a

practice of loving-kindness meditation (LKM). LKM involved thinking of a person for whom they already felt warm and tender feelings (e.g., a close loved one), and then extending these warm feeling to themselves and then to an ever-widening circle of others. Findings indicated that compared to wait-list controls, participants who learned LKM reported more positive emotion throughout the 7-week intervention, which was associated with improvements in self-acceptance, physical health, competence, improved relations with others, and sense of purpose in life (Fredrickson, Cohn, Coffey, Pek, & Finkel, 2008). Growth in these resources also predicted increases in life satisfaction and fewer depressive symptoms among LKM participants. This field experiment provides striking evidence for the build effect and specifically the role of frequent positive emotion in the cultivation of well-being.

In addition to frequency, the *strength* of positive emotional responses may build optimal mental health or flourishing. Flourishing refers to being satisfied with life, being free of mental health concerns, and functioning significantly better than others (Fredrickson & Losada, 2005; Keyes, 2007). It has been found to be associated with higher levels of education, more positive versus negative emotions, and physical health (Keyes, 2007).

To assess build effects related to flourishing, adults were classified into three groups based on their mental health. Flourishers were individuals high in mental health (positive affect, psychological/social functioning) with an absence of mental health problems (e.g., depression, anxiety, substance abuse); non-flourishers included individuals without mental health problems but also without signs of flourishing; and the depressed group included individuals who endorsed mild-to-moderate symptoms of depression. Compared to non-flourishers and depressed groups, flourishers generally reported more positive emotions when engaging in pleasant activities including helping, playing, learning, and engaging in spiritual activity (Catalino & Fredrickson, 2011). Moreover, this greater positive emotional reactivity predicted higher levels of two facets of the cognitive resource mindfulness—*observing* and *non-reactivity to inner experience*—which, in turn, predicted changes in signs of flourishing over time, confirming the build effect and importance of positive emotions in the maintenance of optimal mental health and flourishing.

To assess the underlying processes that contribute to well-being, Cohn, Fredrickson, Brown, Mikels, and Conway (2009) tracked daily emotional experiences of young adults for 1 month. Findings indicated that those who experienced more positive emotions throughout the month showed increases in resilience and life satisfaction. Interestingly, the link between positive emotions and increased life satisfaction was mediated by increases in resilience. These results reveal that experiences of positive emotions help people improve life quality by building resilience, a key psychological resource.

## **Resilience**

Resilience is characterized by effective coping despite significant loss, hardship, or adversity in one's life (Block & Kremen, 1996; Cicchetti & Tucker, 1994; Luthar, 2003; Masten, 2001) and it is an important consequence of positive emotions. Research shows that resilience is comprised of both state and trait characteristics. When faced with adversity, "low-resilient individuals" are more easily thwarted and are less efficient in returning to normative levels of

functioning in their daily lives. In contrast, when either mildly disrupted or faced with significant adversity, “high-resilient individuals” have an ability to change course efficiently, allowing them the flexibility needed to adapt to stress-inducing disturbances in their lives.

To examine trait differences in resilience, Tugade and Fredrickson (2004) examined patterns of cardiovascular recovery from negative emotional arousal among low- and high-resilient individuals. Participants were asked to prepare a self-relevant speech, which they believed would be videotaped for evaluation; this task reliably and robustly induced subjective reports of anxiety. In addition to increasing self-reports of anxiety, the speech preparation task induced cardiovascular arousal for all participants. Two important differences in trait resilience emerged. First, high-resilient (versus low-resilient) individuals were more likely to report experiencing positive emotions, such as interest, alongside their self-reported anxiety. Second, when informed that they would not have to give their speech, high-resilient participants evidenced faster cardiovascular recovery from the arousal, reflecting the ability to physiologically “bounce back” from stress. Mediation analyses revealed that the experience of positive emotions contributed to high-resilient participants’ abilities to achieve accelerated cardiovascular recovery from negative emotional arousal (Tugade & Fredrickson, 2004). These findings suggest that high-resilient individuals make use of positive emotions to cope with stress (Tugade & Fredrickson, 2004, 2007; Tugade, Fredrickson, & Barrett, 2004).

Trait resilient individuals also benefit from the ability to self-generate positive emotions in the midst of a national catastrophe, such as the September 11, 2001 attacks on the United States (Fredrickson et al., 2003). Compared to low-resilient individuals, high-resilient individuals evidenced: (1) lower levels of self-reported depressive symptoms, and (2) greater post-crisis growth (more self-reported optimism, life satisfaction, and tranquility) in the aftermath of the September 11 attacks. Notably, more frequent experiences of positive emotions in the midst of tragedy mediated the relations between trait resilience and these outcomes of lesser depression and more post-crisis growth. These findings indicate that positive emotions are the active ingredients that predict the healthy responses of resilient individuals in the face of threat and adversity (Tugade et al., 2004). Other longitudinal studies have also shown that the ability to generate positive emotions can be beneficial for coping with adverse experiences such as the death of a loved one, illness, violence, national disaster, or caregiving for a loved one with chronic illness (e.g., Bonanno, 2004, 2005; Bonanno, Papa, & O’Neill, 2001; Bonanno et al., 2002). For example, there is growing evidence for the salutary nature of positive emotions in the bereavement process. Behavioral markers of positive emotional experience, such as smiling and laughing while discussing a recent loss of a loved one, are associated with better adjustment over time and stronger social relationships (Bonanno & Keltner, 1997; Keltner & Bonanno, 1997). Experiences of positive emotions have long-lasting consequences for individuals, helping them to build resilience in the face of daily and ongoing stressors and have important implications for future research and practice.

Consistent with the observation that high-resilient individuals benefit from cultivating positive emotions to cope with stress and adversity, laboratory experiments document that positive emotions serve to rapidly downregulate, or “undo” negative emotional experiences. Specifically, when participants induced to feel anxiety (e.g., using the speech-preparation task



described earlier) were randomly assigned to turn their attention to a film that elicited one of two positive emotions (contentment, mild joy), a negative emotion, or a neutral state, those experiencing either of the positive emotions showed significantly faster cardiovascular recovery from negative emotional arousal (Fredrickson, Mancuso, Branigan, & Tugade 2000; see also Fredrickson & Levenson, 1998).

Evidence that positive emotions undo the physiological arousal generated by negative emotions also suggests that they may restore depleted ego resources important for self-regulation. Ego depletion refers to the idea that self-regulation is a limited resource that can be diminished when engaging in activities that require self-control or willpower impairing one's self-control in subsequent situations (Muraven, Tice, & Baumeister, 1998). Across four studies, researchers found that positive (vs. neutral or sad) emotion improved self-regulation (e.g., task persistence, physical stamina) following ego depletion (Tice, Baumeister, Shmeuli, & Muraven, 2007).

In sum, a considerable amount of research has been conducted demonstrating that, in the short term, positive emotions broaden multiple forms of attention and cognitive processes. Likewise, from infancy through adulthood, positive emotions also build long-term resources ranging from infant attention to resilience. From the proliferation of studies, our understanding of the functions of positive emotions has considerably broadened and expanded. Yet, to build even greater knowledge about these effects of positive emotions—the broaden effect and the build effect—a number of questions still remain, particularly those related to underlying mechanisms.

## FUTURE DIRECTIONS

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Here we outline promising future directions, starting with questions related to the underlying mechanisms of broaden and build effects. Specifically, to the extent that positive emotions broaden attention and spark cognitive changes, how does such expanded awareness lead to decision-making or action? Likewise, how do positive emotional experiences lead to the development of long-term resources?

### **Neural mechanisms and correlates of broaden and build effects**

Affective neuroscience represents a key approach to investigating how emotion is represented and embodied in the brain and provides a promising framework with which to probe questions about underlying mechanisms. Specifically, if positive emotions broaden attention and spark cognitive flexibility, what processes are involved and are they associated with decision-making or action? Likewise, how do positive emotional experiences lead to the development of long-term resources? If positive emotions fuel broadened effects on cognition and stimulate enduring mental shifts, how does this build new, long-term resources?

We propose that mechanisms underlying the link between broaden and build effects, in part, include the generation of new learning and response-outcome contingencies, or more precisely, thought-outcome contingencies. Specifically, positive emotions broaden thought-action repertoires, stimulating novel and innovative thought-outcomes, and potentially,

response-outcome contingencies. Momentary experiences of positive emotions may strengthen associations such that individuals accumulate an increase in the quantity and variety of positively conditioned associations. This may result in more engagement in the environment, affording greater contact with sources of potential and actualized rewards. In contrast to an accumulated learning history in which the actions of depressed individuals do not result in positive reinforcement, and do not accumulate and build over time (Ferster, 1973, 1981; Lewinsohn, Biglan, & Zeiss, 1976), we propose that positive emotions fuel an accumulated learning history in which broadened thoughts and actions lead to highly reinforcing contingencies. This accumulated history of positively reinforced contingencies may be a critical mechanism linking broadened thinking to decision-making, and ultimately to the build effect of long-term resources. In sum, the link between momentary broaden effects of positive emotions and the build effect on long-term resources may be partially mediated by reward-associated learning contingencies and related neural circuitry.

Moreover, novel outcomes generated by broaden effects may prime individuals to accumulate more rewarding outcomes. As previously described, Wadlinger and Isaacowitz (2006) reported that, compared to controls, participants in positive moods demonstrated greater broadened effects of attention as evidenced by longer gaze fixations and eye movements toward the periphery of pictorial stimuli. Similarly, these participants demonstrated greater broaden effects to positive versus negative and neutral images, suggesting that positive moods may have sensitized them to rewarding stimuli. Therefore, under conditions of positive mood, thresholds to experience broaden effects on attention may be reduced, facilitating more elaborate processing of information. This may also reflect incentives to maintain and create even greater degrees of expansion and broadened attention.

Activation of critical neurotransmitter systems such as dopamine may also account for and mediate relations between broaden and build effects. For example, an increase in dopamine production may be a key mechanism linking the enhancing effect of positive affect on cognitive flexibility (Ashby et al., 1999). Dopamine activity appears to have reward functions and varies in levels of magnitude and probability. Based on reinforcement learning principles, Schultz (1998, 2010) states that the specific reward delivery (e.g., magnitude, probability) is coded in the dopamine response as a prediction error. A reward that is better than predicted elicits activation (positive prediction error), whereas one that is fully predicted elicits no activation (no response), and one worse than predicted induces a reduction (negative prediction) (Schultz, 2010). Therefore, dopamine neurons only respond when the rewards are better than predicted. Consequently, only increasing rewards will provide continued reinforcement via dopaminergic mechanisms. This may impact our need for rewards fueling cumulative experiences of positive emotions and accumulated histories of thought-contingent and response-contingent behavior, which over time may build long-term resources.

This raises intriguing questions with respect to the broaden effect: Is it possible that the experience of positive affect broadens attention and cognitive flexibility only when the experience and reward is better than predicted? Is dopamine activation and, specifically, a positive prediction error, a necessary correlate of the broaden effect? We propose that rewards that are better than expected and corresponding dopamine activation may be associated with novelty and creativity. Consequently, if dopamine activation only occurs under

conditions when the reward is better than expected, this may be an important correlate of the broaden effect.

To further probe neural mechanisms and regions correlated with broadened thinking and decision-making or action, regions of interest may include the nucleus accumbens, which may modulate subsequent behavior in terms of gain seeking behavior, and the orbitofrontal cortex (OFC) which computes reward magnitude and expected reward value and can represent outcomes and expected outcomes (Rolls & Grabenhorst, 2008). However, the OFC does not represent actions such as motor responses or movements (Rolls & Grabenhorst, 2008), but information from the OFC can contribute to action-outcome learning implemented in the anterior cingulate cortex (Rushworth, Behrens, Rudebeck, & Walton 2007). Thus, with respect to reward processing, cortical-basal ganglia circuitry is critical (Haber & Knutson, 2010). Further research is needed to examine the role of the cortical-basal ganglia loops in reward-related goal-directed behavior as it may be a promising avenue for probing underlying mechanisms of thought–action repertoires.

Likewise, investigating processes at the interface of cognition and reward may help elucidate potential neural correlates and targets of build effects, particularly during sensitive periods of development such as adolescence. Indeed, prior research has demonstrated increased proliferation of synapses in the prefrontal cortex during adolescence along with significant reductions in gray matter, which are associated with significant improvement in cognitive control and flexibility (Giedd et al., 1996). In early adolescence, participants show increased activation in the prefrontal cortex suggesting greater effort and recruitment of this region for cognitive control, yet demonstrate less efficiency in performance (Luna, Thulborn, & Munoz, 2001). Conversely, reward systems are highly activated as evidenced by greater reward seeking, and difficulties delaying reward obtainment, along with differences in regions recruited during reward processing (Dahl, 2004; Geir & Luna, 2009). This protracted development of the cognitive control system coupled with heightened reward seeking renders adolescents vulnerable to significant risk-taking and mortality (Dahl, 2004). Therefore, is it possible that positive emotional experiences may yield build effects by facilitating the development and interconnectivity of these systems during this heightened period of neural plasticity (e.g., reorganization of neural pathways based on experience)? If so, would positive affect interventions designed to promote cognitive control at the interface of cognition and reward demonstrate build effects? Investigations of internal and externally driven influences utilizing affective neuroscience methods to probe potential neural mediators and moderators of build effects are urgently needed.

### **Distinct positive emotions, social transmission, and embodied cognition**

With advancements in the field of positive emotions, emerging theory and research point to the need to examine differentiation amongst distinct positive emotions. Current emotion theories indicate that positive emotions can be uniquely classified based on form and function (e.g., Ellsworth & Smith, 1988; Fredrickson, 1998, 2001; Keltner & Shiota, 2003; Smith, 1991), unique patterns of behavioral displays (e.g., posture, voice, touch, and gaze; Keltner & Shiota, 2003), and distinct motivational functions (e.g., Smith, 1991; Izard, 1977; Keltner & Haidt,

2003). For instance, elevation predicts altruistic behavior, above and beyond feelings of happiness or amusement (Schnall, Roper, & Fesler, 2009). A nuanced examination of distinct positive emotions may reveal how positive emotions broaden and build in different ways (Fredrickson, 1998, 2001), and provide important information about these specific affective experiences.

Other research may investigate novel ways that positive emotions can “broaden” and “build” by investigating whether and how positive emotions contribute to different forms of psychological expansion, such as social transmission. The concept of social transmission or “virality” indicates that ideas, behavior, and phenomena may spread over time from one person to another via immediate or more distant social connections (Berger & Milkman, 2012). Research on emotional contagion, for instance, shows that positive emotions can transfer across people’s social networks, having a “ripple effect” of positive emotions. As demonstrated in a 20-year longitudinal study, positive emotions (e.g., happiness) can spread between individuals, thereby forming clusters of such people within a social network. According to this research, one possible explanation is that positive emotions depend on the positive emotions of others with whom people interact (Fowler & Christakis, 2008). Understanding the mechanisms that explain this “ripple effect” will require additional empirical investigation.

The study of positive emotions may also add to growing area of research that focuses on embodied cognition (e.g., Barsalou, 2008; Niedenthal, 2007). Theories of embodied cognition posit that sensory and motor re-experiencing (i.e., “embodiment”) occurs when one perceives emotion via processes such as reading affective words, recalling affective memories, or observing affective facial expressions. Research has shown that people express slight (imperceptible) smiles and frowns (e.g., activity in the zygomaticus major and corrugator supercilii muscles, assessed via facial electromyography) when presented with subliminal happy or angry faces (Dimberg, Thunberg, & Elmehed, 2000), suggesting that emotions can be embodied even outside of one’s awareness.

Related theories of embodied cognition focus on the sensory-rich experiences reflected in common emotion metaphors. For instance, a study showed that those experiencing social inclusion (e.g., recalling a time when they felt included by others) estimated higher room temperatures, thereby embodying the “warm reception” of social acceptance. In contrast, those experiencing social exclusion (e.g., recalling a time when others left them out) estimated lower temperatures in the same room, thereby embodying the “cold chill” of social rejection (Zhong & Leonardelli, 2008). When considering the embodiment of positive emotions, several new questions may be tested. Metaphorically, positive emotions help individuals to “look on the bright side.” In line with theories of embodied cognition, does activating positive emotion produce sensory experiences of brightness or clarity? This might help explain why people who report greater positive emotional experiences show selective attentional patterns toward positive images (Isaacowitz, 2005), which has been shown to promote adaptive outcomes in emotion regulation (Wadlinger & Isaacowitz, 2006).

Similarly, a common metaphor—“the burden has been lifted”—describes the experience of relief once a stressful experience has passed. Might experiencing positive emotions influence perceptions of lightness in heavy objects? If an important problem has been successfully

managed, then positive emotions may be useful for easing efforts and re-energizing an individual once a stressor has passed. Theories of embodied cognition reveal how representations of emotional states may be grounded in sensory-motor processes (Barsalou, 2008; Niedenthal, 2007). Research endeavors that investigate positive emotions and embodied cognition may have important implications for understanding how positive emotions and the broaden and build effects are represented in one's body, mind, and brain. Individual differences in these effects will be important to explore as they have the potential to enhance our understanding of personally salient aspects of positive emotions and ways to personally tailor interventions and practices designed to enhance positive emotions and promote long-term resources.

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## SUMMARY

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Evidence regarding the form and function of positive emotions has grown substantially in the last decade, with data accumulating to support key tenets of the broaden-and-build theory. Specifically, positive emotions have been shown to broaden and expand our attention, fueling novel approaches to thought and action. Over time, positive emotions “add up” leading to the long-term build effect on consequential personal resources. In addition, positive emotions likely build resources through non-linear and indirect trajectories. Investigating these trajectories will be critical to furthering our understanding of how experiences of positive emotion reverberate and multiply, leading to growth and adaption within a dynamic system with effects that span well beyond initial conditions (VanderVen, 2008). Applications to enhance positive emotions could spur the development of resources with far-reaching effects. Indeed, the empirical foundation has been laid for further and more nuanced investigations of positive emotional experiences and the numerous functions they may serve.

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