Overview

Emotion and perception: the role of affective information

Jonathan R. Zadra and Gerald L. Clore*

Visual perception and emotion are traditionally considered separate domains of study. In this article, however, we review research showing them to be less separable than usually assumed. In fact, emotions routinely affect how and what we see. Fear, for example, can affect low-level visual processes, sad moods can alter susceptibility to visual illusions, and goal-directed desires can change the apparent size of goal-relevant objects. In addition, the layout of the physical environment, including the apparent steepness of a hill and the distance to the ground from a balcony can both be affected by emotional states. We propose that emotions provide embodied information about the costs and benefits of anticipated action, information that can be used automatically and immediately, circumventing the need for cogitating on the possible consequences of potential actions. Emotions thus provide a strong motivating influence on how the environment is perceived. *WIREs Cogn Sci* 2011 2 676–685 DOI: 10.1002/wcs.147

INTRODUCTION

To scientists who study perception as well as to those who study emotion, the idea that emotion routinely alters perception may seem completely foreign. Most of us assume quite reasonably that as we look at a hill, for example, the steepness of the incline in our visual image is more or less the steepness of the hill in the world. The reality, however, is that the incline is far less steep than it appears (most people perceive a 5° hill to be 20° or more).[1,2] Moreover, our perception of the steepness will change from one occasion to the next depending on our mood.[3] For example, when we are feeling sad, we will perceive the hill to be steeper than when we are feeling happy. Such findings indicate that the perception of spatial layout is in fact influenced by non-optical factors, including emotion.

In this article, we review evidence of a variety of emotional influences on visual perception. Rather than a single, general mechanism that explains them all, a number of processes appear to be involved. Thus, we discuss candidate explanations as we review specific findings. The emotional phenomena discussed include effects on early visual processes, global versus local perceptual focus, susceptibility to visual illusions, and perceptions of natural environments. In addition, as emotions have both bodily and motivational components, we also touch on perceptual influences of bodily and motivational states. For example, both emotion and motivation appear to prepare the visual system to detect relevant aspects of the environment by making them easier to see.[4,5] And both emotional and bodily states appear to regulate visual perception of spatial layout. We propose a functional view in which emotional influences on perception can be seen as evolving in the interest of minimizing negative and maximizing positive outcomes, a view consistent with the 'affect-as-information' hypothesis.[6,7] More generally, we propose that emotion influences perception in the interest of resource maintenance.

The reader will note that, although this article concerns emotion and perception, we consider only emotional influences on perception and not the reverse. However, it should be understood that perception is also fundamental to emotion. Indeed, many emotions arise immediately upon the perception of emotionally evocative stimuli, some requiring more interpretation (rising gas prices) and some less (snakes, spiders). But exploration of those phenomena requires a separate treatment (for a review of relevant conceptions, see Ref 8).

*Correspondence to: gclore@virginia.edu

Department of Psychology, University of Virginia, Charlottesville, VA, USA

DOI: 10.1002/wcs.147

FEAR AND ORIENTATION DISCRIMINATION

Emotional arousal guides attention so that people's attention tends to be drawn to objects that are arousing. Indeed, some years ago, Herbert Simon[9] proposed that a chief function of emotion is to interrupt and reorder processing priorities. Thus, even the most avid chess player is likely to stop his game upon noticing that his house is on fire. As we shall see, some of the important influences of emotion on perception are mediated by attention, but emotion can also influence pre-attentive perceptual processes. This fact was discovered by Phelps, Ling, and Carrasco[10] using an orientation discrimination task. The task consisted of showing four sinusoidal gratings simultaneously, in which three of the patterns (distracters) were oriented vertically and one (the target) was tilted 8° clockwise or counter-clockwise. The grating contrast levels were varied on each trial. Participants were to locate the target as quickly as possible. The patterns were preceded by a rapidly presented face displaying either a fearful or a neutral expression. The logic of the experiment was that if emotion enhances perception, discrimination should improve following exposure to a fearful face. The results supported that hypothesis: contrast sensitivity at threshold improved by 1% following a fearful face. Examples of stimuli at the contrast thresholds for the fearful and neutral groups are shown in Figure 1 along with the fearful and neutral faces (which show the psychologist Paul Ekman posing the two expressions).

In a second experiment, the authors[10] asked whether emotion had really changed perceptual sensitivity or whether instead the fearful and neutral faces had differentially influenced covert attention. To find out, they took attention out of the equation by presenting the fearful or neutral face in the same quadrant as the subsequent target grating would appear (instead of in the middle of the screen as in Experiment 1). But again, exposure to a fearful face increased contrast sensitivity, even though attentional shifts were no longer involved. Hence, the authors could conclude that,[10]

> ...the mere presence of a fearful face increased contrast sensitivity.... [and] Emotion actually affects how people see.

In addition, they found that the facial expressions had to be emotionally meaningful—if the faces were inverted, the effect disappeared.

The authors proposed that this effect is probably the result of feedback from the amygdala to the early visual cortex, as well as to regions that enhance attention. The amygdala responds to significant stimuli, including fearful faces, rapidly and prior to awareness. A fearful face indicates that there may be a threat in the environment, but it gives no information as to its form or location, so enhanced contrast sensitivity might aid in detecting the threat.[10]

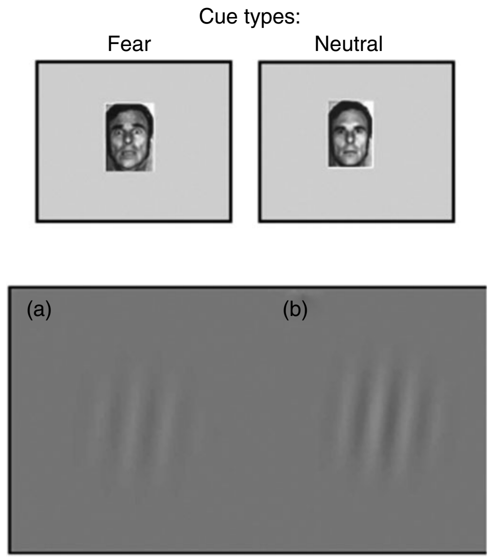

FIGURE 1 | The impact of emotion and attention on perception. The gratings shown represent the contrast threshold (i.e., the contrast necessary to perform the orientation discrimination task at 82% accuracy) in each condition: (a) fearful face, peripheral cue (b) neutral face, peripheral cue.

Other research shows that high-level goals can also influence the responsivity of the amygdala to affective stimuli. The amygdala is believed to respond to affective stimuli more or less automatically, but evidence shows that responses depend on the current relevance of affective stimuli.[11] In an imaging study, participants were asked to rate either the positive or negative aspects of 96 famous names (Adolph Hitler, Paris Hilton, Mother Theresa, George Clooney). The results showed that when evaluating positive aspects, the amygdala responded only to the names of people that a given participant liked, and when evaluating negative aspects, the amygdala responded only to the names of disliked people. Thus, the automatic affective reactions of the amygdala were guided by the current goal of the individual. It is unclear whether the amygdala itself filtered information for motivational significance or whether top-down processes did so before information reached the amygdala. But the results encourage a view of the brain in which high- and low-level processes continually interact—a view within which it becomes less surprising that emotion can affect perception.

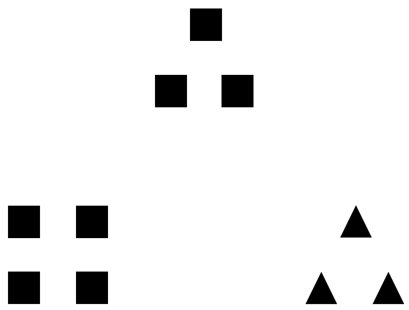

FIGURE 2 | A sample item from the Kimchi and Palmer[18] test of global–local focus. The task is to match the target figure at the top with the comparison figure at the bottom that is most similar.

MOOD AND GLOBAL–LOCAL PERCEPTION

People sometimes say that a person 'can't see the forest for the trees'. In doing so, they imply an incompatibility between perceptions of details and perceptions of wholes. Some conditions encourage global perception and some encourage local perception, but people generally show a tendency to process globally. This is apparently not true of autistic individuals[12] or of individuals in certain cultures[13] who more readily see local details.

Emotion also influences whether people focus on the forest or the trees. After hitting his head during a parachute jump, the psychologist Easterbrook[14] noted that his spatiotemporal field seemed to shrink.[15] With this experience in mind, he later proposed that stress narrows atttention. Fifty years later, many findings support this idea as well as the extension that positive emotion broadens attention.[16,17] Relevant research sometimes employs standard tests to measure global and local perception. On the Kimchi test, respondents are shown a target geometric figure and asked which of two comparison figures is most similar to it.[18] As shown in Figure 2, the target might be three small squares arranged in the overall shape of a triangle. People then choose which of two comparison figures is most similar. One comparison figure is a triangle composed of small triangles, and the other is a square composed of small squares. A local response would be to choose the figure with squares, because the target figure had been composed of squares. A global response would to choose the figure with triangles, because the overall shape of the target figure had been a triangle. When investigators induce happy or sad moods (e.g., by having participants spend a few minutes writing about a happy or sad event from their lives), participants in happy moods often adopt a global perceptual style, whereas those in sad moods adopt a local perceptual style.[19]

Another standard method, the Navon procedure, involves measuring reaction times to large or small letters.[20] For example, a large 'L' might appear made up of many smaller 'Ts'. Respondents might be asked to indicate as quickly as possible whether they see an 'L' on a given trial. Comparing the reaction times to detect letters appearing as global stimuli and those appearing as local stimuli yields a measure of whether global or local perceptual styles are dominant.

Some research findings using this measure suggest that although global processing occurs in generic positive moods, states in which a specific object elicits approach motivation (e.g., hope) can lead to local rather than global responses.[21] Still other research findings suggest that rather than a dedicated relationship between affect and perceptual style, positive affect may facilitate and negative affect may inhibit whatever orientation is most accessible in a given situation. In many situations, a global focus is dominant,[20] a tendency sometimes called the 'global superiority effect'. It is possible, then, that affect influences whether one focuses on the global forest or on the local trees simply because positive affect says 'yes' and negative affect says 'no' to the (generally more accessible) global focus. A test of that hypothesis used cognitive priming techniques to alter whether a global or a local orientation was momentarily more accessible.[22] The results showed that when local responding was made especially accessible, the usual result was reversed. Positive affect then led to a focus on details and sad moods to a focus on the big picture. It appears, therefore, that positive affect may facilitate whatever the dominant orientation is rather than being specifically tied to a global focus. Thus, whether one focuses on the global forest or the local trees is indeed influenced by one's current emotional state. However, rather than reflecting a direct connection to perception, these data indicate that positive affect can empower (and negative affect can inhibit) either a big or a small view, depending on which is dominant in a given situation.

MOOD AND THE EBBINGHAUS ILLUSION

The tendency for negative affect to lead to a local perceptual style is also evident in research on visual illusions. For example, the Ebbinghaus illusion (Figure 3) involves a visual contrast effect in which the same target circle appears smaller when surrounded by big circles and bigger when surrounded by small circles. The illusion is very compelling, but recent research shows that sad moods reliably reduce the

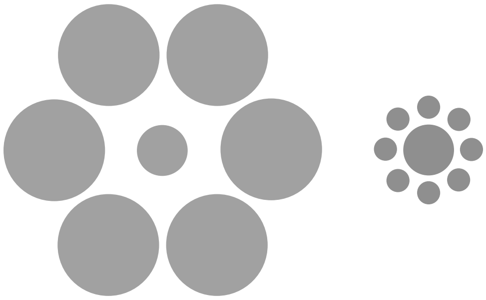

FIGURE 3 | The Ebbinghaus Illusion. The circles in the middle of these two figures are the same size, but in their respective contexts, the one on the left looks smaller than the one on the right.

effect.[23] In the same research, sad moods were found to reduce context effects and increase the accuracy of judgments of the temperature of lukewarm water after exposure to hot or cold water and of the weight of a 1-kg box after lifting a heavier box.

A similar tendency for sad mood to lead to the exclusion of contextual stimuli is evident in studies of semantic priming.[24] Whereas people are usually slightly faster to identify words after a brief exposure to a word similar (compared to dissimilar) in meaning, this does not occur for individuals in induced sad moods, even though such mild states do not slow responding overall. This phenomenon is interesting in the current context because it suggests that emotional factors may have similar effects on perceptual and conceptual processes. Explanations have stressed that sad moods interfere with the usual *relational processing* (processing incoming information in relation to current mental context), leading to item-specific or *referential processing*.[24] That explanation is also compatible with the idea that negative affect narrows attention.[15,16]

EMOTION AND ATTENTION

The studies we have reviewed show that emotional and motivational factors can regulate global versus local orientations to visual stimuli and whether or not perception includes or excludes contextual stimuli. But, as noted above, the same is also true when the stimuli are conceptual rather than sensory. For example, individuals feeling happy are more likely to use stereotypes and other categorical information when forming impressions of others. By contrast, when forming impressions, people feeling sad focus on behavioral or other detailed information and tend not to use global categories.[25–27] Such results may indicate that the influences of affect on global–local perception and conception are mediated by attention.

Attention is sometimes thought of as a spotlight that directs limited processing resources to the most relevant stimuli.[28,29] If affect signals value[30] or motivational significance,[31] then we might expect affect to influence attention. For example, activating an affective attitude leads to attitude-consistent judgments[32] by biasing attention toward attitude-relevant stimuli.[33]

Studies examining the role of emotion in attention have sometimes employed a spatial probe task for measuring attention. In the spatial probe task, two words are presented briefly in different locations followed by a dot probe in one of the locations. If an emotion-relevant word attracts attention, the dot appearing in that location will be detected faster than a dot appearing in the other location. Speed of response to the dot is thus a useful measure of selective attention.[32]

Some of the research using this technique has been conducted by clinical psychologists interested in the effects of anxiety. The general finding is that fear and anxiety bias attention toward threatening stimuli, including words and pictures.[34,35] Selective attention may thus serve to facilitate the processing of threat information.[28] But of course, if affect governs attention and attention in turn governs affect, then when affect draws people's attention to possible dangers, it is likely to induce stress and anxiety.[36]

Positive affective reactions signal opportunities rather than dangers, raising the question of whether positive affect also directs attention. Indeed, evidence from dot probe studies indicates that positive moods bias attention toward positively valued stimuli.[37] As a result, positive affect should make rewards easier to detect, just as anxiety facilitates threat detection. Of course, attending to the upside, rather than the downside, of events is also likely to elevate mood and subjective well being.

TOP-DOWN EFFECTS OF MOTIVATION AND EMOTION

Vigilance

Traditionally, the study of perception has stressed low level, bottom-up visual processes. But research suggests that higher level processes may play a role as well. A recent study demonstrated top-down effects of emotional information on face perception.[38] The study involved a binocular rivalry task, in which a different image is presented to each eye—for instance, a face and a house. In that task, only one image is consciously experienced at a time, and which image is seen tends to alternate every few seconds. The images essentially compete for dominance, the more important or relevant image being perceived relatively longer. In this experiment, faces became more dominant in the rivalry task after being paired with descriptions of negative social information, such as, that the person lied, stole, or cheated. The results suggest that gossip and other social information may tune the visual system, aiding in the detection of persons who should be avoided without requiring any direct negative experience with them. This idea that the emotional significance of objects may make them easier to see has a long and interesting research history, as we see next.

Goals

Years ago, the 'New Look' in perception proposed that perception should be influenced by motivation. For example, Bruner and Goodman[39] reported an experiment in which a sample of poor children from the Boston slums perceived coins to be larger than did children from wealthier Boston families. The same effect did not appear for similarly sized cardboard disks, leading the authors to conclude that motivation can influence perceptions of size, making motivationally relevant objects easier to see. At the time, the idea that visual perception, our window to objective reality, might be guided by subjective desires was seen as quite unacceptable. Moreover, when the New Look was elaborated to include predictions from Freudian theory, it was soundly rejected by many investigators.

But the basic hypothesis that motivation might affect perception has since been revisited. Recent evidence shows that, for example, people who are thirsty perceive a glass of water as taller than those who are not thirsty.[5] And when typically neutral goals, such as gardening, are made positive by pairing them with positive stimuli, tools associated with the goal (such as a shovel) appear larger.[5] Similarly, smokers deprived of cigarettes tend to overestimate the length of a standard cigarette.[40] Other findings also indicate that ambiguity in visual stimuli (e.g., a stimulus that could be seen either as the letter 'B' or as the number '13'), will tend to be resolved by seeing the stimuli in a way that leads to reward in an experimental situation.[41]

In related research, participants who had agreed to walk on their campus wearing a large, embarrassing sign underestimated the distance to be walked.[42] The authors reasoned that the misperception of distance was a way of reducing the cognitive dissonance of having freely chosen to engage in such an unpleasant action. Consistent with the original New Look logic, such data again suggest that goals can tune the visual system to see the world in motivationally consistent ways (for more on the social psychology of perception, see Ref 43). Whereas most of the emotional effects we have discussed have been evident only in limited, somewhat artificial laboratory settings, this experiment and the research to be discussed in the remainder of this review concern perception in the world.

SPATIAL PERCEPTION

Emotional effects in real-world environments may be more pervasive than most people realize. It is often assumed that one of the primary goals of the visual system is to recreate the environment, forming a representation in the brain that is as accurate as possible. However, research over the past 10 or 15 years has demonstrated that this is not the case. Rather than reproducing pictures inside the brain, research results indicate that what we perceive is a systematically altered version of reality. Part of what we 'see' is the opportunities for and costs of acting on the environment. For example, the ground is perceived relative to its walkability and to the bioenergetic costs that this action would incur. However, these nonvisual influences are not limited to energy-related factors: emotions too are a source of nonvisual information that affects visual perception. Moreover, the influences of such nonvisual information generally appear oriented toward such beneficial consequences as conserving energy, attaining goals, or avoiding danger.

In the following sections, we first review research showing the role of extra-visual influences in the perception of spatial layout. We then review research indicating that emotions may serve a similar function, and are integrated into perception in a similar manner.

BIOENERGETIC INFORMATION

When one leaves the gym fatigued, the distance between the gym and one's car may look greater than it did on the way in. The effect is not obvious, because we can be in only one state at a time and have no way of directly comparing how the environment looks in two different states. But if one's perception of the distance was assessed in a covert manner both before and after exercising, one might be surprised at the difference.

This example illustrates what might be called the 'bioenergetics' of perception. 'Bioenergetics' refers to the study of the flow and transformation of energy within an animal and between an animal and its environment. A substantial and growing body of research indicates that people integrate bioenergetic information into their perceptions of spatial layout (for reviews see Ref 44,45). For example, hills appear steeper and distances appear greater when metabolic energy is low or when the anticipated energy costs of climbing a hill or walking a given distance are increased.[45] Thus, people perceive hills to be steeper when they are fatigued, in poor physical condition, or anticipating greater effort,[1,2] and they also perceive distances to be greater when anticipating increased effort.[46,47] Some experiments manipulated the anticipated effort of climbing a hill by having participants wear a heavy backpack loaded with 20% of the participants' weight.[2] Compared to the estimates of control participants, the added weight of the heavy backpack increased estimates of the steepness of hills and of the distances to targets.

Prior experiments allowed us only to infer that bioenergetic factors were responsible for such perceptual changes. More recent research has directly assessed the role of bioenergetics in perceptions of spatial layout by manipulating blood glucose levels.[48] (Glucose is the primary source of energy for immediate muscular action, and the sole source of energy for the brain[49,50]).

Some participants were given a beverage sweetened with glucose, while others received a beverage with artificial sweetener. The results indicated that a mentally taxing task (shown to deplete blood glucose[51]) made a hill look especially steep for those given only an artificially sweetened drink, whereas an energy-rich, glucose-sweetened drink yielded perceptions of the slant that were not so exaggerated. A second experiment replicated these results, adding measures of individual differences on a host of bioenergetically relevant properties. Thus, in addition to the effects of experimentally induced variations in glucose, participants reporting fatigue, poor sleep quality, stress, and negative mood also perceived hills to be steeper. Across both glucose-manipulation groups, individuals with characteristics associated with a reduced energy state perceived the hill as steeper. These findings have recently been replicated for distances as well.[52]

Bolstering the earlier results, these studies confirm that bioenergetic information may be integrated directly into conscious visual perception. Why should that be the case? Such an arrangement seems sensible if we keep in mind that vision evolved to support survival, rather than to provide a geometrically accurate picture of the environment. For animals that must perform a careful balancing act between energy intake and energy expenditure in order to avoid starvation, conserving energy is critical, especially when reserves are low. An explicit cognitive computation of the running balance between available resources and anticipated costs would be impossible for most animals and prohibitively expensive in time and energy for humans. Alternatively, the relevant information might simply be incorporated directly into perception. The steeper a hill looks or the farther a distance appears, the less inviting climbing or traversing it becomes. The incorporation of bioenergetic information into visual perception could thus help the organism achieve an 'economy of action' effortlessly, unconsciously, and instantaneously.[44]

It should be noted that these effects occur only for *explicit* perception—perceptions of which we have conscious experience. In various experiments by Proffitt and colleagues, explicit perception is assessed by asking participants to verbally report the steepness of a hill in degrees or by performing visual-matching tasks. When assessed by such verbal or visual-matching measures, hills tend to seem steeper than they really are. But apparent steepness can also be assessed with a motoric measure, a palm board, in which a board is adjusted to match the incline of a hill by touch rather than by looking at the board. Unlike verbal and visual-matching response measures, motoric responses tend to be quite accurate. An explanation of this discrepancy emphasizes that vision supports two very different functions. Explicit perception incorporates a conscious motivating factor to economize action, whereas an implicit stream of visual information guides effective actions in the environment.[53] It may be adaptive for explicit perceptions of slant and distance to become inflated when resources are low in order to regulate the motivation for costly action. But it would not be adaptive for implicit perceptions also to become inflated, leading to motoric responses that were poorly calibrated with the environment (for an in depth discussion of this subject, see Ref 44,45].

It is reasonable to ask whether these and the many other observed effects on perception of spatial layout reflect actual perception, or are response biases (e.g., participants saying that the hill looks steeper even though it looks the same to everyone). Relevant evidence comes from several recent studies. First, indirect measures of perceived distance demonstrate effects consistent with perceptual changes but not explicable as post-perceptual response biases. For example, consider that objects within reach with a tool are reported as closer than the same objects out of reach when one lacks a tool (direct measure).[54] In this context, when a triangle is projected across the reaching boundary (such that the farthest point is within reach with a tool and beyond reach without one) the triangle appears shorter only to those reaching with a tool (converging indirect measure).[55] Second, it is the intended action of the perceiver that determines whether or not there will be a perceptual change. In a clear and decisive experiment, viewers were primed to expect to either walk to a target or throw a beanbag to a target by repeating several trials of one task.[47,56] Next, they walked on a treadmill for several minutes. This manipulation causes a recalibration of the relationship between walking effort and forward movement. For the few minutes following, it leads blindfolded participants to walk beyond an intended target location. In the experiment, after viewing the target, participants donned a blindfold and were instructed to blindwalk to the target. Thus, whereas all participants responded to the target in the same manner, they had viewed the target with different intentions. Those who had intended to walk exhibited the usual effect of the treadmill manipulation, walking farther than those who had viewed the target with the intent to throw. An additional experiment accounted for potential practice effects by repeating the procedure without the treadmill manipulation: there was no effect. Thus, it was clear that the perceptual change must occur at the time of viewing (perception), and not during the response (post-perceptual response bias).

EMOTION AND PERCEPTION OF SPATIAL LAYOUT

If post-workout fatigue alters one's perceptions when leaving the gym, how might a hill appear to someone who has to climb it on the way to work on a Monday morning when grumpy and unhappy about going to work? Would the same hill look different on a Friday when the sun is shining, the birds are chirping, and the person is happy about prospects for the impending weekend? If feeling exhausted affects perception, as indicated earlier, what about feelings of emotion? Following from the affect-as-information hypothesis,[6] we argue that affective information is integrated into visual perception in a similar manner. Just as information reflecting one's bioenergetic state is integrated into perceptions of the environment, information from one's emotions may also.

Affect As Information

The 'affect-as-information' hypothesis[6,7] is an account of the influence of affect, mood, and emotion on attention, judgment, and thought. It emphasizes the idea that affect provides information, and because the information is embodied, it is also motivating. Affective experiences are often characterized as having two dimensions, valence (pleasant vs unpleasant) and arousal (excited vs calm). According to the 'affect-as-information' account, pleasant–unpleasant feelings are embodied information about value (goodness vs badness), whereas excited-calm feelings are information about importance or urgency.[22,57]

Emotions are generally thought of as momentary states organized around perceptions that some event, action, or object is good or bad in some way.[58] Moods are also affective states, but whereas emotions are generally about something specific, the objects of moods, if any, are less salient. Rather than being a signal of something in the environment, moods often simply represent the state of the organism itself. Moods may thus provide information important for regulatory action. Thus, feeling listless, tired, or sad saps any motivation for enterprise or adventure; whereas feeling energetic, optimistic, or happy may lead one out of the safety of one's cave, home, or hotel room and into the world. Indeed, evolutionary biologist Randy Nesse[59] concludes that

> mood exists to regulate investment strategies, so that we spend more time on things that work, and less time on things that don't.

As we shall see, one way that mood and emotion can exercise this regulation is by influencing perceptions of spatial layout in a manner similar to that of bioenergetic information.

Sadness

A series of experiments[3] asked whether people feeling sad would perceive a hill to be steeper than people feeling happy. In some experiments, mood was induced by having people listen to either happy or sad music through headphones as they viewed a hill. In others, mood was induced by having people outline, with the intent of later writing a story about a happy or sad event in their lives. Not only did perceptions of the hill differ for the groups made happy or sad, as predicted, but variations of mood within the groups had significant effects as well. Thus, for participants in the sad group, those who were sadder perceived the hill as even steeper. In addition, the results showed that current mood state, rather than more general affective traits, was the specific factor that predicted changes in perception.

The aspect of mood that was important in this study[3] was valence rather than arousal. We suggest that the experience of unpleasant affect when looking uphill was experienced as a burden, as it produced effects similar to those observed when people made similar judgments while wearing a heavy backpack. Affect and emotion thus also appear to carry information about the energy costs of potential actions.

Emotional Information Transcends the Moment

A system in which perceptions are modulated by the energy available may be useful for making decisions about action. But this arrangement handles only decisions about currently visible obstacles. And as mood states may also reflect current resources, their role in decision making may also be limited. Emotions, on the other hand, are reactions to objects that need not be physically present. Absent objects may be represented symbolically so that they can be from the past, the future, or one's imagination. Emotions can thus inform decisions about a range of situations with long term as well as immediate implications.

Fear

Fear, on the other hand, concerns not one's current resources, but also the possibility of resource loss, a possibility leading to vigilance and caution. Whereas sadness influences perceptions of incline when hills are viewed from the bottom, fear might influence apparent steepness when hills are viewed from the top. To assess that possibility, some research participants were asked to estimate the slant of a hill in a state of mild fear induced by standing on a skateboard at the top of the hill (prevented from rolling by chocking the wheels).[60] Those in a control condition stood on a stable wooden box of equivalent dimensions. Standing on a wobbly skateboard as opposed to a stable box made the hill look steeper. Moreover, in both skateboard and box conditions, fear levels were positively correlated with perceptions of slant. It was known from prior research[1] that people generally perceive steep hills to be even steeper when viewing them from the top than from the bottom. In addition to differences in the visual angle involved in looking down versus up a hill, such overestimation may thus also involve some level of fear elicited by the possibility of falling down the hill.

The role of fear in perception of spatial layout was next assessed more directly by having people judge heights by looking down. The weak-in-the-knees, wobbly, suddenly lightheaded feeling that results from inching up to the edge of a high cliff or the roof of a building is one that probably everyone has experienced at some point. In relevant research, fearful individuals were found to overestimate the distance from a balcony to the ground, relative to non-fearful individuals.[61] Extreme fear of heights, acrophobia, is one of the most common phobias, and recent findings suggest that acrophobics may in fact perceive the world differently from the rest of us. People with acrophobia may get this feeling not so much as an overreaction to viewing heights as from perceiving heights to be greater than those of us without the phobia.

To assess this possibility, individuals who were either high or low in acrophobic symptoms were asked to look down from a balcony and estimate the distance to the ground.[61,62] As expected, participants in the group with high acrophobic symptoms perceived the height to be greater. A similar study in which emotional arousal was manipulated found that increased arousal led to still more elevated height perception.[63] That people perceive a height to be greater when viewed from above than from the ground is not new,[64] but these results imply that a fear of falling may be involved.

CONCLUSION

Traditionally, the study of perception has been quite distinct from the study of emotion. Psychologists have tacitly viewed perception, cognition, emotion, and other basic processes as separable phenomena to be studied in isolation. Increasingly, however, we are coming to see relevant areas of the brain and the processes they support as highly interactive.

Such interaction is clearly evident in the studies of emotion and perception reviewed in this article. Not only is it possible for emotion to influence perception, but also in fact it seems to happen quite frequently—across many levels of visual perception and in response to a variety of affective stimuli. Affective valence and arousal carry information about the value and importance of objects and events, and the studies we have reviewed indicate that such information is incorporated into visual perception of one's environment. Thus, we noted that fear increases the chances of seeing potential threats, that positive moods encourage one to maintain one's current way of looking at things, and that negative moods encourage a change. Research indicates also that objects in the environment with emotional and motivational relevance draw attention and may become more easily detected by appearing larger. We reviewed evidence that perception is systematically altered in ways that may aid goal attainment and that emotion can alter the perception of spatial layout to motivate economical action choices and deter potentially dangerous actions. The coupling of affect and perception in this way thus allows affective information to have immediate and automatic effects without deliberation on the meaning of emotionally evocative stimuli or the consequences of potential actions.

ACKNOWLEDGMENTS

Support is acknowledged from NIMH Research Grant RO1-MH050074 and NSF Research Grant 0518835 to Gerald Clore and NIH Research Grant R01MH075781 to Dennis Proffitt.

REFERENCES

1. Proffitt DR, Bhalla M, Gossweiler R, Midgett J. Perceiving geographical slant. *Psychon Bull Rev* 1995, 2(4):409–428.
2. Bhalla M, Proffitt DR. Visual-motor recalibration in geographical slant perception. *J Exp Psychol Hum Percept Perform* 1999, 25(4):1076–1096.
3. Riener CR, Stefanucci JK, Proffitt DR, Clore GL. An effect of mood on the perception of geographical slant. *Cogn Emotion* 2011, 25:174–182.
4. Bruner JS, Postman L. Emotional selectivity in perception and reaction. *J Pers* 1947, 16:69–78.
5. Veltkamp M, Aarts H, Custers R. Perception in the service of goal pursuit: motivation to attain goals enhances the perceived size of goal-instrumental objects. *Soc Cogn* 2008, 26:720–736.
6. Schwarz N, Clore GL. Mood, misattribution, and judgments of well-being: Informative and directive functions of affective states. *J Pers Soc Psychol* 1983, 45:513–523.
7. Schwarz N, Clore GL. Feelings and phenomenal experiences. In: *Social Psychology: A Handbook of Basic Principles*. 2nd ed. New York: Guilford Press; 2007, 385–407.
8. Clore GL, Ortony A. Appraisal theories: how cognition shapes affect into emotion. In: *Handbook of Emotions*. 3rd ed. New York: Guilford Press; 2008, 628–642.
9. Simon H. Motivational and emotional controls of cognition. *Psychol Rev* 1967, 74(1):29–39.
10. Phelps EA, Ling S, Carrasco M. Emotion facilitates perception and potentiates the perceptual benefits of attention. *Psychol Sci* 2006, 17(4):292–299.
11. Cunningham WA, Van Bavel JJ, Johnsen IR. Affective flexibility: evaluative processing goals shape amygdala activity. *Psychol Sci* 2008, 19:152–160.
12. Frith U. Autism: explaining the enigma. Oxford: Blackwell Scientific Publications; 1989.
13. Davidoff J, Fonteneau E, Fagot J. Local and global processing: observations from a remote culture. *Cognition* 2008, 108(3):702–709.
14. Easterbrook J. This week's citation classic. *Curr Contents* 1982, 12:20.
15. Easterbrook J. The effect of emotion on cue utilization and the organization of behavior. *Psychol Rev* 1959, 66(3):183–201.
16. Derryberry D, Tucker DM. Motivating the focus of attention. In: Niedenthal PM, Kitayama S, eds. *The Heart's Eye: Emotional Influences in Perception and Attention*. San Diego, CA: Academic Press; 1994, 167–196.
17. Fredrickson B. The role of positive emotions in positive psychology: the broaden-and-build theory of positive emotions. *Am Psychol* 2001, 56(3):218–226.
18. Kimchi R, Palmer SE. Form and texture in hierarchically constructed patterns. *J Exp Psychol: Hum Percept Perform* 1982, 8:521–535.
19. Gasper K, Clore GL. Mood and global versus local processing of visual information. *Psychol Sci* 2002, 13:34–40.
20. Navon D. Forest before trees: the precedence of global features in visual perception. *Cognit Psychol* 1977, 9(3):353–383.
21. Gable PA, Harmon-Jones E. Approach-motivated positive affect reduces breadth of attention. *Psychol Sci* 2008, 19:476–482.
22. Huntsinger JR, Clore GL, Bar-Anan Y. Mood and global-local focus: priming a local focus reverses the link between mood and global-local processing. *Emotion* 2010, 10:722–726.
23. Aramova YR, Stapel DA, Lerouge D. Positive mood increases and negative mood decreases the effect of context on perception. *J Pers Soc Psychol* 2010, 99(2):203–214.
24. Storbeck J, Clore GL. The affective regulation of cognitive priming. *Emotion (Washington, DC)* 2008, 8:208–215.
25. Bless H, Schwarz N, Kemmelmeier M. Mood and stereotyping: affective states and the use of general knowledge structures. In: *European Review of Social Psychology*. 7th ed. Chichester: John Wiley & Sons; 1996, 63–93.
26. Bodenhausen GV. Emotions, arousal, and stereotypic judgments: aheuristic model of affect and stereotyping. *Affect, Cognition, and Stereotyping*. San Diego: Academic Press; 1993, 13–37.
27. Isbell L. Not all happy people are lazy or stupid: Evidence of systematic processing in happy moods. *J Exp Soc Psychol* 2004, 40:341–349.
28. Posner MI. *Chronometric explorations of mind*. Hillsdale, NJ: Erlbaum; 1978.

29. Treisman A. Strategies and models of selective attention. *Psychol Rev* 1969, 76(3):282–299.
30. Clore G, Huntsinger J. How emotions inform judgment and regulate thought. *Trends Cogn Sci* 2007, 11(9):393–399.
31. Kitayama S, Niedenthal PM. Introduction. In: Niedenthal PM, Kitayama S, eds. *The Heart's Eye: Emotional Influences in Perception and Attention*. San Diego, CA: Academic Press; 1994, 1–14.
32. Navon D, Margalit B. Allocation of attention according to informativeness in visual recognition. *Q J Exp Psychol A* 1983, 35(3):497–512.
33. Roskos-Ewoldsen D, Fazio R. On the orienting value of attitudes: attitude accessibility as a determinant of an object's attraction of visual attention. *J Pers Soc Psychol* 1992, 63(2):198–211.
34. MacLeod C, Mathews A. Anxiety and the allocation of attention to threat. *Q J Exp Psychol* 1988, 38:659–670.
35. Williams J, Watts F, MacLeod C, Mathews A. *Cognitive psychology and the emotional disorders*. 2nd ed. Chichester, England: John Wiley & Sons; 1997.
36. MacLeod C, Rutherford E, Campbell L, Ebsworthy G, Holker L. Selective attention and emotional vulnerability: assessing the causal basis of their association through the experimental manipulation of attentional bias. *J Abnorm Psychol* 2002, 111(1):107–123.
37. Tamir M, Robinson M. The happy spotlight: positive mood and selective attention to rewarding information. *Pers Soc Psychol Bull* 2007, 33(8):1124.
38. Anderson E, Bliss-Moreau E, Barrett LF. The visual impact of affective information. *Psychol Sci*. in press.
39. Bruner JS, Goodman CC. Value and need as organizing factors in perception. *J Abnorm Soc Psychol* 1947, 42:33–44.
40. Brendl CM, Markman AB, Messner C. The devaluation effect: activating a need devalues unrelated objects. *J Consum Res* 2003, 29:463–473.
41. Balcetis E, Dunning D. See what you want to see: motivational influences on visual perception. *J Pers Soc Psychol* 2006, 91(4):612.
42. Balcetis E, Dunning D. Cognitive dissonance and the perception of natural environments. *Psychol Sci* 2007, 18(10):917–921.
43. Balcetis E, Lassiter GD, eds. *The Social Psychology of Visual Perception*. New York: Psychology Press; 2010.
44. Proffitt DR. Embodied perception and the economy of action. *Perspect Psychol Sci* 2006, 1(2):110–122.
45. Proffitt DR. An action specific approach to spatial perception. In: Klatzky RL, MacWhinney B, Behrmann M, eds. *Embodiment, Ego-Space, and Action*. New York: Psychology Press; 2008.
46. Proffitt DR. Distance perception. *Curr Dir Psychol Sci* 2006, 15:131–135.
47. Witt JK, Proffitt DR, Epstein W. Perceiving distance: a role of effort and intent. *Perception* 2004, 33(5):577–590.
48. Schnall S, Zadra JR, Proffitt DR. Direct evidence for the economy of action: glucose and the perception of geographical slant. *Perception*. in press.
49. Benton D, Parker PY, Donohoe RT. The supply of glucose to the brain and cognitive functioning. *J Biosoc Sci* 1996, 28(4):463–479.
50. Gailliot MT, Baumeister RF. The physiology of willpower: linking blood glucose to self-control. *Pers Soc Psychol Rev* 2007, 11(4):303–327.
51. Gailliot MT, Baumeister RF, DeWall CN, Maner JK, Plant EA, Tice DM, Brewer LE, Schmeichel BJ. Self-control relies on glucose as a limited energy source: willpower is more than a metaphor. *J Pers Soc Psychol* 2007, 92(2):325–336.
52. Zadra JR, Weltman AL, Proffitt DR. The physiology of distance perception. in preparation.
53. Milner AD, Goodale MA. *The Visual Brain in Action*. 2nd ed. Oxford; New York: Oxford University Press; 2006.
54. Witt JK, Proffitt DR, Epstein W. Tool use affects perceived distance, but only when you intend to use it. *J Exp Psychol Hum Percept Perform* 2005, 31(5):880–888.
55. Witt J. Tool use influences perceived shape and perceived paralelism, which serve as indirect measures of perceived distance. *J Exp Psychol Hum Percept Perform*. in press.
56. Witt JK, Proffitt DR, Epstein W. When and how are spatial perceptions scaled? *J Exp Psychol Hum Percept Perform* 2010, 36(5):1153–1160.
57. Storbeck J, Clore GL. Affective arousal as information: how affective arousal influences judgments, learning, and memory. *Soc Pers Psychol Compass* 2008, 2:1824–1843.
58. Ortony A, Clore GL, Collins A. *The Cognitive Structure of Emotions*. New York: Cambridge University Press; 1988.
59. Goode E. Viewing Depression As Tool for Survival. *New York Times*. 2000: Tuesday, February 1, section F; 7.
60. Stefanucci JK, Proffitt DR, Clore G, Parekh N. Skating down a steeper slope: fear influences the perception of geographical slant. *Perception* 2008(37):321–323.
61. Stefanucci JK. Looking down from high places: the roles of altitude and fear in the perception of height. University of Virginia; 2006.
62. Teachman BA, Stefanucci JK, Clerkin EM, Cody MW, Proffitt DR. New modes of fear expression: perceptual and implicit association biases in height fear. *Emotion* 2008, 8:296–301.
63. Stefanucci JK, Storbeck J. Don't look down: emotional arousal elevates height perception. *J Exp Psychol: General* 2009, 138:131–145.
64. Sinai MJ, Ooi TL, He ZJ. Terrain influences the accurate judgment of distance. *Nature* 1998, 395:497–500.

