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Emotion Elicitation With Neurological Patients

This chapter presents a set of issues and methods related to studying emotional functioning in neurological patients. It incorporates discussions of the advantages and disadvantages of two primary paradigms for studying neural substrates of human emotion (patient studies and activation studies); of the importance of studying multiple emotion processes, emotion types, and emotion response systems; and of the details of specific elicitation methods (along with modifications that may be necessary for use with patients). Throughout, there is a recounting of "lessons learned," based on our own experience taking methods that we had developed and used over several decades for studying emotion in normal individuals and adapting them to study patients suffering from focal lesions (e.g., orbitofrontal lesions), congenital brain damage (e.g., Moebius syndrome), and neurodegenerative diseases (e.g., frontotemporal lobar degeneration, Alzheimer's disease, amyotrophic lateral sclerosis).

Affective Neuroscience: The Two Approaches

Affective neuroscience is concerned with understanding the neural substrates of emotional functioning. As with other areas of neuroscience, questions pertaining to localization of function loom large early on. On this foundation, more complex questions concerning the nature of neural circuits and the bidirectional interactions between affective and cognitive processes are built. As has been the case with cognitive neuroscience, research in affective neuroscience has primarily utilized two paradigms, one studying the emotional functioning of patients with damage in particular brain areas and the other studying the activation of particular brain regions during well-defined emotional activities. Although some laboratories specialize in one or the other methodology, opportunities for using the findings from one methodology to inform research using the other abound.

Patient Studies

Studies of neurological patients have been critical to advancing our understanding of the human brain. In some instances, fundamental insights were gained and doors opened to entire new areas of inquiry based on findings from a single patient, such as Phineas Gage and the frontal lobes (Harlow, 1848) and patient H.M. and the organization of memory (Scoville & Milner, 1957). In other instances, findings from a small group of patients were seminal, such as epileptics treated with cerebral commissurotomy and hemispheric specialization (Gazzaniga & Sperry, 1967). In addition to these spectacular advances, there has been a steady and continuing parade of findings derived from the deceptively simple strategy of identifying individuals with loss in particular brain areas of interest, determining how their abilities and functioning differ from the norm, and studying the ways that they change over time. The great power and advantage of patient studies is that the behavioral, cognitive, and emotional "dependent measures" need not be constrained. Patient studies allow use of the entire armamentarium of methods and techniques available for studying the full range of basic behavioral and social processes under both controlled and naturalistic conditions.

The great disadvantage of patient studies pertains to the localization of brain injuries. Many brain injuries are diffuse, and even focal lesions can be highly idiosyncratic. This greatly complicates attempts to assemble groups of individuals with comparable brain damage. Neurodegenerative disorders also produce quite diffuse damage and, by definition, are constantly changing. Nonetheless, damage caused by lesions and neurodegeneration can be localized and quantified using methods such as voxel-based morphometry (Ashburner & Friston, 2000) and diffusion tensor imaging (Basser, Mattiello, & LeBihan, 1994), which can then be correlated with specific behavioral, emotional, and cognitive deficits and changes. A second problem with patient studies comes into play when patients with "old" injuries are studied. Humans are masters of compensation, and even the adult brain retains considerable plasticity (Jenkins, Merzenich, & Recanzone, 1990). Over the years that ensue following the injury, "work-arounds" for recovering lost functions using uninjured areas of brain can mask or alter the nature of the functional deficits associated with the original injury. Finally, brain injuries can produce ancillary damage that can make testing difficult or misleading. For example, a patient with changes in emotional behavior associated with temporal lobe damage may be much harder to test and findings much more difficult to interpret if the damage extends to language comprehension areas as well (e.g., is observed lack of emotional response to an emotion-eliciting film due to damage to the emotional production areas or lack of comprehension of the film's dialogue?).

Activation Studies

Despite the stellar history of scientific yield from patient studies, the spotlight in affective neuroscience now clearly shines most brightly on studies that use technologically sophisticated imaging methodologies (e.g., functional magnetic resonance imaging [fMRI]; positron emission tomography [PET]) that utilize hemodynamic information to quantify ongoing brain activity. Older methods that directly measure the brain's electrical activity, such as the classic electroencephalogram (EEG), have continued to evolve with changes in acquisition methodology (e.g., dense-electrode arrays), paradigms (e.g., event-related analyses), and analyses (e.g., current source localization). Magnetoencephalography (MEG) offers a promising alternative to EEG for measuring brain activity, and transcranial magnetic stimulation (TMS) offers a way to stimulate activity in particular brain areas.

The great advantage of the imaging-based methods is localization. As acquisition technologies and analytic methods have developed, both spatial and temporal resolutions have improved. At this point, it is not unreasonable to utilize fMRI (whose temporal resolution has always lagged behind the other activation methods) to study a fleeting phenomenon such as emotion. Arguably, only a fool would bet against such stunning technology (and the many talented scientists it has attracted) in the long run. Nonetheless, applying these methods to study emotion engenders some serious problems and significant compromises, which are likely to plague these approaches for the foreseeable future. As a prime example, naturalistic studies of emotion in freely behaving individuals are simply impossible when participants need to be "in the magnet," lying on their backs, awash in hammering sounds, and repeatedly warned that motion (an essential part of "emotion") is forbidden.

Another serious limitation with imaging-based methods is that they are typically highly solitary and isolating. Most human emotion, in contrast, occurs in social contexts, arising from interaction and communication with others. Recreating a meaningful social context is highly challenging in any laboratory environment, but even more so in the typical imaging environment. Thus, for now, social influences can be introduced only in highly diluted forms (although recent studies using "alone vs. in the company of another person" comparisons are promising).

The emotional processes studied in activation studies are often limited by the methodologies used. The implications of these limitations for interpreting findings are often not explicitly and fully considered. For example, many fMRI studies have participants make emotional judgments (e.g., identifying the emotion in photographs of faces or in paragraphs). On minimal reflection, wouldn't most agree that *identifying* an emotion conveyed in a photograph or paragraph is a very different process than *having* an emotional reaction to some significant event? Moreover, these processes are likely to involve quite different neural substrates. Thus using emotion judgment paradigms as a proxy for emotion production paradigms is highly suspect.

Last, activation studies must deal with the pervasive problem of stimulus equivalency. Stimuli such as slides and films that are typically used to elicit different emotions or emotion-related states (e.g., loneliness, sympathy) often differ greatly in other dimensions, such as familiarity, color, cognitive complexity, and movement, any of which could account for findings of differential regional brain activation between experimental conditions. Adequately controlling for these sources of variation requires great care, and there is often a dramatic trade-off between applying the experimental controls necessary to insure comparability of stimuli and preserving their ecology validity (Levenson, 2003).

Emotional Functioning: Processes, Types, and Response Systems

Modern neuropsychological testing of cognitive functioning is based on a highly differentiated model of human cognition in which deficits can appear in any of a number of processes (e.g., memory, executive function, language, computation, attention). Moreover, many of these major cognitive functions can be broken down into component processes that can also be assessed (e.g., working memory and long-term memory).

The state of affairs is much less advanced when it comes to testing emotional functioning. As with cognition, there are compelling theoretical, empirical, and anatomical reasons to consider emotion as consisting of a number of different processes and subprocesses. However, relatively few tests are available for assessing different emotional processes in neurological patients, and, for those that are available, the relationship with specific emotion processes is often not well articulated. In fact, in many neuropsychological batteries, only a single emotion process is tested (typically the ability to recognize the emotion being expressed in photos of facial expressions). Just as no one would consider a particular test (e.g., maze drawing) designed to assess a particular cognitive function (i.e., executive control) adequate for assessing overall cognitive functioning, extrapolating overall emotional functioning from a test of a single emotional process seems logically flawed and practically misguided.

What needs to be included in a comprehensive assessment of emotional functioning? Akin to many fundamental issues in emotion, significant controversy exists among emotion theorists and researchers about how best to parse emotion into its component processes, types, and indicators. There are many models of emotions, and they differ widely in their relative emphasis on biological features, cognitive features, appraisal processes, motor action patterns, expressive behavior, language, and coping. The definition we have proposed (Levenson, 1994) emphasizes the adaptive, organizing function of emotion:

> Emotions are short-lived psychological-physiological phenomena that represent efficient modes of adaptation to changing environmental demands. Psychologically, emotions alter attention, shift certain behaviors upward in response hierarchies, and activate relevant associative networks in memory. Physiologically, emotions rapidly organize the responses of disparate biological systems including facial expression, somatic muscular tonus, voice tone, autonomic nervous system activity, and endocrine activity to produce a bodily milieu that is optimal for effective response. Emotions serve to establish our position vis-à-vis our environment, pulling us toward certain people, objects, actions and ideas, and pushing us away from others. Emotions also serve as a repository for innate and learned influences, possessing certain invariant features, and others that show considerable variation across individuals, groups, and cultures. (p. 123)

Reflecting this definition of emotion, our assessment of emotional functioning focuses on brief emotional phenomena (not on longer moods) and on the activation of multiple response systems (which requires assessing multiple indicators of emotion rather than relying on a single indicator, such as verbal report of subjective emotional experience) and includes assessment of emotion in interpersonal contexts.

Three Emotion Processes

There are three processes that should be included in any comprehensive assessment of emotional functioning: (1) *emotional reactivity,* (2) *emotional regulation,* and (3) *emotional understanding.* Emotional reactivity refers to the type, magnitude, and duration of responses that occur in reaction to changes in the internal and external environment and that have significance for our goals and well-being. Emotional regulation refers to the adjustments in type, magnitude, and duration of emotional responses that are made to meet personal, situational, and interpersonal demands. Emotional understanding refers to the recognition of emotions in oneself and others and the understanding of the reasons they have occurred and their consequences.

These processes capture three of the most fundamental qualities of human emotional life—having emotion, controlling emotion, and knowing what we and others are feeling. Although the evidence is far from conclusive, we hypothesize that each of these processes is subserved by somewhat different neural circuitry. Patient studies can shed light on this hypothesis if they utilize methods that allow for studying these processes separately. The methods presented in this chapter have been designed explicitly with this goal in mind.

Emotional Reactivity

Emotional reactivity is usually operationalized in terms of the type, magnitude, and duration of response. In the laboratory, emotional reactivity is typically assessed by presenting the individual with a standardized or personally tailored emotion-eliciting stimulus and measuring the reactions in one or more response systems (discussed later).

Emotional reactivity should be assessed in vivo, that is, at the time emotions are actually produced. Procedures in which individuals are asked to indicate what emotional responses they *think* they have or would have in certain situations reflect an uncertain amalgam of additional processes (e.g., actual self-awareness, "emotional intelligence," cultural beliefs and norms, self-presentation biases).

Emotional Regulation

Gross (1998) defines emotional regulation as:

> the processes by which individuals influence which emotions they have, when they have them, and how they experience and express these emotions. Emotion regulatory processes may be automatic or controlled, conscious or unconscious, and may have their effects at one or more points in the emotion generative process. (p. 275)

Perhaps because the term *emotional regulation* is so closely associated with learning how to rein in emotions during childhood, it is easy to think of emotional regulation as being limited to emotional down-regulation. However, it is clear that emotional regulatory competence goes beyond this to include the ability to amplify emotion (when emotional signals need to be clear and unambiguous) and to substitute one emotion for another (e.g., when social conventions call for the display of a particular emotion that may be different from what is actually being felt).

Emotional reactivity and emotional regulation can be quite difficult to separate. For example, consider the case of a patient who exhibits very small facial expressive and autonomic responses to a highly emotional film. Is this patient showing a low level of emotional reactivity or a high level of emotional regulation (suppression, in this example)? The difficulty of making this distinction underscores the value of assessing *instructed* regulation (i.e., the person is explicitly told how to alter emotional response and the ability to comply with this instruction is assessed), in addition to *spontaneous* regulation (i.e., the person is placed in situations in which regulation would be expected but is not explicitly requested). Instructed regulation provides an indication of what the person *can* do and can be measured quite precisely; spontaneous regulation provides an indication of what the person *does* do and is always difficult to separate completely from emotional reactivity. Moreover, spontaneous regulation often depends not only on the ability to regulate emotion per se but also on other abilities, such as knowing social norms and recognizing situational demands.

Emotional Understanding

Emotional knowledge takes a number of forms, ranging from the relatively simple (e.g., knowledge about whether or not we or others are experiencing emotion) to the more differentiated (e.g., knowledge about the particular emotion or emotions being experienced) to the highly complex (e.g., knowledge of cultural norms that apply to emotional expression in the current situation).

We consider the basic building block of emotional understanding to be empathic accuracy (Ickes, 1997), which is the ability to recognize what another person is feeling. In its simplest form, empathic accuracy can be assessed by having an individual identify the particular emotion being shown in a photograph or expressed in a vocalization. Two common tests of this sort are the Florida Affect Battery (Bowers, Blonder, & Heilman, 1991) and the Pictures of Facial Affect (Ekman & Friesen, 1976). More complex and arguably more ecologically valid assessments of emotional understanding utilize dynamic stimuli in which the emotional content is embedded in a meaningful social context and unfolds over time. Examples of these include recognizing and/or tracking emotions during films (Gross & Levenson, 1995) and social interactions (Levenson & Ruef, 1992).

Three Emotion Types

Three broad categories of emotion should be considered when assessing emotional functioning: (1) *negative emotions,* (2) *positive emotions,* and (3) *self-referential emotions.* Whereas early theories tended to posit a single mechanism that was thought to apply to all types of emotion (e.g., unexplained physiological arousal coupled with cognitive appraisal; Schachter & Singer, 1962), contemporary emotion theories and research are less likely to treat emotion as a monolith. Thus the assumption that what holds for one emotion holds for all emotions—whether it be antecedent conditions, appraisals, activating mechanisms, functions, or manifestations—is no longer tenable.

Negative Emotions

Negative emotions prepare the organism for dealing with conditions of threat, challenge, and opportunity. "Basic" negative emotions such as anger, disgust, fear, and sadness can be characterized as having different associated patterns of facial expression, motor action, and physiological activation (Ekman, 1992) that have been selected through evolution as being most likely to deal successfully with the eliciting condition most of the time (Levenson, 2003). Early theorizing about and laboratory studies of emotion focused primarily on negative emotions, emphasizing adaptive patterns such as "flight" and "fight" and attempting to document associated physiological activation (Ax, 1953; Levenson, 1992; Roberts & Weerts, 1982). Traditionally negative emotions are thought to reside in limbic regions of the brain, with medial temporal circuitry involving the amygdala playing a critical role (LeDoux, 1992, 2000).

Positive Emotions

Until recently, positive emotions were relatively understudied and their functions less well understood. Clearly, "fight or flight" is not a good metaphor for positive emotions such as amusement and joy. In our work, the role that positive emotions play in calming, soothing, and "undoing" the physiological effects of negative emotions has been emphasized (Fredrickson & Levenson, 1998; Levenson, 1988). Others have emphasized the role that positive emotions play in broadening perspectives, increasing flexibility of response, and increasing group cohesion (Fredrickson, 1998; Isen, 1999). In contrast to long-held views that emotion is a right-hemisphere phenomenon, Davidson (e.g., Davidson & Fox, 1982) has argued that the left hemisphere is particularly important for positive emotion.

Self-Referential Emotions

Self-referential emotions arise when our behavior is evaluated against social norms. These evaluations and the ensuing emotions can be negatively (e.g., shame, guilt, embarrassment) or positively (e.g., pride) toned. Because they require self-monitoring, complex appraisals, and knowledge of norms, self-referential emotions appear relatively late in ontogeny and phylogeny. Research with neurological patients suggests that these emotions are particularly vulnerable to injury to frontal brain regions (Beer, Heerey, Keltner, Scabini, & Knight, 2003; Sturm, Rosen, Allison, Miller & Levenson, 2006).

Four Emotion Response Systems

Emotion researchers always have to deal with the thorny issue of how to account for the multiple emotion response systems. Even in normal individuals, the extent of coherence between different indicators of emotion (e.g., autonomic nervous system, expressive behavior, subjective experience) varies depending on person, situation, response system, and emotion (Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005). In neurological patients, this problem can be compounded when central and peripheral neural systems responsible for certain emotion responses are damaged. Moreover, the kinds of disjunctions between emotion response systems that have been found with psychiatric populations (e.g., low levels of facial expression combined with high levels of subjective experience and autonomic response in schizophrenics with "blunted affect"; Kring & Neale, 1996) could prove important in neurological populations. Thus, for an adequate accounting of emotional functioning, it is important to measure multiple emotional response systems.

Self-Reported Emotional Experience

Self-reported emotional experience can be measured in several ways. In our laboratory, we ask participants to do one or more of the following: (1) describe their emotional responses in an open-ended fashion, (2) rate the intensity of discrete emotions (e.g., fear, anger, amusement) and dimensions (e.g., pleasantness), or (3) use a rating dial to indicate moment-to-moment emotional changes (see Ruef & Levenson, chapter 17, this volume). For neurological patients with language and/or memory problems, we have developed modified versions of these measures that can be used as needed (e.g., rating scales with reduced ranges, pictures rather than words, pointing rather than writing/speaking, online ratings or very short time intervals between emotional events and retrospective ratings).

Emotional Expressive Behavior

Emotional expressive behavior is typically quantified by applying objective coding systems to videotapes of participants' emotional behavior. In our laboratory, we use a number of different coding systems, including: (1) the Facial Action Coding System (FACS; Ekman & Friesen, 1978), which decomposes facial expressions into their component muscular actions and involves no inference; (2) the Emotion FACS (EMFACS; Friesen & Ekman, 1983), which provides emotion predictions for certain combinations of FACS scores; (3) the Emotional Expressive Coding System (Gross & Levenson, 1993), which includes descriptions of specific facial actions and inferential codes for different emotions; and (4) the Specific Affect Coding System (SPAFF; Coan & Gottman, chapter 16, this volume; Gottman, 1989), which is generally used for dyadic interaction and which assigns codes to emotions based on multiple indicators, including facial expression, tone of voice, and content of speech. These coding systems can all be employed with neurological patients; however, for those with language problems, SPAFF coding can be difficult because of its use of speech cues.

Peripheral Physiology

Peripheral physiology is usually quantified in terms of selected measures of cardiovascular, electrodermal, respiratory, and somatic activity. Measurement timing is very important because these systems are often under the influence of emotion for only brief periods before they return to the service of other functions (e.g., homeostasis). In our laboratory, we precede each emotion elicitation with a resting baseline period and then obtain measures continuously throughout the elicitation and during a postelicitation "cooling down" period. Analyses focus either on the times during which we attempted to stimulate emotion (e.g., while the participant watched a film) or when we have independent evidence that an emotion has occurred (e.g., when an emotional facial expression appeared during a dyadic interaction). Measures of peripheral physiology are very useful with neurological patients because they do not depend on language. However, it is important to take into account any impact that the disease process has on autonomic centers (see the section on control tasks later in the chapter) and the autonomic effects of patient medications (e.g., medications with cholinergic and/or adrenergic effects, such as antimuscarinics, phenothiazines, and beta-blockers).

Emotional Language

Emotional language can be quantified by determining the frequency or proportion of words used in different categories (e.g., all emotion words, negative emotion words, fear words). Verbatim transcripts of participant responses are prepared and processed using text-analysis computer software (e.g., Marchitelli & Levenson, 1992; Mergenthaler, 1985; Pennebaker, Francis, & Booth, 2001). To control for the paucity of language in some neurological patients, word usage in particular emotion categories of interest can be expressed as a percentage of total words spoken.

Laboratory Tests of Emotion

In this section, the laboratory tasks we use to assess emotional functioning are described, along with the modifications necessary for use with neurological patients.

Acoustic Startle Reflex

The acoustic startle reflex is a primitive, defensive response to the threat posed by a sudden loud noise (Sokolov, 1963). We use a 115 db, 100 ms burst of white noise administered through loudspeakers directly behind the patient (roughly commensurate with a close-proximity gunshot). The startle response exists on the boundary between reflex and emotion (Ekman, Friesen, & Simons, 1985). The initial response (typically occurring in the first 500 ms) consists of a stereotyped pattern of somatic and facial muscle actions (Ekman et al., 1985) and attendant activation of autonomic nervous system response (Soto, Levenson, & Ebling, 2005). This is often followed by a secondary emotional response, a "response to having been startled" that varies across individuals. As the person takes stock of what has happened (including his or her reaction to the loud noise), the secondary response can take several emotional forms, including amusement, embarrassment, anger, or fear. In our work with neurological patients, we have found this secondary response to be particularly vulnerable to frontal lobe damage (Sturm et al., 2006).

We administer the startle under three conditions (unanticipated, anticipated, inhibited), which enables us to probe different aspects of emotional functioning. In the unanticipated condition, the startle occurs without warning. This assesses emotional reactivity to a simple aversive stimulus. In the anticipated condition, the startle is preceded by a 20-s countdown. Because participants know exactly when it will occur, most use the time to try to reduce the impact of and their response to the startle. This procedure provides a good measure of spontaneous regulation (we have found deficits in this kind of regulation in patients with orbital prefrontal cortex damage; Roberts, et al., 2004). Finally, in the inhibited condition, the startle is preceded by a 20-s countdown and instructions to try to minimize the reaction. This enables us to assess participant's capacity to regulate emotion on demand and thus provides a measure of instructed regulation. A variant of the inhibited condition, in which participants are instructed to exaggerate the visibility of reactions, can also be included.

Startle Eyeblink Modulation

The acoustic stimulus described in the previous section is sufficiently loud to activate an intense defensive whole-body reflex (Sokolov, 1963). An acoustic stimulus of considerably lower amplitude (typically ranging from 95–100 db) will activate a much smaller startle reflex (Bradley, Cuthbert, & Lang, 1990) that can be quantified by electromyographic measurement of the intensity of the associated eyeblink. To put this in perspective, the 115 db acoustic stimulus used to generate the defensive reflex is more than 30 times as powerful as the 100 db stimulus used to generate the startle eyeblink. Unlike the high-amplitude startle, the lower amplitude startle does not disrupt ongoing activity and thus can be used as a repeated background "probe" stimulus while the person is engaged in other activities. The amplitude of the startle eyeblink reflects higher cortical functioning, such as attentional and emotional processing. Importantly, it is also sensitive to affective valence—with positive/approach states attenuating the amplitude of the eyeblink and negative/avoidance states having a potentiating effect (Bradley et al., 1990). Startle eyeblink modulation can provide useful information about underlying attentional and emotional processes in ways that are relatively free of demand characteristics and reporting biases (e.g., Bradley & Vrana, 1993). These qualities are appealing for use with patient populations with whom self-report might be problematic.

Films

Carefully selected excerpts from commercial and other films can be used to elicit particular emotions (Gross & Levenson, 1995; Philippot, 1993). Emotions in real life often occur in response to dynamic external visual and auditory stimulation; thus films have a relatively high degree of ecological validity. Use of films as laboratory stimuli can be traced back to early studies of diffuse "stress" responses (e.g., Lazarus, et al., 1962). However, for assessing emotion, it is important to have films that are sufficiently thematically pure to target specific emotions (or at least specific types of emotion). Gross and Levenson (1995) describe a set of films that can be used to elicit the emotions of amusement, anger, contentment, disgust, fear, sadness, and surprise, as well as a neutral emotional state. Based on this work, it appears that anger is the most difficult emotion to elicit reliably using short film excerpts. Films can be used to assess the emotional processes of reactivity (by having participants just watch the film and measuring their responses), regulation (by instructing participants to alter their emotional responses), and understanding (by having participants indicate the emotions being experienced by characters in the film).

When using films with neurological patients, it is important to consider possible cognitive and language deficits. Films vary greatly in their thematic complexity and in the extent to which emotional cues are embedded in language, action, or situation. Thus it is important to select films that are appropriate for the cognitive capabilities of the population. Fortunately, we have found that, even with highly impaired neurological patients, it is possible to assess emotional reactivity, regulation, and understanding with carefully selected, thematically simple films in which the emotion is embedded more in action and situation than in language.

Slides

The International Affective Picture System (Lang, Greenwald, & Bradley, 1988) consists of more than 700 colored images of situations selected because of their ability to evoke emotion and to be internationally understandable. These pictures have been used in a large number of studies of emotional and cognitive functioning, including many activation studies. The pictures were developed to explore a dimensional model of emotion; thus normative ratings are available for pleasure and arousal for each picture rather than for specific emotions.

Although in theory the full array of specific emotions could be represented, there are clear biases (e.g., pictures of contamination and mutilation, which would primarily elicit disgust, dominate the high unpleasant–high arousal quadrant).

The International Affective Picture System (IAPS) slides have primarily been used to assess emotional reactivity, the emotion process for which they are best suited. However, they could also be used to assess regulation, especially if the emotional impact were extended through longer times of exposure and/or viewing sequences of similarly themed slides. Emotional understanding could also be assessed using slides that portray people having emotional reactions. Because these pictures are static and cognitively simple and do not require language processing, they can be very useful when working with impaired patients.

Relived Emotions

Recalling memories of emotionally significant events can be a powerful elicitor of emotion. Interestingly, even in patients suffering from retrograde amnesia that affects neutral and semantic autobiographical memories, emotional memories can be spared (Daum, Flor, Brodbeck, & Birbaumer, 1996). We use emotional memories of two kinds: (1) personally relevant, autobiographical emotional memories (e.g., recalling one's saddest or happiest moment; Ekman, Levenson, & Friesen, 1983), and (2) memories of shared historic or group events (e.g., flashbulb memories, such as recalling the events of September 11, 2001). Autobiographical memories can elicit intense emotion, but their idiosyncratic nature leads to differences in the characteristics of memories across individuals. Flashbulb memories provide much better comparability of the memory itself, but they still can vary greatly across individuals in personal salience and capacity to elicit emotion.

To identify personally relevant autobiographical memories, we use a semistructured interview to prompt participants to retrieve memories of a specific event that elicited a specific emotion (Ekman et al., 1983). Subsequently, participants are asked to relive those memories as strongly as possible. Emotional responses can be assessed during both the retrieval and reliving periods. We consider relived memories to be most useful for assessing emotional reactivity and less so for assessing emotional regulation and understanding. Because memory is involved, these tasks need to be used judiciously with patients who have memory impairments.

Singing

Among the self-referential emotions, embarrassment is probably the best understood (Keltner & Buswell, 1997). To elicit embarrassment, we use a singing task in which participants unwittingly become objects of attention and evaluation. Participants are seated in front of a television monitor while their expressive behavior is recorded. After sitting quietly through a baseline period, participants are asked to sing a familiar song (e.g., we use "My Girl") while the instrumental background music is played through headphones and the lyrics are presented on the television monitor. On completion of the song, the experimenter removes the headphones and instructs participants just to watch the television for the next task. Without warning, they are then shown a recording of their just-completed singing performance. In our laboratory, participants are typically alone while watching themselves sing, but it would be possible to have an "audience" present, which might heighten the effect.

Singing tasks of this sort are effective elicitors of embarrassment and other signs of self-consciousness (e.g., amusement). Other tasks that have been used for eliciting embarrassment include posing complex facial expressions (Keltner, 1995) or having participants disclose personal, emotional experiences (Beer et al., 2003). An advantage of the singing task is that it is thematically and instructionally simple and suitable for use even with quite impaired patients (if patients have trouble reading lyrics, childhood songs such as "Twinkle, Twinkle, Little Star" can be used).

Dyadic Interaction

Most human emotions occur in interpersonal contexts. We have emotional responses to the actions of others, and our emotions serve to regulate social distance, drawing people to us in some instances and away from us in others (Levenson, 1994). Specific emotions can serve important intrapersonal functions, for example, the role that positive emotions play in establishing social bonds (Fredrickson, 1998; Panksepp, 2000) and the role that sadness plays in eliciting help from others (e.g., crying as a distress signal; Bowlby, 1969).

In our laboratory, we assess socioemotional functioning during dyadic interaction (Levenson & Gottman, 1983). Participants engage in the interaction with a spouse, family member, or caregiver. Members of the dyad sit in chairs facing each other and engage in brief conversations (typically 15 min) preceded by silent resting periods (typically 5 min). We have found that discussions of areas of relationship conflict are the most powerful elicitors of emotion. We also use more neutral topics (e.g., discussing the events of the day), positive topics (e.g., discussing things they enjoy doing together), and disease-specific topics (e.g., discussing the ways the illness has changed their relationship). Before each conversation, a facilitator helps the dyad decide on the topic for discussion.

Dyadic interaction allows us to assess emotional reactivity (generating emotional responses), emotional regulation (modulating emotions appropriately), and emotional understanding (recognizing and responding to the emotions of others) under conditions that closely approximate the "real world." In addition to assessing these processes during the interaction (through behavioral coding, analysis of language, and measurement of physiological responding), we also assess subjective emotional experience and emotional understanding using a video recall methodology (Gottman & Levenson, 1985). After the conversation, participants view the video recording and use a rating dial to report continuously on the valence (negative-neutral-positive) of their own emotions during the interaction (emotional experience). An additional viewing can follow in which each participant rates the other participant's emotional state. Comparing the similarity between the two sets of ratings provides an objective measure of emotional understanding (Levenson & Ruef, 1992).

Dyadic interaction is a powerful way to study emotional functioning. It is particularly useful in revealing how patients' specific emotional (and cognitive) deficits and strengths play out in the highly demanding context of social interaction. We have found that this task can be used with even highly impaired patients (although they may not be able to do the rating dial portion).

Control Tasks

When working with neurological patients, we typically have access to a fairly complete clinical examination, neuropsychological workup, medical history, and current medications. We supplement this information with several additional tests conducted in the laboratory that are critical to subsequent interpretation of the results of our testing of emotional functioning.

Understanding Emotion Terms

Participants are asked to match a list of emotion terms (e.g., *anger*) with a list of definitions (e.g., "what you feel when someone takes something that is yours") to ensure that they are familiar with emotion semantics.

Ability to Use Rating Dial

Because we often make use of rating dials to obtain continuous emotional reports, we determine whether the person has the psychomotor skills necessary to use the device by having them move the dial to track a changing color presented on a television monitor.

Autonomic Functioning

We use an isometric handgrip task to ensure that the cardiovascular system responds normally to somatic demand and a valsalva maneuver to ensure that both parasympathetic and sympathetic influences on the heart are present. It is also important to have some test to assess whether the electrodermal system is functional, especially given that many individuals fail to show electrodermal responses to any stimulus (for reasons related to age, disease, skin coloration, calluses, medication, etc.). Electrodermal responses are afforded an important role in affective neuroscience, for example, as part of the somatic marker hypothesis (Damasio, Tranel, & Damasio, 1991). Thus it is particularly important to assess nonemotional electrodermal responding in both patients and controls. Having participants take several deep breaths provides a quick indication of the intactness of the electrodermal system. An alternative is to use a calibrated orienting stimulus such as a low intensity tone or light flash. This has the advantage of exposing all participants to the same stimulus, and thus the magnitude of the electrodermal response can be used as a nonemotional covariate in other analyses.

Facial Responding

Because emotional facial responding is an important nonverbal indicator of emotional state, it is important to know whether patients have any damage to circuitry that controls the action of the facial muscles. If not tested as part of the neurological exam, voluntary facial expression can be quickly assessed by having participants make individual facial actions (Ekman & Friesen, 1982) and simple emotional expressions. Because voluntary and spontaneous facial muscle actions reflect somewhat different neural pathways (Rinn, 1984), it is important to assess involuntary facial expression as well. This can be monitored informally during the preexperimental interactions (e.g., watching for smiles) or can be evaluated more systematically with simple stimuli that reliably elicit facial responses (e.g., acoustic startle, bad smells, sour tastes).

Utilizing Control Data

We use data obtained from these control tasks as covariates in subsequent analyses. These are supplemented by additional covariates derived from clinical and neuropsychological data, such as use of autonomically active medications and overall level of cognitive functioning (Mini-Mental State Examination; Folstein, Folstein, & McHugh, 1975). This analytic strategy reflects our interest in isolating deficits in emotional functioning above and beyond those that could be accounted for by cognitive, motor, and medication-related factors. Obviously, for this kind of covariance strategy to be effective, it is important that reasonable variation in the covariates exist *within* the groups being studied and not only between groups.

Summary of Elicitation Methods

In Table 10.1, the various tests of emotional processing discussed in this chapter are summarized in terms of the emotion processes, emotion types, and emotion-response systems they can assess. For each test, advantages and disadvantages are briefly noted.

Conclusions

In this chapter I have argued for the value of patient studies at a time when activation studies have become the primary coin of the realm in affective neuroscience. I have also presented a case for the importance of a comprehensive assessment of emotional functioning, which includes testing of three different emotion processes (reactivity, regulation, understanding), three different emotion types (negative, positive,

Table 10.1
Summary of various tests of emotional processing

	Emotion Processes	*Emotion Types*	*Emotion Response Systems*	*Advantages*	*Disadvantages*
Acoustic startle reflex	Reactivity Regulation (instructed) and spontaneous)	Negative Positive and self-referential in secondary reaction	Subjective Behavioral. Physiological	Requires little cognitive processing	Produces a general defensive response initially rather than specific emotions
Startle eyeblink modulation		Negative Positive	Behavioral	Requires little cognitive processing Unobtrusive and continuous	Does not produce rich repertoire of emotional behavior
Films	Reactivity Regulation (instructed) Understanding (identify or track emotions of target)	Negative (anger difficult) Positive Self-referential	Subjective Behavioral Physiologica	High ecological validity (dynamic, socially embedded)	High cognitive demands if thematically complex Difficult to elicit anger
Slides	Reactivity Regulation (instructed)	Negative (anger difficult) Positive	Subjective Behavioral Physiological	Minimal cognitive and language demands	Biased toward eliciting disgust, amusement, sexual arousal
Relived emotions	Reactivity	Negative Positive Self-referential	Subjective Behavioral Physiological Language	Makes high demands on memory	Idiosyncratic stimuli—not standardized
Singing	Reactivity	Self-referential	Subjective Behavioral Physiological	Simple, effective	Need to be sensitive to patient discomfort Useful only for embarrassment
Dyadic Interaction	Reactivity Regulation (usually spontaneous, but instructed possible, too) Understanding	Negative Positive Self-referential	Subjective Behavioral Physiological Language	Produces highly naturalistic samples of emotional functioning High ecological validity	Responses influenced by both members of dyad

self-referential), and four different emotion response systems (self-reported experience, expressive behavior, peripheral physiology, language). Arguably, this kind of comprehensive assessment is critical for studying emotional functioning in all areas of emotion research (e.g., individual and group differences, development, social and cultural influences, emotion-cognition interactions, and impact of psychopathology and neuropathology). The methods described for testing emotional functioning are suitable for use in studies of both normal populations and, with some modifications and controls, neurological patients. Comprehensive, differentiated assessment of emotional functioning is clearly essential for advancing our understanding of the neural substrates of emotion. Applied to neurological patients, this approach may also help inform and improve the diagnosis and treatment of the many neurological and psychiatric disorders that affect emotional functioning.

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This material is based on a recent chapter written with Elizabeth Ascher, Madeleine Goodkind, Megan McCarthy, Virginia Smith, and Kelly Werner (Levenson, et al., 2006) that described our approach to studying emotional functioning in frontal lobe patients. For this volume, I have rewritten and expanded a number of the sections, shortened others, and added several new sections, all in the hopes of making the chapter more useful to the emotion researcher interested in working with neurological patients. Still, there is much that is similar between the two chapters. My thanks to my coauthors and to the editors for agreeing to allow this material to appear in both volumes. Thanks also to my collaborators Bruce L. Miller, Howard J. Rosen, and Richard J. Perry (and to the many other members of the Memory and Aging Center) in the Department of Neurology at the University of California, San Francisco, for making this work possible, interesting, and so enjoyable.

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