Chapter 25

Laboratory testing of emotion and frontal cortex

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25.1. Introduction

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

The state of affairs is much less advanced for testing emotional functioning. As with cognition, there are compelling theoretical, empirical, and anatomical reasons to consider the emotion system as consisting of a number of different processes and subprocesses. However, there are relatively few tests available for assessing emotional functioning and, among those, the relationship with specific emotion processes is often not well articulated. In fact, in many neuropsychological batteries, only a single emotion process is tested (e.g., the ability to recognize the emotion being expressed in a photo of a facial expression). In our view, extrapolations about overall emotional functioning based on testing a single emotional process can be very misleading.

This chapter begins with a discussion of what we consider most critical for a comprehensive assessment of emotional functioning and then describes the assessment procedures we use. Because our work is primarily conducted in the laboratory, our procedures are designed for that environment. In recent years we have used these procedures with hundreds of patients with neurodegenerative diseases (frontotemporal lobar degeneration, Alzheimer’s, amyotrophic lateral sclerosis, Moebius syndrome), congenital neurological diseases (Moebius syndrome), and focal lesions (orbitofrontal), as well as with neurologically normal controls. We consider the laboratory to be an excellent test bed for developing, refining, and evaluating assessment techniques. Those techniques that prove most useful can then be translated into forms more appropriate for use in the clinic and at the bedside.

25.2. Emotion

Definitions of emotions vary in terms of their emphasis on biological features, cognitive features, appraisal processes, motor action patterns, expressive behavior, language, and coping. The way that emotion is defined significantly influences the design of the assessment battery necessary to assess emotional functioning. The definition we have proposed emphasizes the adaptive, organizing function of emotion: ‘Emotions are short-lived psychological-physiological phenomena that represent efficient modes of adaptation to changing environmental demands.’ (Levenson, 1994, p. 123).

For us, emotion serves a number of functions, altering attention, adjusting behaviors upward and downward in response hierarchies, and activating relevant associative networks in memory. An important function of emotion is to organize numerous biological systems (including facial expression, somatic muscles, voice tone, autonomic nervous system, endocrine system) into a bodily milieu that is optimal for effective response. Emotions serve important social functions, moving us toward certain people and away from others. Reflecting this view, our laboratory assessment of emotional functioning focuses on brief emotional phenomena (not on longer moods) and on the activation of multiple response systems (not on a single system such as verbal report of emotional experience). Moreover, it includes assessment of emotion in interpersonal contexts.

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We believe that three emotional processes should be included in any comprehensive assessment of emotional functioning: (a) emotional reactivity, (b) emotional regulation, and (c) emotional understanding. Emotional reactivity refers to the type, magnitude, and duration of response that occurs in reaction to changes in the internal and external environment that have significance for our goals and wellbeing. Emotional regulation refers to the adjustments in type, magnitude, and duration of emotional response that are made to meet personal goals and situational demands. Emotional understanding refers to the recognition of emotions in self and others, and to the understanding of why these emotions have occurred and what their consequences may be. We believe that each of these processes is subserved by different neural circuitry, and that they can be differentially impacted by injury and disease.

25.3. 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 stimulus thought to elicit emotion in most people (e.g., viewing a film of a child mourning the death of his father) or a personally meaningful stimulus (e.g., remembering the death of one's own parent) and then measuring the reaction in one or more emotional response systems (see below).

It is our belief that emotional reactivity can be assessed accurately in vivo, that is, as emotions are actually produced. Procedures in which individuals are asked to indicate the emotional responses they think they would have or have had in particular situations measure different processes (e.g., emotional self-knowledge, knowledge of normative responses) and are prone to biased and erroneous reports.

25.3.1. 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 and intensity of emotion being experienced), to the highly complex (e.g., theories of emotion and emotional regulation, metacognitions about emotion, beliefs about the relationships between emotions and other aspects of the human condition such as health, wellbeing, and relationship stability).

We consider the basic building block of emotional understanding to be empathic accuracy—the ability to know what another person is feeling. This can be assessed in its simplest form by having people identify which particular emotion is shown in a photograph. Two common tests of this sort are the Florida Affect Battery (Bowers, 1992) and the Facial Expressions of Emotion (Young et al., 1992).

25.3.2. Emotional regulation

Gross (1998, p. 275) defines emotional regulation as: the processes by which individuals influence what happens to them 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.

Perhaps because the term ‘emotional regulation’ is so closely associated with reining in emotions, it is easy to think of emotional regulation as being limited to emotional inhibition. However, it is clear that emotional regulatory competence also involves the ability to amplify or exaggerate emotion in situations where the emotional signal to conspecifics must be clear and unequivocal.

Often emotional reactivity and regulation are difficult to separate. Take, for example, a situation in which a patient exhibits a very small behavioral response to a highly stressful film. Is this patient showing a low level of emotional reactivity or a high level of emotional regulation? The difficulty of making this distinction underscores the value of assessing the individual’s capacity to regulate emotion when instructed to do so. This capacity to regulate on demand can be determined with some certainty, whereas assessing the emotional regulation that occurs spontaneously will always be difficult to separate completely from emotional reactivity.

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25.4. Emotion types

There are three broad categories of emotion that should be considered when assessing emotion functioning: (a) negative emotions, (b) positive emotions, and (c) self-referralent emotions. Most contemporary emotion researchers and theorists do not view emotion as a monolithic, Thus, it is no longer tenable to assume that what holds for one type of emotion holds for all types of emotions.

25.4.1. 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 are characterized as having different associated patterns of facial expression, motor action, and physiological reaction that occur spontaneously will always be difficult to separate completely from emotional reactivity.

25.4.2. Positive emotions

Positive emotions were relatively understudied and their functions less well documented until recently. In our work, the role that positive emotions play in calming, soothing, and ‘undoing’ the physiological effects of negative emotions has been emphasized (Fredrickson and Levenson, 1998; Levenson, 1988). Others have focused on the role positive emotions play in broadening perspectives, increasing flexibility of response, and increasing group cohesion (Fredrickson, 1998; Iden, 1999).

25.4.3. Self-referential emotions

Self-referential emotions involve evaluation of the self with respect to social norms. They can be negatively toned (e.g., shame, guilt, embarrassment) or positively toned (e.g., pride). These emotions, which require some degree of self-consciousness and self-awareness, appear relatively late in ontogeny and phylogeny.

25.5. Emotion response systems

A comprehensive assessment of emotion should sample from the various systems that constitute the emotional response including: (a) self-reported emotional experience, (b) emotional expressive behavior, (c) peripheral physiology, and (d) emotional language.

25.5.1. Self-reported emotional experience

Self-reported emotional experience can be obtained in a number of different ways. In our laboratory, we ask participants to provide ratings of the intensity of their subjective experience for a list of discrete emotions (e.g., fear, anger, amusement) and dimensions (e.g., pleasantness, arousal) after an emotion eliciting event. Additionally, we sometimes have participants use a rating dial to indicate how they are feeling (positive-neutral-negative) continuously throughout an emotional experience (Mauss et al., 2005).

25.5.2. 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 coding systems designed to elicit emotional activity (facial action coding system [FACS]; Ekman and Friesen, 1978) or on multiple indicators including facial expression, tone of voice, and content of speech (Cotton, 1989; Gross and Levenson, 1993). FACS is the most exacting and laborious of these systems, allowing the coder to decompose any observed facial expressions into its component facial muscle actions based on repeated, slow-motion viewing of video recordings.

25.5.3. Peripheral physiology

Peripheral physiology is usually quantified in terms of selected measures of cardiovascular, electrodermal, respiratory, and somatic activity. Measurement is quite important because these systems are often used only under the influence of emotion for brief periods before they return to the service of other functions (e.g., homestasis). In our laboratory, we precede each emotion elicitation with a resting baseline period and then obtain measures continuously throughout the elicitation and during a post-elicitation ‘cooling down’ period. Analyses focus either on the times during which we attempted to stimulate emotion (e.g., while the participant watches a film) or when we have independent evidence that an emotional response has occurred (e.g., when an emotional facial expression appears during an interaction between a patient and caregiver).

25.5.4. Emotional language

Emotional language is often quantified by determining the frequency or proportion of words used in different
25.6. Laboratory tests of emotion

25.6.1. Acoustic startle reflex

The acoustic startle reflex is a primitive, defensive response to the threat posed by a sudden loud noise (Sokolov, 1963). It consists of a stereotyped pattern of somatic and facial muscle actions (Ekman et al., 1985) and attendant activation of autonomic nervous system response (Soto et al., 2005). We use a 115 db, 100 ms burst of white noise administered through loudspeakers behind the patient (roughly commensurate with a close proximity gunshot) to elicit the startle under three conditions, which enable us to probe different aspects of emotional functioning. In the unanticipated condition, the startle occurs without warning. This provides a good measure of emotional reactivity to a simple aversive stimulus (Sokolov, 1963). An acoustic stimulus of considerably lower amplitude (typically ranging from 95–100 db) will activate a smaller startle reflex (Lang et al., 1990) that can be assessed by electromyographic measurement of the intensity of the associated eye blink. To put this in perspective, a 115 db acoustic stimulus is more than 100 db+ louder than a 95–100 db acoustic stimulus. 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 eye blink is an indicator of higher cortical functioning such as attention and emotional processing. In particular it reflects affective valence-positive/approach states attenuate the amplitude of the eye blink and negative/avoidance states have a potentiating effect. Startle eye-blink modulation tests can provide useful information about underlying attentional and emotional state processes without being subject to demand characteristics or voluntary reporting biases (e.g., Bradley and Lang, 1994). These qualities make them particularly appealing for use with patient populations where self-report might be difficult or unreliable.

Startle eye-blink modulation can be considered in terms of valence match or mismatch. In the low negative the secondary response can take any of several forms, including amus- ement, embarrassment, anger, or fear. We have found that the secondary response can be quite variable to certain types of brain injury (e.g., dramatically reduced in frontotemporal lobar degeneration; Sturm et al., 2006).

25.6.2. Startle eye-blink modulation

The acoustic stimulus used to elicit the startle response 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 smaller startle reflex (Lang et al., 1990) that can be assessed by electromyographic measurement of the intensity of the associated eye blink. To put this in perspective, a 115 db acoustic stimulus is more than 100 db louder than a 95–100 db acoustic stimulus. 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 eye blink is an indicator of higher cortical functioning such as attention and emotional processing. In particular it reflects affective valence-positive/approach states attenuate the amplitude of the eye blink and negative/avoidance states have a potentiating effect. Startle eye-blink modulation tests can provide useful information about underlying attentional and emotional state processes without being subject to demand characteristics or voluntary reporting biases (e.g., Bradley and Lang, 1994). These qualities make them particularly appealing for use with patient populations where self-report might be difficult or unreliable.

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25.6.3. Films

Carefully selected excerpts from commercial and other films can be used to elicit emotions. Real-life emotions are often induced by dynamic, external visual and auditory stimuli that unfold over time, thus films have a relatively high degree of ecological validity. Films have been used in laboratory studies for years, going back to their early use to induce diffuse ‘stress’ responses (e.g., Lazarus et al., 1962).

Gross and Levenson (1995) identified a set of films that 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 have also been found to be useful for producing general positive and negative valenced states (Hubert and de Jong-Meyer, 1990). Film clips lend themselves to the assessment of emotional reactivity (by having participants simply watch the film), emotional regulation (by instructing participants to alter emotional responses), and emotional understanding (by having participants indicate the emotion being experienced by characters in the film). It is important to consider possible cognitive and language deficits when using films with patients. The complexity of films varies greatly, thus it is important to match films to the cognitive capabilities of the patients being assessed. We have found that, even with highly impaired patients, it is possible to elicit emotion with carefully selected, thematically simple film stimuli.

25.6.4. Slides

The International Affective Picture System (Lang et al., 1988) consists of over 700 colored images of situations that are selected because of their properties of evoking emotion and being internationally understandable. These pictures have been used in a large number of studies of emotional, cognitive, social, and biological functioning. Normative ratings of pleasure and arousal for each picture are available, which help in stimuli selection and comparing findings across laboratories. A multi-system assessment of frontal lobe function has been made to find stimuli that fill all quadrants of the pleasure/arousal effective space, including the difficult quadrant comprised of stimuli that are unpleasant, but minimally arousing.

The pictures utilize real-world settings in order to induce the automatic perception of emotion. Although in theory the full array of specific emotions could be represented, there are clear biases (e.g., pictures of comic strips and mutilation in the high unpleasant/high arousal quadrant that typically elicit the emotion of disgust).

The IAPS slides are primarily useful for assessing emotional reactivity. Slides that portray emotional facial expressions could also be used to assess that aspect of emotional understanding. Because these pictures are static, cognitively simple, and do not require language processing, they can be very useful when working with impaired patients.

25.6.5. Relived emotions

Recalling memories of emotionally significant events can be a powerful elicitor of emotion. Long-term memories of emotional events may be stored in particularly strong forms due to the interaction of the adrenergic system (which is active during strong emotions) and the amygdala (Cahill, 1996; 1999). Emotional memories may be relatively spared in individuals suffering from retrograde amnesia that affects emotional or semantic autobiographical memories (Daum et al., 1996; Hamann et al., 1997). A growing body of research suggests that autobiographical memory is mediated by complex networks of frontal, temporal, and occipital areas that differ as a function of type of knowledge, emotional valence, and temporal remoteness (Fink et al., 1996; Conway et al., 2001; Markowitsch, 1999; Peelle et al., 2003).

We use emotional memories of two kinds: personally relevant, autobiographical emotional memories (e.g., recalling one’s saddest or happiest moment), and memories of shared historic or group events (‘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 per se across categories (e.g., all emotion words, negative emotion words, fear, words). A number of computer-assisted approaches can be used that facilitate this kind of text analysis (Mengenthaler, 1975; 1978). Multisystem assessment of emotional functioning has a number of advantages, especially when working with patients for whom measurement of one or more systems may be unreliable (e.g., self-report of subjective experience in aphasic patients). Multisystem assessment is also important when the pathology is thought to affect the organization or coherence among response systems (Mauss et al., 2005).

Intact autonomic responding to non-emotional stimuli has been found in the context of frontal lobe injury (Damasio et al., 1990). However, there is evidence that patients with frontal lobe damage (i.e., orbitofrontal damage) show disrupted autonomic responding to emotional and social stimuli (Damasio et al., 1990; Roberts et al., 2004) in spite of normal reactivity to an unanticipated startle stimulus (Mauss et al., 2004). Injury to the amygdala (e.g., from head injury or neurodegenerative disease) is likely to also damage the pathways that connect regions of the frontal lobes (e.g., anterior insula) with subcortical structures (e.g., hypothalamus). Although these pathways are thought to be involved in autonomic responding to emotional stimuli, it is unclear if their disruption affects the kind of low-level autonomic reactivity embodied in the startle response (Chu et al., 1997).
individuals but can vary greatly in terms of personal salience and capacity to elicit emotion.

To identify personally relevant autobiographical memories, we use a semi-structured interview format to prompt participants to retrieve memories of specific events that elicited a specific emotion (Ekman et al., 1983). Subsequently, participants are asked to relive those memories as strongly as possible. Emotional responses (self-reported subjective experience, expressive behavior, physiology, language) are assessed during both the retrieval and reliving periods. We consider relived memories to be most useful for assessing emotional reactivity, less so for assessing emotional regulation (it is difficult to both recall/relive a memory and control it at the same time), and least useful for assessing emotional understanding. Because memory is involved, these tasks need to be used judiciously with patients who have memory impairments.

25.6.7. Interpersonal interaction

Emotional displays are thought to serve important interpersonal functions, such as facilitating social bonds (e.g., joy during play; Fredrickson, 1998; Panksepp, 2000) and eliciting help from others (e.g., crying as a distress signal; Bowlby, 1969). Exhibiting these displays appropriately, as well as successfully reading and responding to the emotions of others, are critical skills for adaptive emotional functioning. We assess socioemotional functioning in the laboratory by using an interpersonal interaction task that we originally developed to study the interactions of husbands and wives (Levenson and Gotman, 1983). This task allows us to sample naturalistic interpersonal interaction between patients and their spouses, partners, or caregivers. It provides a 'real world' assessment of emotional reactivity (generating emotional responses during the interaction), emotional regulation (modulating emotions appropriately for the situation), and emotional understanding (recognizing and responding to the emotions of the other person).

In this task, the patient and interaction partner sit in chairs facing each other and engage in 15-minute conversations preceded by a 5-minute silent resting period; during this 20-minute task behavior is videotaped and physiological monitoring continuously on the valence (negative-neutral-positive) of their own emotions during the interaction.

Table 25.1: Laboratory tests of emotional processing

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INTERPERSONAL INTERACTIONS PROVIDE AN ADDITION WAY OF ASSESSING EMOTIONAL UNDERSTANDING. AFTER THE CONCLUSION OF EACH CONVERSATION, WE HAVE PARTICIPANTS VIEW THE VIDEO RECORDING AND USE A RATING SCALE TO CONTINUOUSLY REPORT ON THE VALENCE (NEGATIVE-NEUTRAL-POSITIVE) OF THEIR OWN EMOTIONS DURING THE INTERACTION.
25.7. Laboratory and bedside testing

In Table 25.1 we summarize the various laboratory methods used in emotional processing tasks, processes, and response systems they sample; their advantages and disadvantages; and their suitability for use at the bedside.

25.8. Conclusion

In this chapter we have provided an overview of a more differentiated view of emotional functioning in neurological patients than has been typical in the clinical and research literatures. It is our belief that comprehensive testing of emotional functioning should consider key emotion processing components, types, and response systems they involve. In summary, although emotional stimuli can provide a vivid snapshot of emotional strengths and deficits, including important deficits, they may not be revealed using other methods.

25.6.8. Control tasks

When working with frontal lobe patients, we typically have access to a fairly complete clinical examination and neuropsychological workup. This information is used in conjunction with right hemisphere lesions involving basal ganglia and temporoparietal cortex and atrophy in frontal and diencephalic areas in acute stroke patients (Starkestein et al., 1994).

Although static emotional stimuli are quite convenient, interpersonal interaction provides a powerful and natural way to study most aspects of emotional functioning. Even with quite impaired patients, interpersonal interaction can provide a vivid snapshot of emotional strengths and deficits, including important deficits (e.g., mutual gaze patterns, listening behaviors) that may not be revealed using other methods.
26.1. Introduction

With the increasing of the population of older adults, there is a growing interest in improving quality of life in old age and in early detection and prevention of cognitive decline. One important aspect of this endeavor is to identify individuals at an earlier point in the cognitive decline associated with aging and fully developed symptoms of dementia such as those seen in Alzheimer's disease (AD). The rationale for the study of MCI is derived from the assumption that the sooner one intervenes in a degenerative process, the more likely the damage done to the central nervous system can be prevented. Hence the construct has been developed to represent a transitional stage between the cognitive changes of aging and very early dementia.

26.2. History

The concept of MCI has evolved considerably over the years. The first attempt to characterize cognitive changes at the normal tail-end of the continuum dates back to 1962, where VA Kral used the term senescent forgetfulness to describe very early memory impairment in AAMI (Levy, 1994). The operational criteria for MCI of AAMI were felt to be variant of normal aging (Crook et al., 1985). The international psychogeriatric association coined the term age-associated memory impairment (AAMI) to refer to memory changes that are assumed to decline in normal aging and included age- and education-adjusted normative values. Alternatively, the Canadian Study of Health and Aging defined cognitive impairment to memory domain only and comparison of memory function in older adults to performance of young adults. As such, AAMI was unable to delineate individuals at risk of developing pathophysiological conditions from those undergoing the process of normal aging. The international psychogeriatric association coined the term age-associated cognitive decline (AACD) in an effort to bypass many of the shortcomings recognized in AAMI (Levy, 1994). The operational criteria for AACD referenced a variety of cognitive domains presumed to decline in normal aging and included age- and education-adjusted normative values. Alternatively, the Canadian Study of Health and Aging coined the term cognitive impairment-no dementia (CIND) to identify individuals with impaired cognitive function but not of sufficient severity to constitute dementia (Graham et al., 1982; 1988; Flicker et al., 1991). Another classification scheme of CIND encompasses individuals with lifelong disability. Recently, some investigators have defined subsets of persons with CIND who more closely resemble MCI subjects (Fisk et al., 2003).

The term MCI was initially used in the late 1980s by Reisberg and colleagues to describe individuals with a Global Deterioration Scale (GDS) of 3 (Reisberg et al., 1982; 1988; Flicker et al., 1991). Another classification has used the Clinical Dementia Rating Scale (CDR) to identify individuals with CDR 0.5 stage of 'questionable dementia.' (Morris, 1993; Morris et al., 2001) While both GDS and CDR are useful scales for classification of individuals along the continuum of severity of cognitive impairment, they do not necessarily correspond to


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Chapter 26

Neuropsychological characterization of mild cognitive impairment

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