

amplitude is less certain and may depend on whether a representation of the stimulus has been laid down by prior training. We discuss the possible organization of these responses in the auditory cortex and how the mechanisms underlying their modification by experience may evolve over the life span.

#### FUNCTIONAL AND STRUCTURAL BRAIN ATTRIBUTES IN RELATION TO PITCH PERCEPTION AND MUSICAL ABILITY

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The pitch of harmonic complex sounds, such as instrumental sounds, is perceived by either decoding the fundamental or spectral pitch, respectively. Applying an auditory judgment task, a large cohort of musicians including symphony orchestra musicians was classified to be either fundamental or spectral pitch listeners, dependent on the dominant perceptual mode. Both MRI and MEG demonstrated a strong neural basis for both types of pitch perception. The left-right asymmetry of gray matter volume in lateral Heschl's gyrus and the underlying auditory evoked P50m activity in response to harmonic complex sounds correlated strongly with pitch perception and musical instrument preference irrespective of musical ability. In particular, fundamental pitch listeners revealed leftward asymmetry and played percussive or high-pitched instruments (e.g. drums, piano, guitar, trumpet or flute), whereas spectral pitch listeners possessed predominantly a rightward asymmetry and preferred lower-pitched melodic instruments (e.g. bassoon, saxophone, french horn, organ or double bass) and singing. Furthermore, professional musicians exhibited twofold larger gray matter volume and fivefold larger P50m magnitude as compared to non-musicians. The gray matter volume reflected only musical aptitude, whereas the P50m magnitude only correlated strongly with musical long-term practice. Overall, it is likely, that both magnitude and asymmetry of lateral HG, and related perceptual mode, may have impact on preference of timbre, tone and size of particular musical instruments and on musical performance.

#### THE INSIDE STORY OF ADDICTION: CONTROL OF DRUG EFFECTS BY INTEROCEPTIVE CUES

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It is well-established that cues present at the time of drug administration become associated with the drug effect. These cues elicit conditional responses that mediate tolerance (when the drug is administered) and "withdrawal symptoms" (when the drug is not administered). The contribution of predrug cues to tolerance and withdrawal typically is evaluated with readily-manipulated environmental cues; however, there is evidence that interoceptive cues, as well as exteroceptive cues, become associated with a drug effect. We have been studying two types of interoceptive cues: (1) pharmacological cues inherent within an administration (i.e., early drug-onset cues as signals for the later, larger drug effect), and (2) self-administration cues, (i.e., the association that develops, in the organism that self-administers a drug, between response-initiating - or response-produced - cues and the drug effect). There is evidence that these interoceptive cues function as do exteroceptive cues in the control of tolerance and the expression of withdrawal symptoms. Moreover, these interoceptive cues are highly salient and may overshadow simultaneously-present exteroceptive cues. The results have implications for addiction treatment.

#### Symposium 15

#### AFFECTIVE AND MOTIVATIONAL PERSPECTIVES ON ERROR-RELATED BRAIN ACTIVITY

Chair: Greg Hajcak, University of Delaware

The error-related negativity (ERN or Ne) is a response-locked fronto-centrally maximal midline event-related brain potential (ERP) that peaks nearly 50 ms

after errors. The ERN has been source-localized to the anterior cingulate cortex (ACC) and is thought to reflect the mismatch between an intended and actual response; this is conceptualized as a reward-prediction error in the reinforcement learning theory of the ERN, and in terms of error-correcting activation evident in the response-locked ERP from the perspective of the conflict theory of the ERN. Both of these theories conceptualize the ERN purely in terms of information processing. The major goal of this symposium is to consider the relationship between error-related brain activity and both affective and motivational factors, and how these data relate to contemporary theories of the ERN and ACC function. Similarly, the role of affective and motivational factors on the error positivity (Pe) - a second ERP that follows the ERN and is maximal at centroparietal midline sites - will also be discussed. Together, these presentations will clarify the sensitivity of both the ERN and Pe to motivational, affective, and personality factors, and shed light on the nature of the ACC activity during response monitoring.

#### ANTERIOR CINGULATE CORTEX AND NEGATIVE AFFECT IN EVALUATION OF EXPECTANCY VIOLATIONS

Phan Luu  
University of Oregon and Electrical Geodesics, inc

Over the past several years, research has shown that affective reactions are central to action monitoring. In particular, when errors are committed the affective response appears to be predominantly negative. Measures of action monitoring and action outcomes, such as the error-related negativity and mediofrontal negativity, respectively, have been shown repeatedly to correlate with both trait and state measures of negative affect. It is proposed that this relation between negative affect and monitoring of actions and their outcomes reflects the role of the endogenous opiates in evaluation.

#### ERROR VALUE, AFFECTIVE DISTRESS, AND THE ERN/PE COMPLEX

Greg Hajcak, Jason S. Moser, & Robert F. Simons  
University of Delaware

A number of studies have reported abnormalities of the ERN in relation to psychopathology, especially disorders characterized by affective distress (e.g., anxiety and depression). In this talk, I will first review studies from our laboratory in which we investigated the relationship between error-related brain activity (ERN and Pe) and affective distress between-groups. In these studies, anxious participants have consistently been characterized by an increased ERN, and a reduced Pe. Next, I will review four subsequent studies in which we investigated the role of affective distress and error value on error-related brain activity within-subjects. Two studies involved manipulating state anxiety and affective distress, and two studies involved manipulating the value of errors. Based on these results, I will suggest that the increased ERN in anxious subjects might be accounted for by motivational factors, such as the tendency for affectively distressed subjects to overvalue their errors. On the other hand, I will argue that the reduced Pe in anxious subjects relates more directly to state measures of affective distress. The utility of combining within- and between-group designs will be highlighted in efforts to understand the relationship between error-processing and affective distress, and these results will be discussed in terms of current theories of response monitoring and ACC function.

#### ERROR-RELATED POTENTIALS: RELATIONS WITH REWARD AND PUNISHMENT SENSITIVITY, AND CORTISOL REACTIVITY

Mattie Tops, Maarten A.S. Boksem, & Anne E. Wester  
University of Groningen

It has been proposed that the response-locked potential called the error-related negativity (ERN/Ne) reflects a negative reward prediction error signal that is

carried by dopaminergic input to the anterior cingulate cortex. Recently the ERN has been positively related to individual difference measures of negative affect and neuroticism, which suggests the ERN may be related to punishment, but not reward, sensitivity. In the present study we investigated the relationship between error-related potentials and temperament scores that reflect punishment and reward sensitivity (the BIS and BAS, respectively). In addition, we sought to determine whether error-related brain activity was related to cortisol changes across the experimental testing session. Individual differences in levels or responses of the stress hormone cortisol have been related to stress responsivity and sensitivity to reward and punishment. To this end, saliva samples were collected for cortisol measurement before and after an Erikson Flanker task from twenty-four female subjects aged 18–22. There was a strong positive correlation (.85) between the cortisol increase during task performance and the difference ERN (error trials minus correct trials). BIS scores correlated positively with the ERN but not with the error positivity (Pe). BAS scores correlated positively with the Pe but not with the ERN. We discuss the relevance of the present results in terms of potential mechanisms responsible for the generation of error-related potentials.

#### ERROR CORRECTION AND ERROR SIGNALING - DIFFERENTIAL MOTIVATIONAL EFFECTS REFLECTED IN THE ERN

Markus Ullsperger

Max Planck Institute for Human Cognitive and Brain Sciences

The error-related negativity (ERN) is an event-related potential component associated with errors. An immediate consequence of an error can be its correction by a second key press. Alternatively, participants can be instructed to merely signal error detection by pressing a specific signaling button. It is conceivable that the opportunity to correct errors has a different motivational effect on the participant than the instruction to merely signal errors. When errors can be corrected, they may seem more admissible. To compare behavioral and event-related potential correlates of immediate error correction and signaling, we tested 15 participants in two sessions of a flanker task. In one session they were asked to immediately correct errors by pressing the correct response, whereas in the other session they should press an error signaling button on which no response to the primary task was mapped. Session order was counterbalanced. Participants made more errors and less late responses during the correction session than during the signaling session, suggesting increased response impulsivity. The ERN amplitude was significantly increased during error signaling, and no significant relationship to the decreased error rate was found. In accordance with previous findings it seems that increased response impulsivity and lower motivational significance of errors in the correction session are reflected in reduced ERN amplitudes. An additional finding is that error correction and signaling responses were followed by a second frontocentral negativity, the correction-related negativity.

#### THE ERN AND THE EMOTIONAL MODULATION TO EVENTS

Sidney J. Segalowitz, Diane L. Santesso, & Jane Dywan  
Brock University

We have been focusing on the extent to which the ERN is sensitive to the way the person self-modulates to events. We have shown that manipulating the degree to which the participant is concerned about errors alters the ERN response to those errors, an effect moderated by conscientiousness and neuroticism. We have further documented a relation between the ERN amplitude and empathy in general, which agrees with other work associating empathic responses with ACC activation. One can also modulate one's affective state by external means, and the ERN amplitude should be lower in those who engage in sensation-seeking and risk-taking behaviors. We will present evidence of the ERN having an inverse relation with sensation-seeking, risk-taking and sensitivity-to-reward. These results support a model of the ACC as a modulator of affective response to events (whether internal or external) and the ERN as an index of this modulation.

#### Symposium 16

#### PSYCHOPHYSIOLOGICAL SIGNATURES OF APPRAISAL

Chairs: Klaus R. Scherer, University of Geneva & Craig A. Smith, Vanderbilt University

Most research conducted by appraisal theorists has relied on self-report measures, although many appraisal processes are expected to be rapid, unconscious, and automatic. This symposium emphasizes the importance of psychophysiological measures in studying the appraisal process. First, Aue et al. present first evidence for differential and sequential efferent effects of different appraisals on ANS and SNS responses, as proposed by Scherer's Component Process Model of Emotion. The results suggest that different physiological variables can be considered as markers for different underlying mechanisms. Second, Dan et al. present a series of studies using a secondary task paradigm to examine timing and SNS effects of novelty and valence appraisal. Third, Wright & Gendolla demonstrate that there is no simple relationship between fatigue (related to ability appraisals) and cardiovascular activity in challenge situations. Instead, the relationship appears to be dependent on task difficulty and importance. Fourth, Kirby & Smith review data from a series of studies, with the accent on a differential implication of the ANS and the SNS in appraisals. The contributions and potential implications for psychophysiological appraisal research are discussed by Kappas.

#### FIRST EVIDENCE FOR DIFFERENTIAL AND SEQUENTIAL EFFERENT EFFECTS OF GOAL RELEVANCE AND GOAL CONDUCTIVENESS APPRAISAL

Tatjana Aue<sup>1</sup>, Anders Flykt<sup>2</sup>, & Klaus R. Scherer<sup>1</sup>  
<sup>1</sup>University of Geneva & <sup>2</sup>Mid Sweden University

Several appraisal theorists predict that appraisal outcomes produce specific patterns of ANS and SNS activity. In addition, Scherer has suggested that these signatures can help to confirm the theoretical claim that appraisal results for different criteria become available in a fixed sequence, e.g., novelty < goal relevance < goal conduciveness < coping potential. In the context of a memory task, participants were presented with pictures displaying biological and cultural threat stimuli or neutral stimuli (goal relevance manipulation) with superimposed symbols signaling monetary gains or losses (goal conduciveness manipulation). Results for heart rate and facial electromyogram show differential efferent effects of the respective appraisal outcomes and provide first evidence for sequential processing. It is suggested that different physiological variables can serve as markers of different underlying processes, with activity over the brow region (M. Corrugator supercilii) signaling cognitive processing, heart rate changes representing response mobilization for action preparation, and activity over the cheek region (M. Zygomaticus major) serving communicative purposes.

#### ON USING RT AND FACIAL EMG TO EXAMINE THE TEMPORAL SEQUENCE OF NOVELTY AND VALENCE APPRAISAL

Elise S. Dan<sup>1</sup>, Tatjana Aue<sup>1</sup>, Anders Flykt<sup>2</sup>, & Klaus R. Scherer<sup>1</sup>  
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Some appraisal theorists suggest that appraisal unfolds over time and that successive stimulus evaluations on different criteria yield efferent effects in a fixed order. This work aims to determine the relative time window during which the appraisal process produces an identifiable outcome on two specific appraisal criteria, novelty and valence, using behavioral parameters and facial EMG. A first study showed that a secondary task technique paradigm can be potentially useful to assess the timing of valence appraisal outcome by combining IAPS picture viewing with a probe detection task. The response latency to the probe is suggested to reflect resource allocation at systematically manipulated delays between picture onset and appearance of the probe. In a second experiment both timing and SNS effects of novelty and valence appraisals were investigated using RT and facial EMG (M. Corrugator supercilii, M. Zygomaticus major, M. Frontalis) assessment. In addition to presenting data from these studies, theoretical implications and issues for future research will be discussed.