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Modulation of involuntary and voluntary behavior following emotional stimuli in healthy subjects

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Abstract

Introduction: Alterations of behavior control are core symptoms of various psychiatric disorders. Patients present with changes in complex behavior patterns and basic motor functions. Little is known about emotional modulation of voluntary behavior. Therefore, a paradigm was developed to study simultaneously influence of emotions on voluntary and involuntary movements.
Method: Healthy volunteers (n=30) documented aspects of their mood and personality including depression, anxiety, and impulsivity. Individuals were instructed to view color slides of different emotional content and switch off the slide after by pressing a button, which was placed in a standardized distance from the resting point. The startle reflex was elicited while looking at the slides and quantified by EMG. Kinematic measures of hand movements by infrared detection were used to analyze the patterns of voluntary movements.
Results: This study confirmed previous findings about the modulation of the startle reflex by emotional stimuli which may reflect activity of the amygdala and subcortical stimulus processing. Voluntary movements, which may result from cortical processing of stimuli, were not influenced by the emotional context. In individuals with higher impulsivity scores, the startle reflex amplitudes were lower and relative time to peak velocity of the movement smaller.
Conclusion: Voluntary movements were not modulated by emotional stimuli, but time to peak velocity was shorter in individuals with greater impulsivity. The ability to generate adequate behavior as a key function of the brain is relevant for social functioning and activities of daily living. The studied paradigm could be useful to assess impulsivity and behavior control in psychiatric disorders.

Keywords: Behavior control; Impulsivity; Startle reflex; Voluntary movement

1. Introduction

Alterations of behavior and impaired behavior control are core symptoms of many psychiatric disorders including affective disorders (Sobin and Sackeim, 1997), schizophrenia (Cheung and Schweitzer, 1998) and personality disorders (Moeller et al., 2001). Davidson et al. (2000) suggested that a dysfunction in the neural circuitry of emotion regulation plays a key role in poor behavior control, leading to impulsive and aggressive acts. Not only complex behavior is altered in psychiatric disorders, but also basic motor skills such as walking (Lemke et al., 2000a),

Abbreviations: ANEW, Affective Lexicon of English Words; ANOVA, analysis of variance; ANCOVA, analysis of covariance; BDI, Beck Depression Inventory; BIS, Barratt Impulsiveness Scale; EMG, electromyography; DFM, duration of finger movement; DHM, duration of hand movement; FMC, finger movement curve; IADS, International Affective Digitized Sound System; IAPS, International Affective Picture System; HMC, hand movement curve; MINI, Mini-International Neuropsychiatric Interview; NEO-FFI, NEO Five-Factor Personality Inventory; PVF, peak velocity finger; RTPVF, relative time to peak velocity finger; RTPVH, relative time to peak velocity hand; SAM, self-assessment manikin; SCID, Structured Clinical Interview for DSM; SE, startle-eyeblink reflex; SEM, startle-eyeblink modification; STAI, State-Trait Anxiety Inventory.

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handwriting and drawing (Sabbe et al., 1996; Mavrogiorgou et al., 2001). Padberg et al. (2001) found indications for modulatory effects of emotions on psychomotor performance. However, the impact of the emotional context on voluntary movements has not been studied yet.

1.1. Emotional stimuli

Emotionally evocative stimuli for experimental investigations may be presented by different methods including the International Affective Picture System (IAPS) (Lang et al., 1970), the International Affective Digitized Sound System (Bradley and Lang, 1999a,b) and the Affective Lexicon of English Words (Bradley and Lang, 1999a,b). The IAPS is a large set of color photographs that includes a wide range of semantic categories. It has been intensively used to investigate both subcortical (Lang et al., 1990) and cortical functions in emotional processing (Northoff et al., 2000). The IAPS showed reliability in different experimental settings in healthy controls and in patients with various psychiatric disorders (Filion et al., 1998).

1.2. Involuntary movement: startle reflex

Relevant sensory input is projected directly from the thalamus to other subcortical areas such as the amygdala. Extensive anatomical connections to cortical and subcortical areas suggest that the amygdala might have a neuromodulatory role with regard to both sensory processing and response coordination (Morris et al., 1998). The output of the amygdala depends on the affective significance of the stimuli (Nishijo et al., 1988). Animal and human studies examined the fear-potentiated startle reflexes in which the influence of attendant emotion on the magnitude of the startle-response is measured (Filion et al., 1998). The human startle-eyeblink reflex (SE) is a short-latency defensive behavior, elicited by a sudden and intense acoustic stimulus. The amplitude of the SE is augmented in an aversive context and inhibited or attenuated in a non-aversive context. In human experiments, the SE is usually elicited by a sudden burst of noise while watching affective color slides. The magnitude of the SE measured using the amplitude of the EMG at the musculus orbicularis occuli increases in the presence of unpleasant stimuli and decreases in the context of pleasant stimuli (Lang et al., 1990). The neural pathway of this defensive reflex includes the central nucleus of the amygdala that interferes with the nucleus reticularis pontis caudalis, the second neuron of the SE pathway. The amygdala is believed to play a key role in the stimulus dependent modification of the startle reflex (Lee et al., 1996). In order to study sensorimotor gating, attention and emotional processing, startle-eyeblink modification (SEM) paradigms have been applied to a variety of clinical populations, including affective disorders, schizophrenia and personality disorders (Filion et al., 1998).

1.3. Voluntary movement: reaching movement

Observable movements are the result of cortical and subcortical processing of a given stimulus. The reaching movement is a functionally relevant and common motor task in activities of daily living. Its neuronal and behavioral organization has been studied in human adults, children and in animals (Jeannerod, 1988; Kuhtz-Buschbeck et al., 1998). Spatial positioning of the arm seems to be coded predominantly in areas of the premotor cortex, which are linked to distinct regions of the posterior parietal lobe (Jeannerod et al., 1995). Multi-joint goal-directed movements can be performed in an almost infinite number of equivalent variations. However, unrestrained reaching movements of adults show stereotypical kinematic features (Kalaska and Crammond, 1992). Hand transport is characterized by a single-peaked smooth, approximately bell-shaped velocity profile including an acceleration and deceleration phase. The velocity increases with the target distance, which has been proposed to be a way of achieving an invariant movement duration (Jeannerod, 1984). The velocity itself may not be a good criterion for emotional modulation of voluntary movements. However, the velocity profile is a highly reliable, stable marker in healthy individuals and the behavioural manifestation of the central nervous motor program. Various basic motor tasks have been found to be impaired in psychiatric patients (Lemke et al., 2000a, 1997; Sabbe et al., 1996).

To our knowledge, no paradigm has been described which allows simultaneous examination of both, voluntary and involuntary motor responses to emotional stimuli. Therefore, the goal of this study was the assess effects of emotional stimuli and mood, anxiety, and impulsivity simultaneously on involuntary and voluntary motor functions in healthy individuals. These measurements may be useful for further understanding of the behavioral alterations and impaired behavior control in psychiatric disorders.

2. Methods

2.1. Subjects

The study sample consisted of 30 healthy subjects (14 females and 16 males, mean age 30.5±8.9 years, range 19–56 years, profession: worker: 2, employee: 3, academic: 21). Subjects were recruited from hospital staff and medical students as well as their relatives and acquaintances. Eligibility for the study was initially assessed through a brief interview. To be eligible, subjects were required to demonstrate adequate reading and comprehension skills for completing the informed consent agreement and demographic, personality, and mood state questionnaires. Potential subjects were excluded if they