



The acoustic startle reflex and its modulation: effects of age and gender in humans

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Abstract

The acoustic startle reflex and its modulation by prepulse inhibition (PPI) and habituation are used in many studies in different fields of neuropsychiatric research. The aim of this study was to examine the effects of age and gender on PPI, startle magnitude, and habituation in healthy human volunteers. Twenty-seven male and 28 female participants of four different age groups (range: 20–60 years) were investigated in an acoustic startle paradigm using a startle stimulus of 115 dB and a prepulse of 86 dB (16 dB over the white noise background) with five different lead intervals (30, 60, 120, 240, and 2000 ms). Seventeen males and 16 female participants were tested three times at monthly intervals. Aged participants showed significantly lower startle magnitude and significantly more habituation than younger participants, but there was no effect of age on PPI or prepulse facilitation. Moreover, there were no effects of gender on startle magnitude, PPI, prepulse facilitation, or habituation measures. Healthy males and females exhibited stable startle magnitudes and PPI across sessions. The results demonstrated that PPI and startle are reliable measures of sensory information processing in both genders and that startle magnitude and habituation are age-dependent measures.

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1. Introduction

The acoustic startle reflex and its modulation, including prepulse inhibition (PPI) and habituation, are commonly used in various studies in animals and human participants. The startle response is defined as “an immediate reflex response to sudden, intense stimulation” (Landis and Hunt, 1939). The acoustic startle reflex, elicited by a sudden and intense auditory stimulus (Davis, 1984), is increased in patients suffering from anxiety disorders (summarized in Koch, 1999), or in subjects viewing aversive pictures (Lang et al., 1990). PPI and habituation are forms of modulation of the startle reflex that are commonly viewed as operational measures of information processing functions (Braff and Geyer, 1990). After a weak prepulse or after repeated presentations of startle stimuli (habituation), the amplitude of the startle reflex is reduced. Schizophrenia-spectrum disorders exhibit deficient PPI (Braff et al., 1978, 1992), an abnormality that has been suggested to be a trait-linked marker of schizophrenia (Braff, 1993; Cadenhead et al., 1993). However, deficits in PPI are not specific to schizophrenia, and have been found in various neuropsychiatric disorders having known dysfunctions in cortico-striato-pallido-thalamic circuitry (Braff et al., 2001; Swerdlow et al., 2001b). The neurotransmitter systems and functional neuroanatomy of the startle reflex and its modulation have been studied extensively in animal and human studies (for reviews see Geyer et al., 2001; Swerdlow et al., 2001b; Koch, 1999; Braff et al., 2001).

Startle measures exhibit relatively high variability in healthy subjects. In a meta-analytic approach, Hamm et al. (2001) demonstrated that different studies report comparable values of startle measures in schizophrenia patients, but appreciable variability in healthy participants. Hence, differences in startle measures across various studies with schizophrenia-spectrum patients may not depend on differences between patients but on the composition of control groups. In pharmacological studies with repeated testing, within-subject designs and matching strategies are commonly used to reduce the variability of startle measures (Swerdlow et al., 2001a). However, within-subject designs are not applicable in all contexts. For example, to examine information-processing deficits across different neuropsychiatric disorders, a comparison between patient and control groups is necessary. Therefore, it is useful to clarify the influence of potentially important variables on startle magnitude, PPI, and habituation.

To provide more information for future human studies of the startle reflex, the present study examined the effect of gender and age in healthy human participants on startle magnitude, PPI, and habituation. Age and gender could well contribute to the variability in startle and PPI measures described in studies with healthy human participants. The effects of age and gender on startle measures have typically been examined in animals. Studies in rodents show that the magnitude of the acoustic startle reflex is age-dependent (Rinaldi and Thompson, 1985; Varty et al., 1998; Ison et al., 1997). Furthermore, young rodents showed less habituation than aged rodents (Rinaldi and Thompson, 1985; Varty et al., 1998). In contrast, PPI was age-independent in studies of mice (Ison et al., 1997) but was reduced somewhat in a study of very old rats (Varty et al., 1998). Furthermore, previous studies of gender

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