

## Personality and Regional Cerebral Blood Flow

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**Summary:** The extraversion–introversion dimension of personality is believed to have an inverse relationship with cortical arousal. Brain capillary perfusion is a well established index of brain function and arousal. Regional cerebral blood flow was measured in 51 right-handed females whose personality structure was examined with the Eysenck Personality Inventory (EPI). Significant inverse correlations were found between the brain blood flow and the extraversion–introversion score of EPI.

Personality encompasses the fundamental characteristics and ways of behaviour of an individual which determine perception of and reaction to the environment, and that of the environment towards him/her. Personality characteristics which pervade all aspects of adult behaviour are relatively stable over time. Personality has been the focus of intense research from many theoretical viewpoints, especially behavioural and social, but little is known about the biological mechanisms which underlie the behavioural characteristics of an individual. Divergent views exist about the best ways to measure personality, and a wide variety of classificatory systems have been proposed. Most of these systems are based exclusively upon the behavioural and social aspects (Hall and Lindzey, 1968).

Eysenck propounded a two dimensional (extraversion–introversion and neuroticism–stability) theory of personality which has had heuristic value for subsequent psychological as well as biological research (Eysenck, 1947; Eysenck, 1967; Eysenck, 1970; Morris, 1979). He developed an inventory, the Eysenck Personality Inventory (EPI) (Eysenck and Eysenck, 1968), for the measurement of these two dimensions of personality which were claimed to account for most of the variance in the personality domain. Individuals scoring high on the extraversion scale tend to be outgoing, impulsive, and uninhibited having many social contacts and frequently taking part in group activities. An introvert, a quiet retiring sort of person, introspective, more fond of books than people, who is reserved and distant except to intimate friends, obtains a low score on this dimension. High scores on the neuroticism scale are indicative of emotional lability and over-reactivity. These individuals are emotionally over-responsive and tend to have difficulties in returning to a normal state after emotional experiences. Such

people frequently complain of vague somatic upsets of a minor kind, such as headaches, digestive troubles, insomnia, backaches, etc., and also report many worries, anxieties and other disagreeable emotional feelings (Eysenck, 1947; Eysenck, 1967; Eysenck, 1970; Morris, 1979).

Large numbers of studies conducted on the neurophysiological aspects of these two dimensions suggest an inverse relationship between extraversion–introversion and cortical arousal. Extraverts, who are underaroused, seek to increase their arousal levels through external stimulation and appear outgoing and gregarious. Introverts, whose basal arousal is chronically high, tend to avoid additional stimulation and are seen as quiet and reserved. Neuroticism does not seem to be related to cortical arousal; it is believed to be more intimately associated with the limbic system. Studies involving normal and abnormal populations in which cortical arousal was measured using a wide variety of techniques (mostly indirect) involving sensory thresholds, effects of distraction, stimulus intensity and trans marginal inhibition, flicker phenomenon (critical frequency of flicker-fusion), responses to stimulant and sedative drugs, levels of autonomic nervous system activity, susceptibility to fatigue, reactive inhibition, EEG, speed of conditioning, etc., support these hypotheses (Eysenck, 1947; Eysenck, 1955; Eysenck, 1967; Eysenck, 1970; Morris, 1979; Prentky, 1979; Shagass and Kerenyi, 1958; Lynn, 1960; Lolas and Aguilera, 1982; Hinton and Craske, 1977; Kondo *et al.*, 1978). Research conducted in the USSR using a similar concept of personality (strength of the nervous system) provides further substantiation (Gray, 1967).

In the normal brain, blood flow and function are closely coupled (Raichle *et al.*, 1976; Sokoloff, 1981; Ingvar and Lassen, 1975; Risberg, 1980; Meyer, 1978).

Changes in brain arousal levels have been shown to be associated with parallel changes in cerebral blood flow (CBF) (Obrist *et al*, 1976; Ingvar and Soderberg, 1958; Ingvar, 1979; Meyer *et al*, 1978; Pearce *et al*, 1981). CBF has several advantages over the previous techniques used for measuring arousal. It measures brain arousal directly, and it is possible to quantify levels of activity in different parts of the brain.

We examined the relationship between the two dimensions of personality as measured by the Eysenck Personality Inventory and regional CBF quantified via the  $^{133}\text{Xe}$  inhalation technique (Obrist *et al*, 1975; Meyer *et al*, 1978; Risberg, 1980).

### Method

Fifty-one right handed females (mean age 31.99, SD 8.28 years) participated in the study. All the subjects were examined by a physician to exclude present and past physical and/or mental illnesses. The subjects were required to stay without medication for a minimum of two weeks and to abstain from coffee, tea and tobacco on the day of the CBF measurement. The EPI was administered just prior to the blood flow measurement, and a venous blood sample was withdrawn for the determination of haemoglobin levels. CBF was measured using the  $^{133}\text{Xe}$  inhalation technique, in a semi-dark, quiet room with eyes closed.

A mixture of  $^{133}\text{Xe}$  and air was administered through a close fitting, sterile face mask for one minute, after which the rate of removal of the isotope from different parts of the brain was traced by a system of 16 scintillation detectors mounted on a helmet and applied to the scalp for 10 minutes. Grey matter blood flow was computed from these clearance curves using a bicompartmental model. The blood flow values were corrected for differences in the blood-brain partition coefficient for xenon using the hemoglobin levels. End-tidal levels of carbon dioxide were monitored via a capnograph during the CBF measurement. Electroencephalographic (one channel) and oculographic tracings were displayed on an oscilloscope to detect possible sleep onset (Foulkes and Vogel, 1965). None of the subjects became drowsy during the CBF measurement.

### Results

The subjects obtained a mean score of 11.66 (SD 3.44) on the extraversion-introversion scale and 7.64 (SD 4.74) on the neuroticism scale. Correlation matrices (Pearson's product-moment) were computed using the regional cerebral blood flow (rCBF) values, with and without corrections for differences in levels of end-tidal carbon dioxide ( $\text{PECO}_2$ ), and the two dimensions of personality. Extraversion-introversion

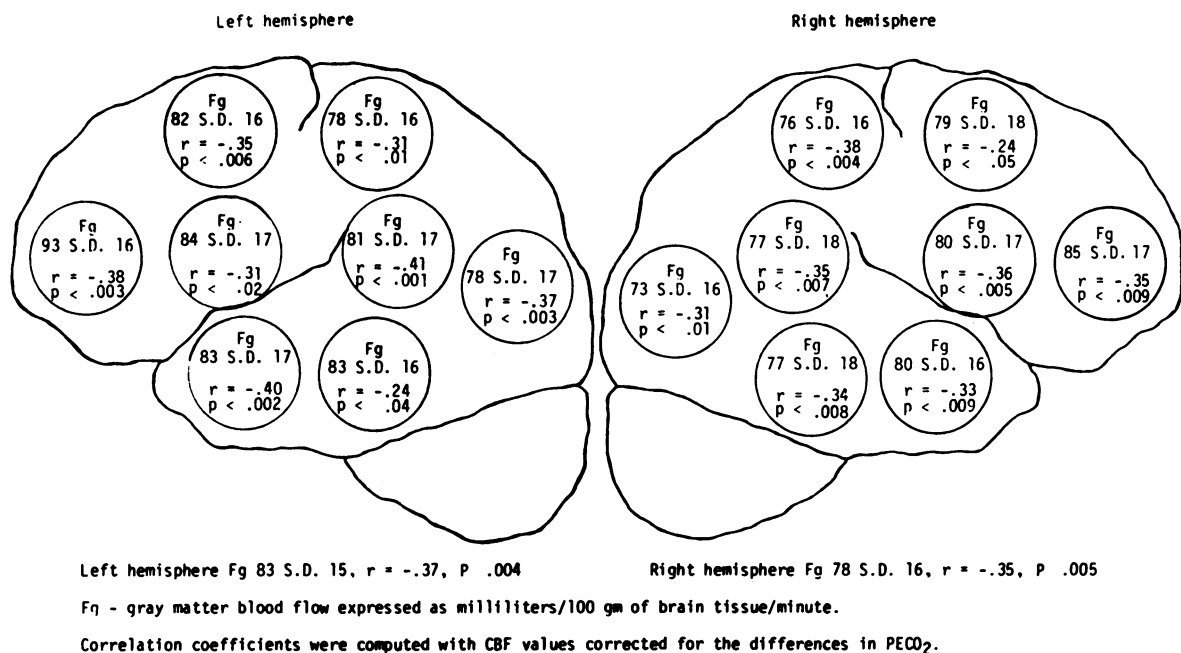


FIG.—Correlations between regional cerebral blood flow and extraversion-introversion (11.66 SD 3.44) in right handed females.

scores and rCBF showed significant inverse correlations in all brain regions (Fig 1). Corrections of the rCBF values for differences in PECO<sub>2</sub> (Olesen *et al*, 1971) increased the significance level. The rCBF values (with and without PECO<sub>2</sub> corrections) did not correlate with the neuroticism scores ( $r = -0.02$  (left hemisphere),  $-0.06$  (right hemisphere)).

### Discussion

The use of CBF as an index of brain function is supported by an impressive volume of studies on normal and abnormal subject populations. The reliability and validity of the <sup>133</sup>xenon inhalation technique for rCBF measurement have also been firmly established (Obrist *et al*, 1975; Meyer *et al*, 1978; Risberg, 1980; Prohovnik *et al*, 1980; Rao *et al*, 1974; Ph. Meric *et al*, 1983; Blauenstein *et al*, 1977). In the present study, special care was taken to minimize the effects of several known non-specific factors on CBF. The subjects were carefully screened for physical and psychiatric illnesses, and they were medication-free. Only right-handed females were included, to ensure homogeneity, since differences in gender and cerebral dominance have been reported to influence CBF (Prohovnik *et al*, 1980; Gur *et al*, 1982; Shaw and Meyer, 1982). Sufficient time was allowed for the subjects to acclimatise to the laboratory so that the CBF values obtained were indicative of basal, resting levels. None of the subjects became drowsy during the measurement. PECO<sub>2</sub> is recognized as the single, most powerful determinant of CBF (Kety and Schmidt, 1946; Reivich, 1964; Yamaguchi *et al*, 1979; Yamamoto *et al*, 1980). PECO<sub>2</sub> levels were monitored during the CBF measurement and the blood flow values were corrected for differences in this across individuals (Olesen *et al*, 1971). The need to correct resting CBF for PECO<sub>2</sub> differences is controversial since only acute changes in carbon dioxide levels cause significant CBF alterations (Evans and Cameron, 1981). It should be noted that the extraversion-introversion scores and the regional cerebral blood flow values, both with and without PECO<sub>2</sub> corrections showed significant inverse correlations.

The <sup>133</sup>xenon inhalation technique, based upon isotope clearance recorded over the scalp, measures mostly cortical perfusion (Obrist *et al*, 1975; Meyer *et al*, 1978; Sakai *et al*, 1979). Thus, the results of this study substantiate previous reports of an inverse relationship between extraversion-introversion and cortical arousal (Eysenck, 1967; Eysenck, 1970; Morris, 1979). Blood flow to different cortical regions showed the same inverse correlation suggesting the involvement of a central factor such as the diffuse brain arousal mediated by the reticular activating system (Lader, 1982). The correlation coefficients between

the extraversion-introversion and rCBF, though statistically significant, were relatively low which indicate the need for replication of the results. The limited range of scores along the personality dimensions may be an explanation for this. Subjects who obtain high scores tend to show psychiatric disorders which were excluded at the outset from the present study.

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