"D" groups than lever presses by the "C" groups [F (29,348) = 2.33; $p < .05$].

The present findings are not the only ones which can be interpreted as contradicting the generalizations of our opening paragraph. Maze running for ICR has shown considerable resistance to extinction (*6*). Other recent investigations also show that extinction of behavior maintained by ICR is similar to the extinction of food-reinforced behavior when the subjects are required to perform similar tasks (*7*). Together these results suggest that anomalous behavior associated with ICR is an artifact of the reinforcing contingencies and not that ICR is essentially different in function from conventional reinforcers.

One other feature of Fig. 3 should be noted. The response rates of the ICR-C and the S-C groups show an increase in the first minute of extinction relative to the rates during regular training the day before; those of the ICR-D and S-D groups do not. It has long been recognized that withdrawal of reinforcement may result in more vigorous behavior (*8*), but Fig. 3 suggests the possibility that this behavioral activation is limited to instrumental, as contrasted with consummatory, responses. If so, such a difference would be but one more reason to distinguish between behaviors mediately and immediately reinforced—a distinction poorly made by many investigators of ICR, including one of us (P.B.P.), over the last 10 years.

WILLIAM E. GIBSON, LARRY D. REID,
MAKOTO SAKAI, PAUL B. PORTER
Department of Psychology, University of Utah, Salt Lake City 84112

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Age, Personality, and Somatosensory Cerebral Evoked Responses

Abstract. *Cerebral responses to stimulation of the median nerve were recorded in 89 healthy subjects, aged 15 to 80 years. Relationships between response characteristics, age, sex, and Maudsley Personality Inventory variables were determined. Amplitudes increased significantly with age. Age interacted with "extraversion" so that more "extraverted" subjects under 20 and fewer "extraverted" subjects over 40 had larger responses.*

The quantitative characteristics of sensory-evoked cerebral responses, recorded from the intact human scalp by averaging methods, vary considerably among individuals. In this report we present evidence that age and a personality factor, designated as "extraversion" in the Maudsley Personality Inventory (*1*), contribute significantly to interindividual variation of somatosensory responses in healthy persons.

The subjects were 89 paid volunteers, recruited as normal controls for comparison with psychiatric patients. Their ages ranged from 15 to 80 years (median, 28); 51 were male, 38 female. Those aged over 60 received a systematic psychiatric examination to exclude mental illness before acceptance as controls; all others were accepted if they denied that they had had previous psychiatric illness or had used psychologically active drugs. Their occupations included: student, hospital attendant, nurse, janitor, housewife, merchant, farmer; several had retired but were active in community affairs. The Maudsley Personality Inventory was administered to obtain additional personal information. The Inventory provides scores for "extraversion" (E) and "neuroticism" (N); subjects answer "Yes", "No", or "Question" to the questions presented. Tests containing more than ten question-mark answers were rejected; 81 valid tests were obtained.

Responses were evoked by stimulating the right median nerve at the wrist through chlorided silver electrodes, affixed with collodion, placed 3 cm apart (anode distal). A constant current stimulator, triggered by a Grass S4 stimulator and isolation unit, generated the stimulus pulse. Duration was 0.1 msec and intensity was 10 ma above the individual's sensory threshold; the intensity-response curve is asymptotic for most subjects at this stimulus strength (*2*). Repetition interval was 1 second. Recording electrodes were placed 6 cm apart in the parasagittal plane 7 cm left of midline; the posterior lead was 2 cm behind a line from vertex to auditory meatus. The electroencephalogram was amplified with Tektronix 122 units and a subsidiary amplifier (frequency response, 0.8 to 10 kc/sec) and led into a Mnemotron computer of average transients for summation. Analysis time was 250 msec. Stimulation occurred at the 20th computer ordinate; a square-wave calibration signal of microvolt potential was placed on each sweep in the midportion of the preceding ordinates (*3*).

Data reported here are based on responses to single stimuli obtained during recovery function tests in which paired and unpaired stimuli were alternated (*4*); they include 19 averaged responses, each to 50 stimuli, for each subject. To quantify the responses, we identified ten successive peaks, consistent both between and within subjects, beginning with the initial negative deflection (latency about 20 msec). The recovery-function tracings were often useful in identifying peaks that may be obscure in responses to single stimuli, for example, points 5 and 6 in Fig. 1. Peaks 2 and 3 were rare in tracings from subjects over age 30, although they appeared regularly during the early phases of recovery; consequently, they were omitted from statistical analysis. For each peak, the amplitude

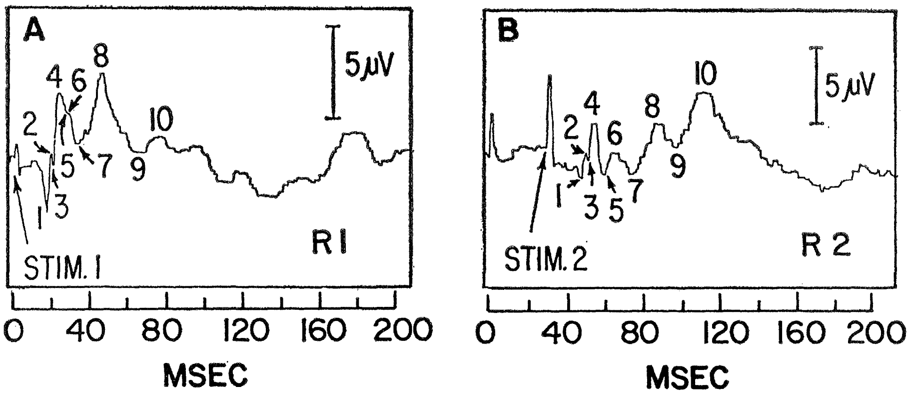

Fig. 1. Tracings illustrating the numbering scheme for evoked-response peaks and the use of paired stimuli in identification (*Stim.*, stimulus; *R*, response). (*A*) Averaged response to 50 unpaired stimuli applied to the median nerve. (*B*) Response to 50 paired minus 50 unpaired stimuli, thereby showing second response alone. Relative positivity at posterior scalp electrodes gives upward deflection. Note that points 5 and 6 are clearly shown in R_2 (*B*), but not in R_1 (*A*). (Interval between stimuli, 30 msec.)

and time from stimulus (latency) were measured, amplitude in terms of microvolts of deviation from an isoelectric line estimated for each record. Data were subjected to analysis of variance in a "mixed" design [type III of Lindquist, (*5*)], so that age and sex could be evaluated in one analysis, and each questionnaire score together with either age or sex in other analyses. Four age groupings were used: under 20, 20 to 39, 40 to 59, 60 or over. Questionnaire scores were divided into high and low at the median (E, 28; N, 16). To achieve proportionality in cells, data for some subjects were randomly discarded.

Analysis of age and sex together (76 subjects) showed that amplitudes varied significantly with age for peaks 1, 6, 7, and 9 ($p < .01$, .01, .05, and .001, respectively); they were greater in older subjects. Latencies 1 and 10 also increased with age ($p < .001$). Females hade significantly shorter latencies than males for peaks 1 ($p < .001$) and 6 ($p < .05$). Longer latencies for point 1 in males, and with increasing age, may be explained on a peripheral basis by the shorter average conduction pathway in females and by reduced conduction velocity with age (*6*). Latency differences for points 6 and 10 are not so readily explained, since intervening peaks gave no significant differences.

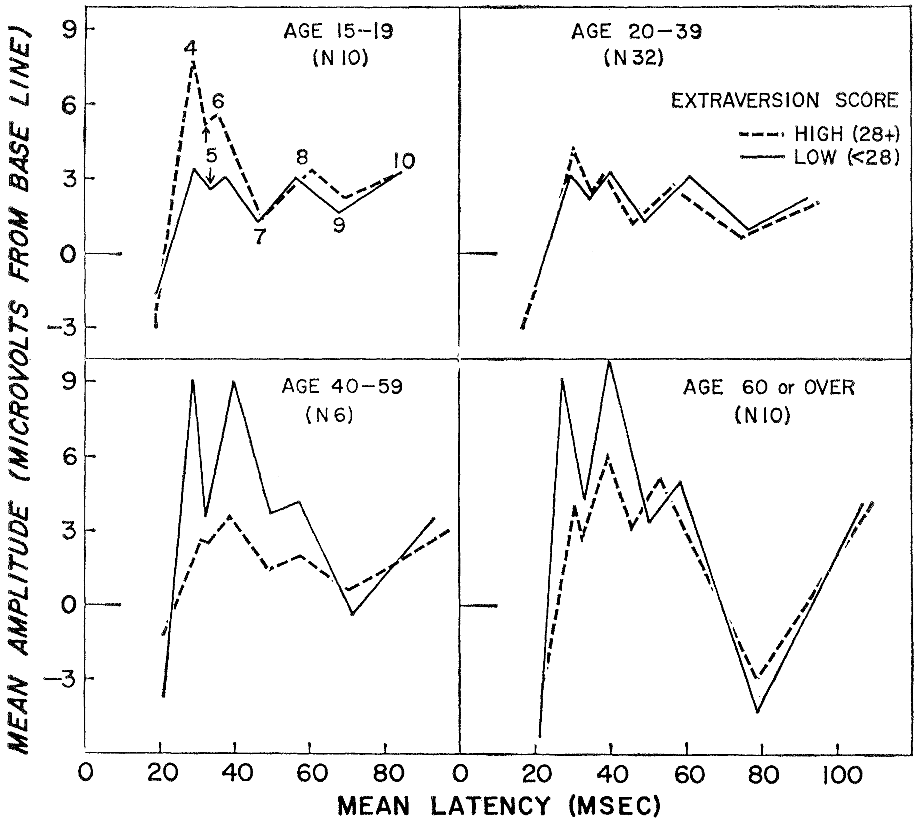

Fig. 2. Mean amplitude-latency curves for subjects with high and low "extraversion" scores in each age group.

In the analysis for age and E together (58 subjects), all amplitudes but that for point 8 were significantly related to age (for points 1, 4, 5, 6, 7, 9, and 10, respectively, $p < .001$, .01, .05, .001, .05, .001, .05). Although amplitudes did not differ with respect to E alone, significant E by age interactions occurred for points 1, 4, 5, and 6 ($p < .001$, .01, .05, and .001, respectively). Figure 2 illustrates the findings; for subjects under age 20, the amplitudes of the first four peaks were much greater in those more "extraverted," whereas the reverse was true for subjects age 40 or older. Comparisons made by Student's *t*-test of subjects having high E scores with those having low E scores within each age group yielded significant differences for points 4 and 5 in the under-20 group ($p < .05$ and .01, respectively) and for points 1, 4, and 6 in the 40-to-59 and over-60 groups ($p < .05$, .01, and .02, respectively, for the 40-to-59 group, and $< .01$, .001 and .05 for the over-60 group). One additional latency, 9, became significantly related to age when E was considered ($p < .05$). Latency 7 was significantly longer in low E subjects with sex considered ($p < .05$; 74 subjects).

The analysis for age and N together (64 subjects) yielded no significant amplitude differences with N, no significant interactions, and only one age relationship beyond those found in the age and sex analysis (point 4, $p < .05$). When N was taken together with sex (76 subjects), latency 5 was significantly longer in low N subjects ($p < .05$) and point 1 showed a significant N by sex interaction ($p < .05$), latencies being longer in low N males and high N females.

Figure 3 shows the mean summed amplitudes of points 1, 4, 5, and 6

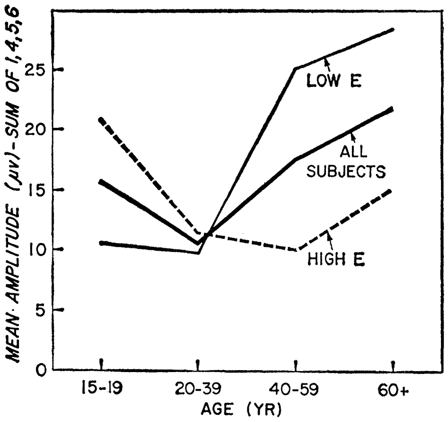

Fig. 3. Mean amplitudes by age group of peaks 1, 4, 5, and 6, summed without regard to sign, in subjects with high and with low "extraversion" scores, and in both together ($N = 58$).

with respect to the score for E. The data suggest that, if it were extrapolated to infancy, the overall curve relating age to amplitude would probably be U-shaped. The ascending limb of the U is demonstrated by our older subjects. The descending limb is shown only by those subjects which had high E scores in the youngest group; they had significantly higher amplitudes than the 20-to-39 group. Should the true curve be U-shaped, decreasing amplitude in early years would be associated with maturation and increasing amplitude in late life with neuronal degeneration (*7*). A further implication would be that neurophysiological maturation and aging both tend to occur later in more "extraverted" individuals. However, it is uncertain that the E score remains stable over many years, or that it has the same meaning at different ages. In our subjects, E decreased significantly with age ($p < .01$). The questions providing the score deal mainly with sociability, for example, "Do you like to have many social engagements?" The low E teenager could be unusually serious and mature, whereas the high E 70-year-old could be unusually lively and well-adjusted. The score may reflect a different kind of adjustment factor at each age. Further studies, with additional tests, will be required to delineate the relevant personality variables.

The results emphasize the need for the use of controls for age and sex in studies of cerebral evoked responses and draw attention to the importance of experimental designs that permit demonstration of interactions with these variables.

CHARLES SHAGASS
MARVIN SCHWARTZ
Department of Psychiatry and
Psychopathic Hospital, State University of Iowa, Iowa City

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Sequential Behavior Induced Repeatedly by Stimulation of the Red Nucleus in Free Monkeys

Abstract. *Rhesus monkeys in a colony were stimulated by means of intracerebral electrodes controlled by radio, for 5 seconds every minute, day and night, for periods up to 14 days. Stimulations of the red nucleus evoked a reliable sequence of behavior including bipedal locomotion, climbing, vocalization, and social interactions. During periods of spontaneous sleep, stimulations produced only a small head movement, but the whole behavioral sequence reappeared as soon as the animal awoke. In monkeys injected with chlorpromazine, the evoked behavior was inhibited in the same way as during spontaneous sleep, while the administration of atropine, Regitine, and Indurol which blocked both sympathetic and parasympathetic systems, produced only minor modifications of the sequential response.*

Excitation of the brain for long periods of time has obvious scientific and therapeutic importance which has been little explored experimentally. We know that rats may learn to stimulate their own brains repeatedly for many hours (*1*), and in previous studies with cats and monkeys I showed that intracerebral electrodes may be used for over 4 years with reliable results (*2*), while if stimulations were repeated 1 hour daily for several days, lasting electroencephalographic disturbances appeared in the amygdala and thalamus (*3*). It is conceivable that repeated stimulation of other cerebral areas less involved in epileptogenic activity would evoke reliable behavioral results without functional or electrical disturbances. In the experiments described here we have explored this possibility.

A colony was permanently established in a cage measuring 1 by 1 by 2 m, with four normal monkeys which served as controls and another animal equipped with intracerebral electrodes which was introduced into the colony for several weeks. Four monkeys with electrodes were tested in this way. Group behavior was recorded day and night by 16-mm time-lapse photography, with plus-X and infrared films. Analysis of the motion pictures permitted a practical and systematic qualification and quantification of spontaneous and evoked behavior as described elsewhere (*4, 5*). The animals were stimulated while completely free within the colony by means of intracerebral electrodes connected through subcutaneous leads to small radio-activated stimulators strapped on their backs, as shown in Fig. 1 (*6*). The stimulations were monopolar, cathodal, exponentially falling pulses of 0.5 msec duration, 100 cy/sec and 1 to 2 ma, applied for 5 seconds every minute for 1 hour or longer. In addition, the animals were studied under restraint for oscilloscopic monitoring of the excitations and for recording of the intracerebral electrical activity. After 5 to 12 months of experimentation, the monkeys were killed under anesthesia for histological study of the brain, so that electrode placement could be verified and neuronal morphology after the long-term stimulations could be analyzed.

Electrical stimulations of the rostromedial part of the left red nucleus evoked a similar effect in each of the four monkeys studied. The effect was characterized by an immediate interruption of the animal's spontaneous activities, change in facial expression, head turning to the right, standing up on two feet, circling to the right, walking on two feet with excellent preservation of equilibrium (Fig. 1*A*), climbing the pole on the cage wall, and descend-