Table 1. Rank order for tests administered after 14 weeks of age. (The higher numbers rank low.)

Test	Rank at age socialized					Controls
	2 wk	3 wk	5 wk	7 wk	9 wk	
			Handling			
Initial attraction to handler	5	4*	3*	2*	1*	6
			Leash control			
Eating in strange situation	4	3	1.5*	1.5*	5	6
Fewer balks	4	5	3*	1*	2*	6
			Reactivity test			
Total activity	2	4	3	1	6	5
Heart rate	6	3	4	1	2	5
Vocal, panting, and tail wagging	2	3	4	1	5	6

*Distinctly superior rank

on the first, one control animal, selected at random, was petted and fondled each day for a period of 3 months. The handling test was readministered at that time, and the animal showed only a slight positive change in score. It is our impression that any of the control pups would have been similarly resistant to socialization.

The leash-control test (*3*), devised to test an animal's resistance to training to a leash, was administered over a period of 10 days. There was significantly greater ease in the training of animals socialized at 5, 7, and 9 weeks of age than with the two younger groups and the controls ($p \leqq 0.01$, Wilcoxen rank test, and see Table 1). It appears that while socialization experiences during the second and third weeks of age were effective, as judged by the handling test, the stress conditions of leash training favored the scores of animals socialized during the fifth, seventh, or ninth week of age.

The final test was the reactivity test (*3*). Each pup was placed in a physiological harness and subjected to various stimuli such as cajoling and threat from a human, acoustic-startle, and electric shock. Heart rate, depth of respiration, and muscle tension were concurrently recorded in an electrocardiographic apparatus, while an observer made note of other aspects of the animal's reactions. This test appears to contrast ease of response (high score) with the tendency to "freeze" (low score). The controls were more inhibited than the seventh-week group on each of three subscores ($p = 0.05$, 0.01, 0.01, Mann-Whitney). In Table 1 we see that the seventh-week group ranked highest on all three subscores, indicating primacy in activity level, heart rate, vocal behavior, and tail wagging.

Although further work is necessary, the net results suggest that the seventh week of age was the period in which the pups were most receptive to socialization, and that 2½ to 9–13 weeks of age approximates a critical period for socialization to human beings. These figures are in accord with the findings of Pfaffenberger and Scott (*4*) and Scott and Marston (*5*). It is important to note that within this period motor and perceptual development reach maturity while, on the other hand, motivation to flee from strange species is not yet strong. We suspect that such a balance of factors is characteristic of a period that is critical for the formation of primary social relationships (*6*).

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Physiological Limits for "Subliminal" Perception

Abstract. Cortical, subcortical, and peripheral sensory nerve potentials were studied in cats to determine comparative thresholds of response. Stimuli capable of eliciting responses in peripheral nerve also invariably elicited responses from thalamus and cortex. Together with relevant data from human studies, the results indicate that stimuli subthreshold for perception do not affect the nervous system. They also have implications for studies of "subliminal" perception.

In recent years much investigative and popular interest has been directed toward the problem of "subliminal" perception. Such perception is said to occur when stimuli which are presumably below threshold, because they are not reported, nevertheless exert some influence upon behavior.

Although the psychological aspects of the problem have received careful scrutiny (*1*), little attention has been paid to physiological mechanisms which might mediate "subliminal" perception. Knowledge of such mechanisms could be crucial in clarifying the nature of the problem. For example, if it were known that stimuli of intensity lower than the sensory threshold can elicit brain responses, this would provide a definite physiological basis for "subliminal" perception. On the other hand, if it were shown that brain responses are produced only by stimuli at or above threshold, it would be clear that "subliminal" perception, in the strict meaning of the term, is not physiologically possible.

The probability that subthreshold stimuli do not produce brain responses has been suggested by three studies of cortical potentials evoked by sensory stimulation in man. Because the cortical potential evoked is not ordinarily visible in the scalp electroencephalogram, averaging methods were employed in these studies to bring out the responses. Shagass and Schwartz (*2*) found that the first evidence of cortical response to ulnar nerve stimulation coincided with the sensory threshold and that stimuli which were not perceived produced no response. Geisler, Frishkopf, and Rosenblith (*3*) obtained sim-
Dawson (*4*) simultaneously recorded
ilar results with auditory stimulation.
cortical responses and action potentials in median and ulnar nerve and found no fibers in either nerve with thresholds lower than that for producing cortical responses. Taken together, the findings of these studies suggest that subthreshold sensory stimuli produce neither peripheral nerve responses nor cortical responses. However, because these investigations relied upon skin electrodes and averaging techniques, it seemed desirable to test this conclusion in a study employing direct recording methods.

In our experiments, simultaneous recordings were made from exposed cortex and either medial lemniscus, thalamus (ventral posterolateral nucleus), or peripheral nerve in the cat. In a total of 13 animals, cortex was compared with medial lemniscus in three cats, to ventral posterolateral nucleus in three, and to superficial radial nerve in ten. Stimulation was applied to superficial radial nerve by a Grass S4G stimulator through a Grass SIU4B isolation unit. Stimulus intensities were varied systematically in steps of 0.1 volt from low levels, producing no responses, to suprathreshold values. Re-

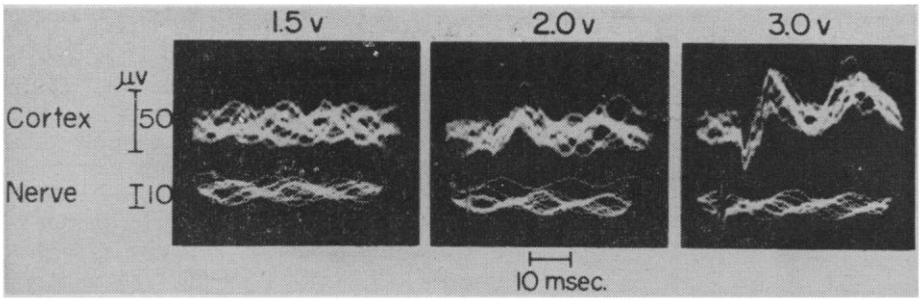

Fig. 1. Superficial radial nerve and cortical responses to varying intensities of stimulation (stimulus duration, 0.01 msec). Ten superimposed sweeps in each. At 1.5 volts only the stimulus artifact is recorded; at 2.0 volts a barely detectable response appears in the nerve while the cortical response is quite apparent; at 3.0 volts both responses are clear.

sponses were amplified by Tektronix type 122 preamplifiers, displayed on a Tektronix type 502 dual beam oscilloscope, and photographed with a Dumont Polaroid camera.

Four animals were studied in the unanesthetized state, after they had been prepared surgically under ether and then immobilized with gallamine triethiodide (Flaxedil) and placed under artificial respiration. The remaining animals were studied under light-to-moderate pentobarbital anesthesia. Cortical records were obtained from somatosensory areas I and II by means of monopolar wick or silver–silver chloride balls with the indifferent electrode on the cut edge of the scalp; depth electrodes were bipolar nichrome wires insulated except at the tips; nerve recordings were from either stainless steel bipolar needles inserted through the nerve or bipolar silver plates on which the nerve rested.

In all instances, stimuli capable of evoking responses either subcortically or in the peripheral nerve also elicited responses from the cortex. Figure 1 illustrates responses elicited by varying intensities of nerve stimulation in simultaneous recordings from superficial radial nerve and somatosensory I in an unanesthetized cat. It can be seen that when stimulation results in peripheral responses, responses are also evoked in the cortex. Identical results were obtained in all animals, anesthetized and unanesthetized. These results are in accord with those of Mark and Steiner (*5*) on deeply anesthetized cats.

The data of Shagass and Schwartz (*2*) indicate that a necessary, though not sufficient, condition for the occurrence of human perception is the elicitation of responses at the cortex. Obviously responses cannot be elicited from the cortex by a stimulus which has not excited the peripheral nerve. Present results and those of Dawson (*4*) indicate, however, that there are no responses peripherally or subcortically without the concurrent evocation of responses in the cortex.

In view of these results, it would appear that the term "*subliminal perception*" is a misnomer in regard to those experiments in which stimuli below threshold for perception are applied (for example, *6*). If these stimuli are truly subliminal, perception *cannot* occur. They have no effect on the nervous system. Those experiments on "subliminal" perception which do employ stimuli capable of producing nervous system responses would seem to be dealing mainly with the relationship between perception and attention. These stimuli may or may not be immediately perceived, depending upon factors, such as distraction, which influence "focus of attention." The experiments of Hernández-Peón *et al.* (*7*) demonstrate a neurophysiological correlate of fluctuations of perception under different conditions of attentiveness. In these experiments evoked sensory potentials diminished when a different and more attention-getting stimulus was concurrently introduced. However, it should be clearly recognized that, although no longer attended to, these stimuli were not subliminal (*8*).

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Cellular Adaptation to Morphine in Rats

Abstract. The respiration of KCl-stimulated cortical slices of brain from control rats is markedly depressed by morphine, whereas the respiration of those from rats chronically dosed with morphine is unaffected. The results demonstrate an adaptation to morphine at the cellular level which is concomitant with the adaptation of the whole animal to morphine.

The stimulatory effect of 0.1*M* potassium chloride on the oxidation of cortical slices from the brain in the presence of glucose is well established. Since the original observation of this effect by Ashford and Dixon (*1*), several workers have studied the effect of depressant agents such as various barbiturates (*2, 3*), hypnotics (*2, 3*), and ethanol (*3, 4*) on the oxidation of KCl-stimulated cortical slices. These authors found a marked depression of the oxidation of stimulated slices with depressant agents at concentrations which are relatively ineffectual, or even stimulatory in the case of ethanol, on the oxidation of unstimulated slices. Studies were never made on cortical slices of brain obtained from an animal chronically treated with depressant agents.

Male Holtzman rats, weighing 200 to 300 g, were chronically morphinized intraperitoneally with an initial dose of 15 mg/kg twice daily, which was increased in 15-mg/kg increments weekly

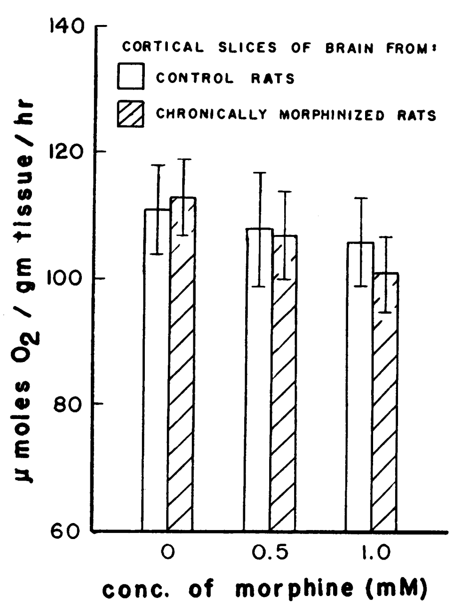

Fig. 1. Effect of morphine on the oxidation of unstimulated cortical slices. Each bar represents an average of 15 rats. The vertical lines at the top of each bar show the standard error. None of the groups are significantly different ($p > 0.2$) from their respective control groups (no morphine).