RESEARCH NOTE
Referred Cutaneous Sensation

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It is well known that stimulation of the viscera or the inner surface of the
body wall can produce painful sensations that are referred to the nearby
skin. Such referred pain is typically diffuse rather widely over the derma-
tomes innervated by the same dorsal root that supplies the internal structures
stimulated (5). This phenomenon is consistent with the idea that there are
orderly point-to-point maps of the body surface in the central nervous sys-
tem, for it is assumed (5), with recent supporting evidence (4, 6), that the
reference localization depends on convergence of visceral inputs onto neurons
that ton the cutaneous map.

Over a period of years I have noticed in myself a second type of referred
sensation that differs in several ways from referred pain. It is elicited by
nonnocussious stimulation of a particular point on the skin and referred to a
second, often distant, skin locus. Recently I have found that the phenomenon
is quite common and below have described some of its features.

The referred sensation is most commonly elicited during unconscious
"grooming behavior": scraping fingernails over the scalp, plucking at hairs,
peeks, minor skin eruptions, etc. A stimulus to a particular point, for
example scratching a particular hair follicle, gives rise, in addition to the
appropriate sensation at the site of stimulation, to a sharp, well-localized
sensation at a relatively distant point on the skin. The sensation is never
painful, but is startling in its suddenness and precise localization. The
sharp sensation is followed almost immediately by an itch which can be
caused by rubbing the site to which the sensation is referred. Roughly half
the twenty individuals questioned about the phenomenon immediately re-
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called having experienced it, and of the remainder, most were able to find a few points at which they could subsequently elicit it. In most cases the sensation was described in roughly similar terms: "sharply," "strange, focal itch," "tingling," but in a few cases the referred sensation was reported as a "numbness" or a "tingling-tingling."

The nature of the adequate stimulus depends on which cutaneous structure is being stimulated, but the stimulus must be usually fairly strong to be effective. For example, some of the most frequently encountered effective sites are hair follicles and the margins of skin irritations. Gentle brushing or poking at these structures is ineffective; however, firmly scraping the follicle or irritation with the fingernail may readily elicit the referred sensation until the structure is scraped away. If care is taken during stimulation to preserve the structure, the sensation can be elicited repeatedly over the course of days without any change in its nature or site of referral. This
finding was particularly dramatic in the case of one individual who for years has elicited a sensation referred to a point on his lower chest by firmly pricking a particular hair on his wrist. If the hair is pulled out, the sensation cannot be elicited again until a new hair has grown.

In order to determine whether the topographic relations between sites of stimulation and referral show any regular patterns, maps were given to volunteers who were requested to plot pairs of stimulation and referral points as they were discovered. Over a period of several months 12 pairs of points were accumulated, fifteen pairs in one individual (Fig. 1). The sensation was always referred ipsilaterally and usually to the same anterior-posterior surface as the initiating stimulus (Figs. 1 and 2). Within a pair there was never any reciprocity: that is, stimulation of a referral site never gave rise to a sensation at the initial stimulus site. This seems to rule out a long axon reflex as an explanation for the phenomenon.

In striking contrast to the pattern in referred pain, the cutaneous sensation was never referred to a site within the same dermatome as the stimulus. In fact a comparison of Figs. 1 and 2 with the dermatome map in Fig. 3
show that the stimulus and referral points may be separated by as many as 21 dorsal roots. Although in some cases two adjacent stimulus points had quite disparate reference sites, e.g., pairs 6 and 7, Fig. 1, in many cases neighboring stimulus points seemed to have referral sites arranged fairly systematically with respect to each other (e.g., Fig. 1, pairs 1–5; 9–11; 13–15).

In Fig. 2, pairs 1 and 2 show that stimuli at homologous points on the two sides of the same individual elicit referred sensations at homologous points. Since several days intervened between the discovery of the first and the second pairs, there is little likelihood that suggestion was involved. In addition to this symmetry within an individual there was often correspondence of roughly comparable pairs between individuals. For example, point 6 in Fig. 1 and point 5 in Fig. 2 both project from the back of the head to the distal, posterior part of the arm. The number of such comparable pairs is not yet large enough to determine the extent of variation between individuals, but a comparison of certain pairs e.g., pairs 6 and 7, Fig. 1 vs pairs 2 and 4, Fig. 2 suggest that the variation may be substantial.

The phenomenon of referred cutaneous sensation cannot be dismissed as merely the consequence of "suggestion" because the distribution of pro-
jection points within individuals (Figs. 1 and 2) and comparisons between individuals show many systematic features. Since each pair of points was recorded essentially independently from all the others, it is hard to imagine how the relatively orderly maps could have arisen through suggestion. The phenomenon described here differs from that of referred pain in that the referred cutaneous sensation is highly localized, less a quality that is apparently unrelated to the nature of the initiating stimuli, and shows a distribution pattern that is not dermatomal. For all of these reasons it seems unlikely that the phenomenon can be explained in precisely the same way as referred pain, that is, by convergence of fibers that innervate different structures and enter the cord through the same dorsal root (4-6). It seems likely that referred cutaneous sensation also arises from central convergence, but the pattern of convergence must depend on something other than a shared dorsal root.

The phenomenon resembles, at least superficially, the experimental one in frogs in which stimulation of belly skin transplanted to the back gives rise to two types of reflexes, normally directed (to the head) and misdirected (toward the belly) (2, 5, 7). The frog experiments indicate quite clearly that at certain points during development the relations between the skin and central nervous system are not fixed and that errors can arise: one skin focus can specify two quite different reflex responses. One wonders whether the present phenomenon might represent errors in original specification of the connections of sensory neurons. If there are really errors in specification, they cannot be purely random for the referral map shows too great a regularity. The question then arises: if this is mis-specification, might it not be a regular reflection of some early embryological event?

The referred phenomena described here are abnormal not only in their topography, but also in the very nature of the sensations. These abnormalities might be related to the fact that referred sensations can so often be elicited at sites of irritation, where nerve endings may be undergoing either regeneration or regeneration. There is evidence, again from experiments in amphibians, that stimulation of regenerating sensory nerves in a blastema can elicit reflexes that are not normally present (8). It is not known whether these abnormal reflex connections represent temporarily established anatomical connections or an altered pattern of impulses in the abnormal fibers.

It will probably be difficult to determine in human subjects whether referred cutaneous sensation arises from embryonic mis-specification of connections or temporarily altered connections made by abnormal fibers, but perhaps the phenomenon will provide a link to the animal experiments. Finally, although the present findings have no obvious relation to acupuncture they do suggest that the failure of a sensory phenomenon to be distributed in dermatomal fashion should not be grounds for dismissing it.