The skin and sensation physiology

The Skin and Sensation Physiology

1. Introduction

Skin is the largest organ of our body that protects us from microbes and helps to regulate our body temperature. It contains different kinds of sensory receptors that respond to variety of stimuli: mechanical, thermal and chemical. The general receptors of the body react to touch, pressure, temperature, pain and change of the environment. The encapsulated receptors which include free nerve endings may sense pain and temperature; Merkels discs, which sense light pressure and root hair plexuses that sense touch by the movement of the hairs. While the encapsulated receptors are enclosed in a capsule of connective tissue which are the Meisnner's, Pacinian and Ruffini's corpuscles. The density of skin receptors is greater in areas that are designed to sense our environment. These receptors convey the information to the CNS thus, any stimulus should be of threshold magnitude in order to detect. The sensory system have a limit of its sensitivity therefore, stimulus below minimum magnitude cannot elicit a response. The cutaneous receptors are scattered throughout the skin and the underlying fascia. These receptors are the mechanoreceptors, thermoreceptors, nocireceptors and proprioreceptors that are sensitive to a certain stimuli.

Sensation is defined as a state of awareness of the internal and external environment. There are four criteria to be considered in order for a sensation to occur. First is the stimulus, the change in the environment in which we should be aware of. Next, there should be a receptor- a cell or organ which is sensitive to the stimulus. There must also have an afferent nerve pathway that will carry the signal to the CNS and lastly, there should be sensory cortex where the signals was analyzed and interpreted.

Hence, this activity aims to demonstrate the sensation acuity using various models in tactile localization and adaption, to determine relative sensitivity of selected areas of the skin and to be able to understand the different features of sensation in relation to various stimuli, adaptation and after image phenomenon.

2. Methodology

1. Tactile Distribution: Two-point Sensibility

Begin the test by asking the subject to close his eye. Using a vernier caliper, test the ability of the subject to differentiate two distinct sensations by setting the vernier caliper at the distance with points close together and gradually increasing one or two points until the subject has reached the sensation when the skin is touch simultaneously at two points. Record the distance in which the subject first felt the two-point threshold and repeat two trials for each body area listed below.

1. Back of the neck or nape area
2. Fingertip
3. Forearm (supine position)
4. Tip of nose
5. Palm of hand
6. Tongue
7. Upper arm
8. Thigh area

9. Leg area

2. Tactile Localization

Begin the test by asking the subject to close his eyes. Using a pencil tip, touch the skin of the test subject until it leaves an indentation. Then ask the subject to locate the exact spot using the pencil tips. Measure the error of localization using the vernier caliper and repeat twice for each body location listed below. Observe the localization of improvement.

1. Palm
2. Fingertips
3. Forearm (dorsal side)
4. Forearm (ventral side)
5. Lips
6. Thigh region

3. Touch Receptor Adaptation

1. Begin the test by asking the subject to sit and close its eyes. Place a coin on the forearm (antecubital fossa) of the subject. Record the time of how long it takes until the sensation cease. Once the sensation has ceased, add coins of the same size and record the time of pressure sensation. Repeat the same procedure on the other forearm and compare the observations.
2. Ask the subject to close his eyes. Using a pencil tip, run the tip over the strand of hair and slowly pulling it up until the hair spring away from the tip. Ask the subject in which the sensation is greater when the hair is being bend or when it springs back.

4. Weber’s Law: Sensation Intensity Difference

Begin the test by asking the subject to sit on a bench and place his hand on the arm rest with eyes close. Put the 2-inch square cardboard on the distal phalanges of his index and middle finger. Gradually add 10 gram weight in the cardboard and ask the subject if he felt the weight. After the subjects feel the weight, remove the cardboard unto the finger and add additional weight from 1 to 5 grams, until he felt the weight increases and compared it with the initial weight. Record the weight increment that produced an added weight sensation.

Test other initial weights at 50, 100 and 200 grams and get the Weber’s fraction.

5. Temperature Adaptation and Negative After-Image

Prepare three 1000 ml beakers with ice water, water at room temperature and waterbath at 50 ^{o} C and assign each container into cold, room temperature and warm water. Ask the subject to immerse each of his hand on the cold and warm water for two minutes. Record which hands adapts faster in the said temperature. Then rapidly immerse both hands in the waterbath. Describe the sensation on each hand.

6. Referred Pain

Ask the subject to place his elbow in ice water for 2-3 minutes. Are there any changes in sensation localization? Record your observation.

3. Results

Various models in tactile localization and adaptation were used on selected areas of the skin for the demonstration of sensation acuity and relative sensitivity of the skin. Also, various stimuli, adaptation and afterimage phenomenon were also applied to understand different features of sensation. The following tables show the results on each exercises performed in this activity.

Table 1. Two-Point Sensibility.

Body areas	Distance
Nape area	10 mm
Tip of nose	8 mm
Tongue	4 mm
Fingertip	2 mm
Palm of hand	8 mm
Forearm	31 mm
Upper arm	34 mm
Thigh area	32 mm
Leg area	36 mm

The table above displays the results taken from the tactile distribution procedure for the two point sensitivity of different areas of the skin. Each area was applied with tactile stimuli from the caliper tips and the distance was recorded once the person had made a distinction of two-points. For the head portion or medial part of the body, the nape area or the back of the neck, the tip of the nose and the tongue got a threshold of 10mm, 8mm and 4mm, respectively. For the upper extremities, the fingertip, the palm of hand, the forearm in supine position and the upper arm got a threshold of 2mm, 8mm, 31mm, and 34mm, respectively. Lastly, for the lower extremities, the thigh area and the leg area got a threshold of 32mm and 36mm, respectively. Out of the nine different areas of the body where the stimuli was applied, the fingertip is noted to be having the most sensitive area while the leg area is the least among them all.

Table 2. Tactile Localization.

Body area	Trial 1	Trial 2	Error of localization
Palm	6 mm	5 mm	1 mm
Fingertips	0 mm	0 mm	0 mm

Forearm (dorsal)	40 mm	34 mm	6 mm
Forearm (ventral)	31 mm	15 mm	16 mm
Lips	0 mm	0 mm	0 mm
Thigh area	40 mm	35 mm	5 mm

The table above displays the results taken from the tactile localization procedure of different areas of the skin. Two trials were performed and their difference measures the error of localization on each area. The fingertips and the lips received no error of localization since the subject had pointed the exact location of the indentation twice. This amount of error was followed by the palm having an error of localization of 1mm since the subject had pointed the indentation from a distance of 6mm on the 1 st trial and 5mm on the 2 nd trial. This was then followed by the thigh area, the dorsal part of the forearm and finally the ventral part of the forearm having an error of localization of 5mm, 6mm and 16mm, respectively. Noticeably, the fingertips and the lips had the least error since it received no error at all as compared to the ventral portion of the forearm that had the most error of them all.

Table 3. a. Adaptation of Touch Receptors.

	Right	Left	Differenc

	Forearm	forearm	e of time in distinction
Single coin	5. 1 sec.	4. 5 sec.	0. 6 sec.
Doubled coin	9. 3 sec.	8. 8 sec.	0. 5 sec.

The table above displays the results taken from the touch receptors adaptation procedure applied on the right and left forearm. The subject had a coin placed on its forearm with the time recorded once it can't feel the weight of the coin anymore. The right forearm's distinction is 5. 1 seconds for one coin and 9. 3 seconds for doubled while the left forearm's distinction is 4. 5 seconds for one coin and 8. 8 seconds for doubled. This shows that the subject's left forearm adapts faster than its right forearm. The difference of time in distinction was measured through subtracting the seconds felt by the right forearm to the left forearm. Having doubled coin received a less difference of time in distinction than having a single coin since the recorded seconds are 0. 5 seconds and 0. 6, respectively. It is also noticeable that the sense of pressure is shorter when there is only one coin then, returned but got longer after the addition of coins.

Table 3. b. Adaptation of Touch Receptors.

	Sensation Felt
Bent hair	+
Sprung back hair	++

(++) = felt most; (+) = slightly felt; (-) = not felt

Another adaptation procedure was performed using the subject's hair and the results are being shown on the table above. Its hair strand was bent and sprung back using a pencil tip. The subject responded that the sensation felt greater when the hair was sprang back and least when it was bent.

Table 4. Sensation Intensity Difference.

Initial Weight Intensity (I)	Intensity Difference (ΔI)	Weber's Fraction (ΔI/I)
10 grams	3 grams	0. 3
50 grams	5 grams	0. 1
100 grams	10 grams	0. 1
200	20 grams	0. 1

grams

The table above displays the results taken from the sensation intensity difference procedure of the fingers using Weber's Law. Different initial weights were given to the subject's two fingers which response was recorded after adding additional weights for the intensity difference. The Weber's fraction came from the quotient of the two weights as how the formula displays on the table above. It is noticeable that the 10g weight got the most Weber's fraction of 0. 3 as compare to the other three weights – 50g, 100g and 200g – that got the same 0. 1 Weber's fraction.

Table 5. Temperature Adaptation and Negative After-Image.

	1 st Beaker (Different Temperatures)	2 nd Beaker (Room Temperature)
Colder hand	–	–
Warmer hand	+	+

(+) = adapts faster; (-) = adapts slowly/not adapting

The table above displays the results taken from the temperature adaptation and negative afterimage procedure of the two hands exposed on different temperatures. With hands in each beaker, the hand that is placed on warm water adapts faster than the ones in the cold water. When both hands were transferred onto the third beaker containing room temperature water, the ones exposed on cold water earlier adapts too slow – “ like it had gone numb” – as compare to the ones exposed on warm water earlier.

Table 6. Referred Pain.

Body Area	Sensation traveled
Upper arm	+
Lower arm	–

(+) = present sensation felt; (-) = no sensation felt

The table above displays the results taken from the referred pain procedure applied at the elbow and had affected the sensation of the arm. After the elbow was dipped on an ice water for 2 minutes, the subject responded that the sensation had a change in location. It was then recorded that the location of the sensation is now felt on the upper arm.

4. Discussion
5. Conclusion

The skin, the largest organ of the body and its somatosensory system or touch system, allows the human body to perceive the physical sensations of pressure, temperature, pain, experience texture and temperature and perceive the position and movement of the body's muscles and joints. Using various models and procedures, several accounts were recorded including the lips and fingertips as the most sensitive and the more intense weights and temperature as the slowest to be adapted. These are all due to the receptor cells found in the skin that can be broken down into three functional categories: mechanoreceptors that sense different ranges of pressure and texture, thermoreceptors that sense and detect changes in temperature, and nociceptors that sense pain ranging from acute and easy to tolerate to chronic and intolerable.

6. Literature Cited

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