An investigation of three theoretical assumptions associated with thermosensory testing

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ABSTRACT

The goal of the study was to explore three theoretical assumptions associated with thermosensory testing, using the local application of thermal stimuli. The first assumption we addressed was that relationship between thermal sensation and physical contact temperature is linear. We also examined the assumption that local thermal discomfort is more sensitive to cold, than it is to heat. Lastly, we examined the assumption that participants exhibit high levels of confidence in repeated thermal sensation ratings, across a wide range of contact temperatures. In nine female, and eight male volunteers, thermal sensation, thermal discomfort, and the confidence in thermal sensation scores, were measured in response to seventeen physical contact temperature stimuli, ranging from 18 to 42°C, applied to the dorsal forearm. Our findings demonstrated that the first theoretical assumption, that local thermal sensations are linearly related to the stimulus temperature, is true. This indicates that the distance between the thermal sensation anchors is close to equal in terms of physical temperatures changes, across the range tested presented. On the contrary, the second assumption, that participants experience local cold as more uncomfortable than local heat stimuli, was not supported by the present data. Rather participants rated a similar thermal discomfort level to both cold and hot thermal stimuli. Indeed, the last assumption presented was also contraindicated by the present study, in which the average confidence of thermal sensation was less than 100% (87.5%). Interestingly, the similar levels uncertainty was observed across the range of physical contact temperature tested.

KEYWORDS

Thermal sensation. Thermal discomfort. Thermosensory

Introduction

A protocol was developed to test theoretical assumptions associated with the interrelationship between thermal sensation, thermal discomfort, and physical contact temperatures in humans. To achieve this, perceptual responses (thermal sensation and thermal discomfort) to the application of seventeen absolute physical temperatures, ranging from cold to hot (18 - 42°C) were examined. In addition, the present study tested the confidence of participants in their thermal sensation ratings also, across a wide spectrum of thermal stimuli. Seventeen Western European university students volunteered and consented to participate in the study. The location of the application of the probe was marked on their skin, ensuring consistent application across temperatures, and all participants were blinded to the environment conditions, as well as the temperature of thermal probe controller unit, to avoid expectation bias. Physical temperatures were applied with a conductive thermal probe

(Physitemp Instruments Inc., USA) consisting of a 25 cm^2 metal surface, applied with a pressure of 4 kPa, in a mixed counterbalanced order. The probe was applied to the skin for 10 seconds for all applications, at the end of which participants rated their local thermal sensation, the confidence of thermal sensation, and local thermal discomfort. A recovery time between thermal probe applications of at least 20 seconds was used. Local skin temperature has been reported to have returned to its baseline value using a single spot infrared thermometer (FLUKE 566, Fluke Corporation, USA) prior to each subsequent thermal probe application.

Findings

A positive linear and sigmoidal fit at forearm described the thermal sensation to physical temperature relationships (r^2 = 0.91 and r^2 = 0.91, respectively). While the sigmoidal model offers an improved relation, the difference between the models was limited. For this reason, it may be concluded that the physical temperature distance between the thermal sensation anchors for the range studied is close and is largely explained by a linear model as shown in Figure 1.

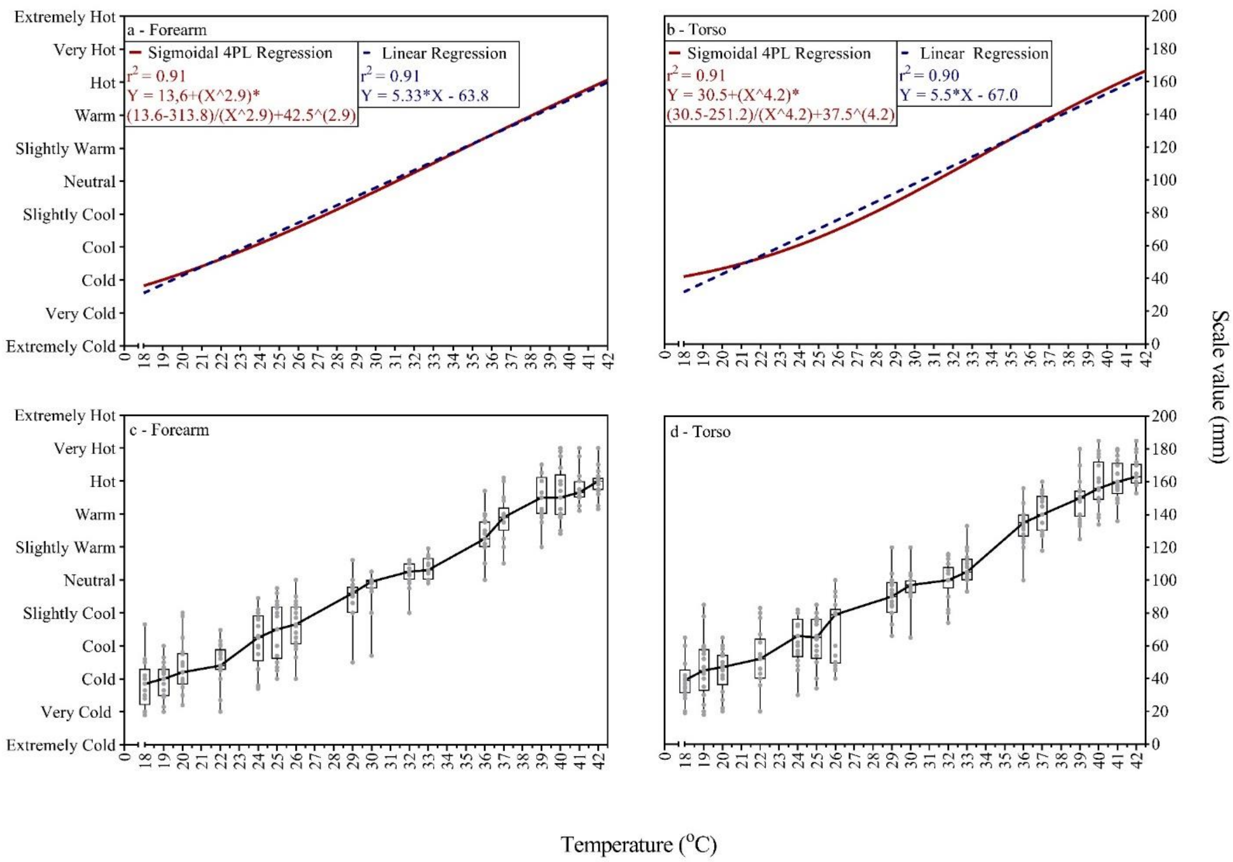

Figure 1: Relationship between applied physical temperature and thermal sensation

The second and third-order fits in the forearm described the thermal discomfort to physical temperature relationships, however predictive value was limited by inter-individual variability (r^2 = 0.33 and r^2 = 0.34, respectively). The data and the degree of discomfort was comparable in both cold and hot for a given increase or decrease in physical contact temperature or thermal sensation (Figure 2).

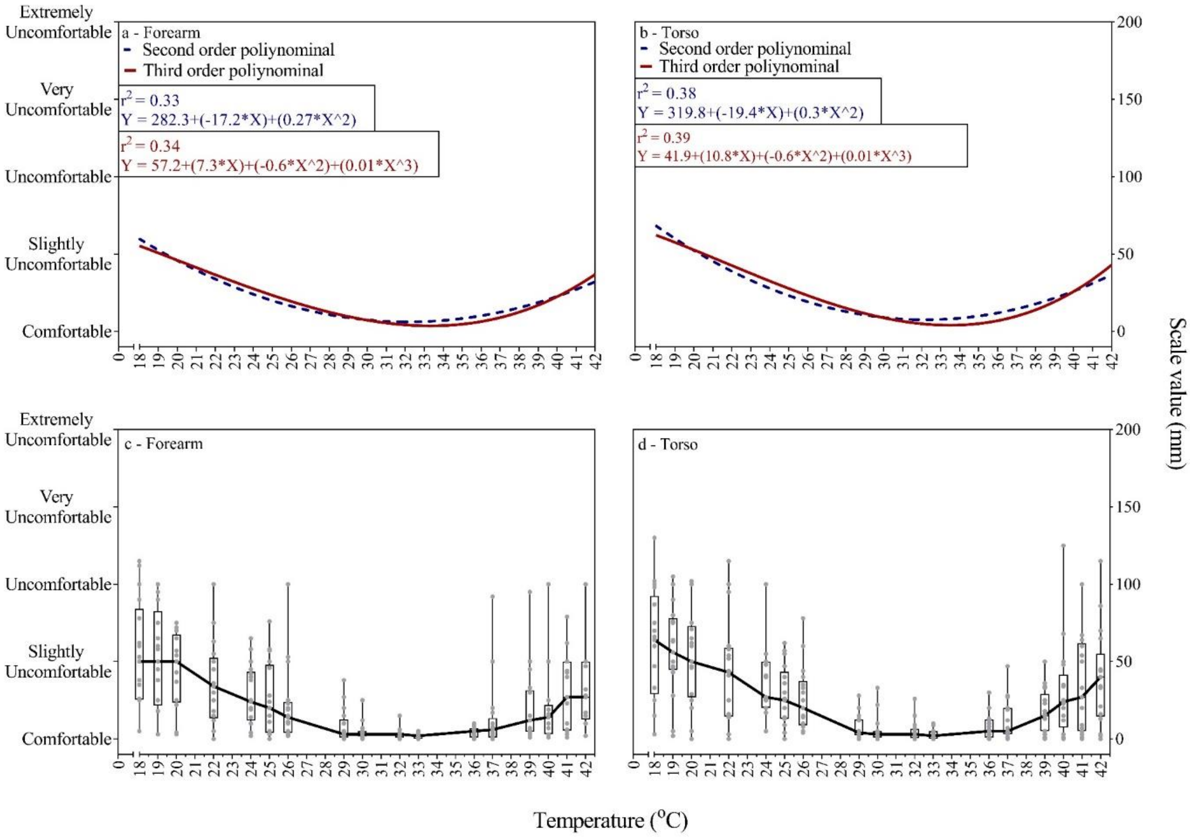

Figure 2: Relationship between applied physical temperature and thermal discomfort

Lately, the results also showed that the confidence in thermal sensation ratings did not depend on the temperature of the physical contact, and that none of the participants rated their thermal sensation with 100% certainty across all contact temperatures tested. The median confidence in the thermal sensation rating of a person was 86%, varying from approximately 40% to 100% (Figure 3).

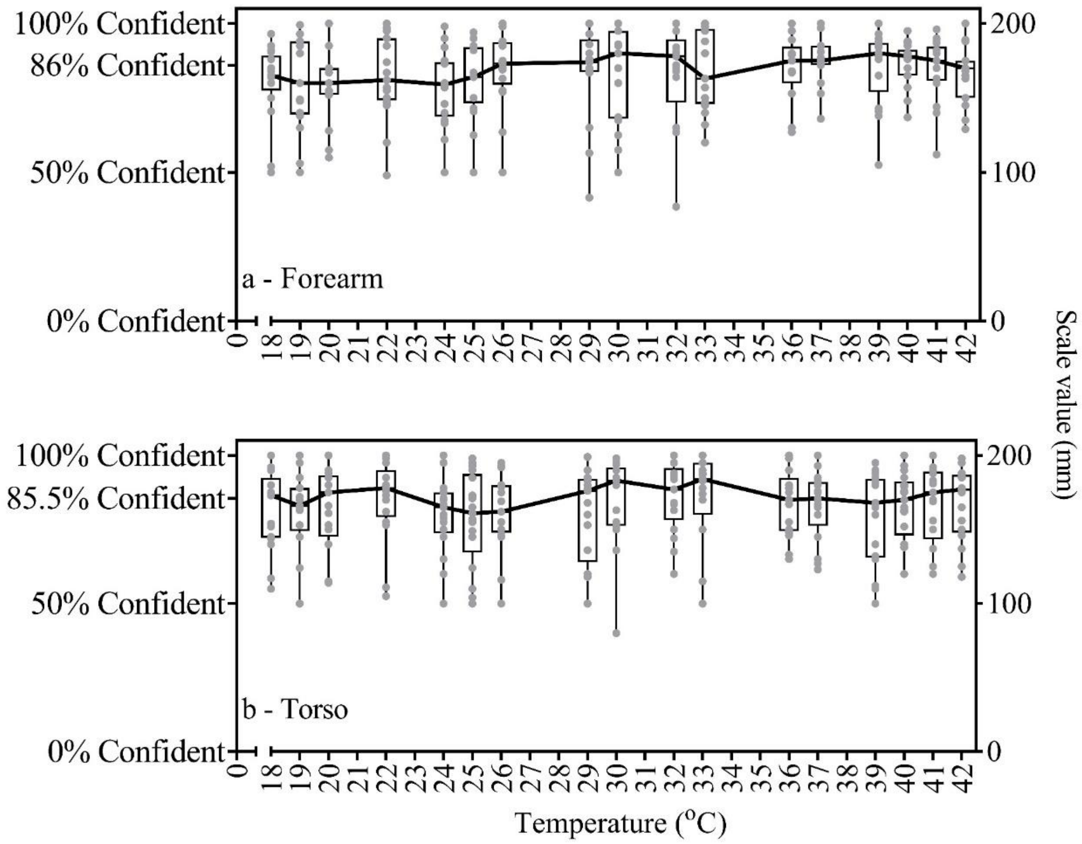

Figure 3: Individual data and box and whiskers with median connection line of the confidence of thermal sensation ratings in forearm (a), and in torso (b)