The hypothesis for the point presentation is that core temperature is defended at a set-point.

The hypothesis for the counter point presentation is that core temperature is not defended at a set-point.
Outline

- Study with evidence for set point
- Counterpoint studies with evidence for null zone
- Location of reference signal
- Vasomotion in the null zone
- Individual variability demonstrating null zone

Null zone: A zone of core temperature with no sweating or shivering, only vasomotion (Mekjavic et al., 1991)
Core temperature is regulated at a set point

(Modified from Cabanac & Massonnet, 1977)
Counterpoint: Cabanac and Massonnet 1977

Major Limitations (Cabanac and Massonnet, 1977)
• Skin temperature not held constant
• Rapid cooling of subjects
• Data presented as averages

Amended Protocol (Mekjavic et al., 1991)
• Constant skin temperature
• Gradual cooling

(Modified from Cabanac & Massonnet, 1977)
Core temperature “null zone” (Mekjavic et al., 1991)

- Threshold for evaporative heat appears to be superimposed with that of thermogenesis (Cabanac, 2006)
- Individual data shows null zone
- Both $T_{es}$ and $T_{re}$ and showed null zone

<table>
<thead>
<tr>
<th>Subj</th>
<th>$T_m$</th>
<th>$T_n$</th>
<th>$T_m$</th>
<th>$T_n$</th>
<th>$T_m$</th>
<th>$T_n$</th>
</tr>
</thead>
<tbody>
<tr>
<td>EC</td>
<td>38.97</td>
<td>37.32</td>
<td>36.26</td>
<td>36.66</td>
<td>0.71</td>
<td>0.66</td>
</tr>
<tr>
<td>IM</td>
<td>37.55</td>
<td>37.35</td>
<td>36.90</td>
<td>37.14</td>
<td>0.45</td>
<td>0.21</td>
</tr>
<tr>
<td>CS</td>
<td>37.59</td>
<td>37.69</td>
<td>37.36</td>
<td>36.86</td>
<td>1.03</td>
<td>0.59</td>
</tr>
<tr>
<td>PM</td>
<td>37.55</td>
<td>37.99</td>
<td>36.94</td>
<td>37.40</td>
<td>0.61</td>
<td>0.59</td>
</tr>
<tr>
<td>UT</td>
<td>37.11</td>
<td>37.53</td>
<td>36.64</td>
<td>35.92</td>
<td>0.47</td>
<td>0.61</td>
</tr>
<tr>
<td>HB</td>
<td>37.78</td>
<td>36.27</td>
<td>37.63</td>
<td>35.83</td>
<td>0.15</td>
<td>0.34</td>
</tr>
<tr>
<td>BF</td>
<td>37.50</td>
<td>36.98</td>
<td>36.80</td>
<td>36.41</td>
<td>0.50</td>
<td>0.47</td>
</tr>
<tr>
<td>RS</td>
<td>37.92</td>
<td>37.59</td>
<td>37.25</td>
<td>36.94</td>
<td>0.67</td>
<td>0.65</td>
</tr>
<tr>
<td>SR</td>
<td>37.25</td>
<td>37.79</td>
<td>36.59</td>
<td>38.30</td>
<td>0.66</td>
<td>0.99</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>37.42±0.29</td>
<td>37.39±0.48</td>
<td>36.84±0.38</td>
<td>36.80±0.39</td>
<td>0.58±0.23</td>
<td>0.57±0.20</td>
</tr>
</tbody>
</table>

Values are given in °C. $Esw$, rate of sweating (cessation of sweating); $\Delta V_o_2$, $O_2$ consumption (onset of shivering).

(Mekjavic et al., 1991)
Effect of $T_{\text{skin}}$ on Sweating

Sweating may be reduced by $4 \text{ cal/sec}$ with every $0.1^\circ \text{C}$ reduction in the level of skin temperature – this occurs at $T_{\text{skin}}$ below $33^\circ \text{C}$

(Benzinger et al., 1961)
Individual Variability affecting null zone

An example of rectal temperature and mean skin temperature throughout the experiment

• Peripheral interthreshold range was ~0.6°C

• Core interthreshold range varied from 0.7°C and 1.2°C

• Counterpoints
  • Use of a water-perfuse suit did not maintain a constant $T_{\text{skin}}$ – however, a null zone was still observed

(Katisuba et al., 2007)
Neuronal model of a reference signal

Counter-points

- This model is proposed by a review
- SEM studies indicate synaptic connections
- How do you explain adjustable set point?

(Boulant, 2006)
Vasomotion – Is it really a null zone?

- A null zone is a zone of core temperature without shivering or sweating, just vasomotion (Mekjavic et al., 1991).
- Vasomotion aids in maintaining $T_{core}$ (Kellogg, 2006).
- Counterpoint: vasodilation << sweating
  - Latent heat of evaporation: ~2595 J/g (Snellen et al., 1970)
  - Sweating rate is ~1.5L/hours = 1081 W
  - Cabanac and Massonet showed a max rate of ~ 50W of heat lost from the hand (1977)
Gender differences demonstrating null zone

The core temperature threshold for sweating, vasoconstriction, and shivering in men and women

- Sweating and vasoconstriction thresholds were significantly greater in women than in men.

- Sweating-to-vasoconstriction interthreshold range was ~0.2°C in each gender.

- Sweating-to-shivering interthreshold range was ~1.4°C.

(Lopez et al., 1994)
Gender differences demonstrating null zone

Tympanic membrane temperatures, sweating, vasoconstriction and shivering thresholds, and thermoregulatory response ranges in men and women

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Men Slow</th>
<th>Men Fast</th>
<th>Women Fast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control core (°C)</td>
<td>36.8 ± 0.2</td>
<td>36.8 ± 0.1</td>
<td>37.0 ± 0.2</td>
</tr>
<tr>
<td>Sweating threshold (°C)</td>
<td>37.0 ± 0.2</td>
<td>37.0 ± 0.2</td>
<td>37.3 ± 0.2*</td>
</tr>
<tr>
<td>Constriction threshold (°C)</td>
<td>36.7 ± 0.3</td>
<td>36.7 ± 0.3</td>
<td>37.1 ± 0.2*</td>
</tr>
<tr>
<td>Shivering threshold (°C)</td>
<td>35.6 ± 0.5</td>
<td>35.6 ± 0.5</td>
<td>36.1 ± 0.6</td>
</tr>
<tr>
<td>Interthreshold range (°C)</td>
<td>0.23 ± 0.16</td>
<td>0.23 ± 0.18</td>
<td>0.18 ± 0.14</td>
</tr>
<tr>
<td>Constriction–shivering range (°C)</td>
<td>1.1 ± 0.6</td>
<td>1.2 ± 0.7</td>
<td>1.0 ± 0.5</td>
</tr>
<tr>
<td>Sweating–shivering range (°C)</td>
<td>1.4 ± 0.6</td>
<td>1.4 ± 0.6</td>
<td>1.2 ± 0.5</td>
</tr>
</tbody>
</table>

*Slow and fast = rate of cooling used

(Lopez et al., 1994)
Evidence supports the hypothesis that humans do not regulate their core temperatures at a set point. Studies that properly control for the effect of skin temperature on $T_{\text{core}}$ demonstrate a null zone. There is individual variability in the amplitude and thresholds for sweating and shivering responses.


