Beyond Bubbles: the contribution of carbonation to the sensory properties of beer

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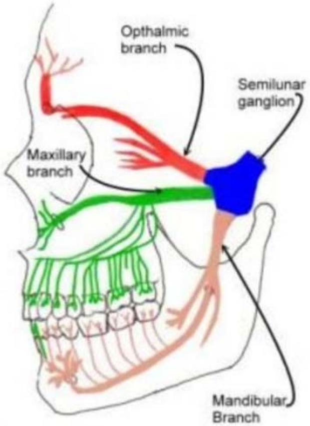
Presentation overview – 2 Studies

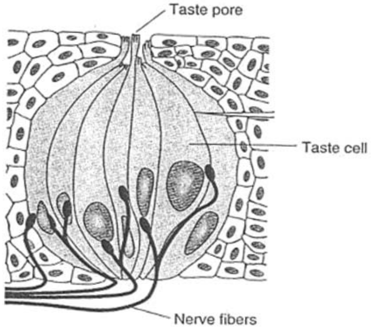
- Influence of carbonation on the sensory properties of beer

- Individual variation in carbonation perception: a brain imaging study investigating Thermal Taster Status

How is carbonation perceived?

- Carbon dioxide is an odourless stimulus
  - Carbonic anhydrase in saliva rapidly converts CO_2 into carbonic acid in the mouth
- Carbonation is perceived via two different mechanisms:
  - **Trigeminal** receptors (temperature, tactile, and pain receptors)
    - Pressure sensors detect mechanical sensation of bubbles (**fizzy** sensation)
    - Pain receptors detect carbonic acid (**tingling** sensation)
  - **Taste** receptors (H+ ion channels): detect H+ which are perceived as an **acidic** taste





(c) Taste bud

Influence of CO_2 on sensory perception

- **Study 1 Objective**
  - Determine impact of changing CO_2 level on the sensory properties of beer in relation to hop acid, sweetener and ethanol content.

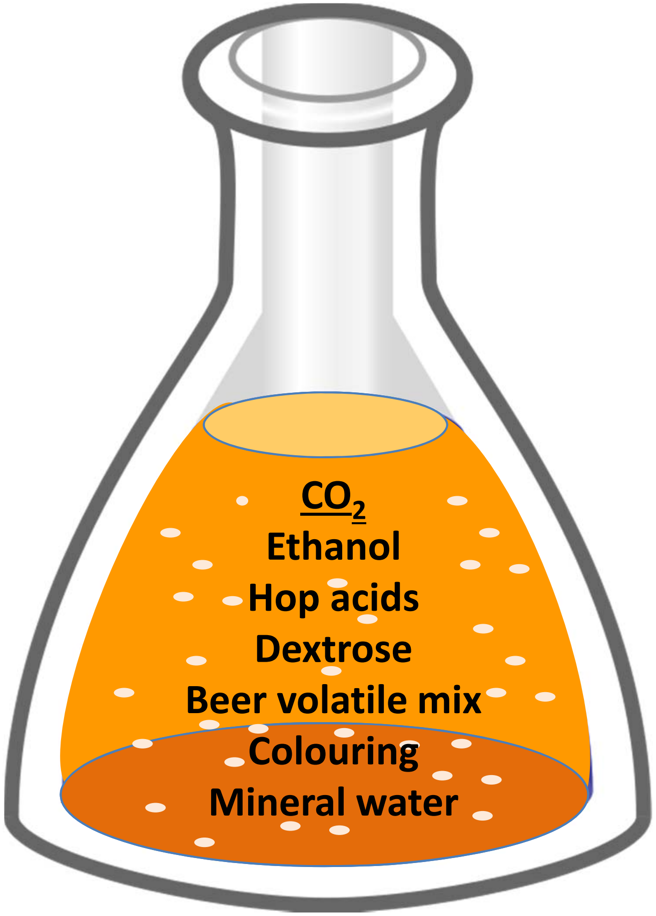



(Clark et al, 2010)

Beer samples

- The model beer enabled individual components to be controlled and manipulated independently

Different in ts, pr g, ages etc…



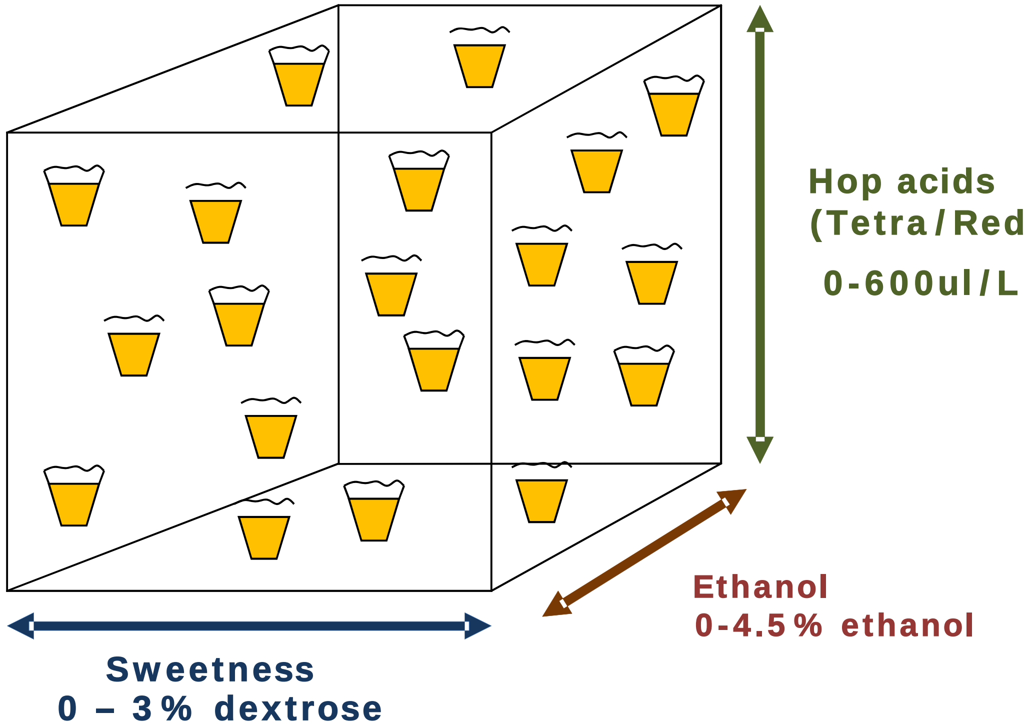
Experimental approach

Used a D-optimal sample design – reduces the number of samples to be tested number (n =31)

Carbonation:

- No CO_2
- Low $CO_{2\ (1.5v)}$
- High $CO_{2\ (3v)}$

Plus constant:
Aroma volatiles
Colouring



attribute = c(CO_2) + x(sweetener) + y(hop acids) + z(ethanol)

Sensory evaluation

- Quantitative Descriptive Analysis (QDA) ‘profiling’ using 10 trained panellists

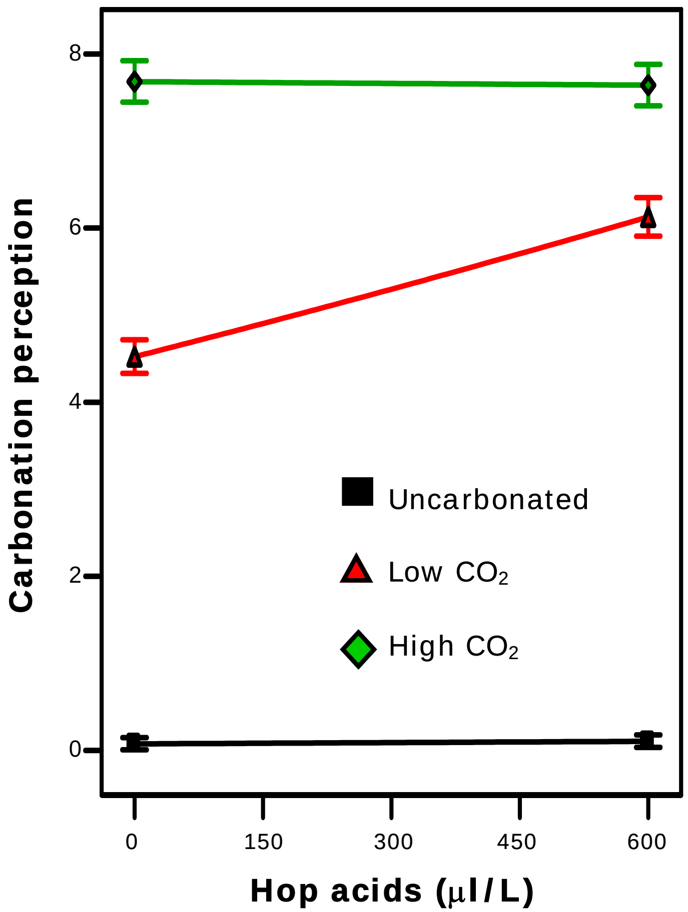
- The panel scored samples for 13 attributes identified across the beer samples
  - Flavour & Aroma: Alcohol, Sweaty/cheese, Floral
  - Complexity of flavour (complexity and balance of flavour)
  - Tingly (painful feeling as bubbles burst), Carbonation (extent of bubbles in mouth)
  - Sweetness, Bitterness
  - Warming, Astringent (both after swallowing)

Results

- Note that CO_2 level had **no effect** on the perception of any **flavour** or **aroma** attributes in this system.

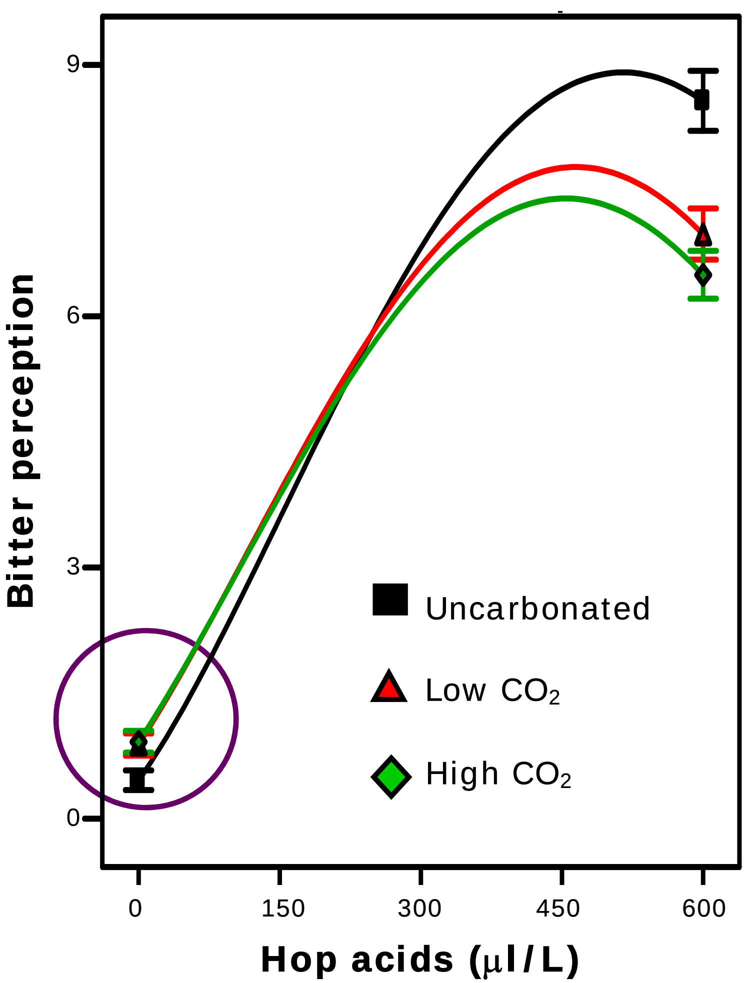
Effect of CO_2 level on Tingly & Carbonation

Tingly and carbonation significantly correlated and both increased with increasing CO_2



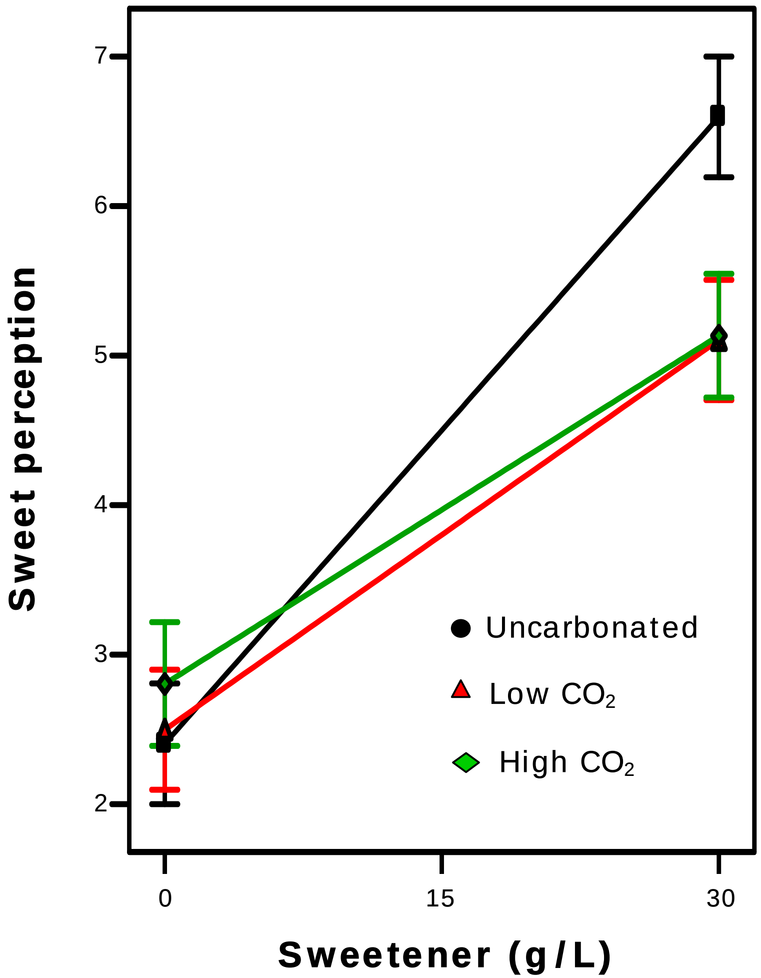
- However, not just CO_2 which increased perception of tingliness and carbonation
- At **Low CO_2** levels high levels of hop acids increased perception of tingliness and carbonation
- Why?
  - Foaming effect of hop acids

Effect of CO_2 level on Bitterness



- Interestingly, CO_2 imparts a bitter taste when no other bitterness is in the system
  - o Does CO_2 taste bitter? Inconsistent data in the literature
- CO_2 interacted with hop acids significantly decreasing bitter perception at higher levels
  - o This effect has also previously found with quinine sulfate (Cometto-Muniz et al, 1987)

Effect of CO_2 level on Sweetness



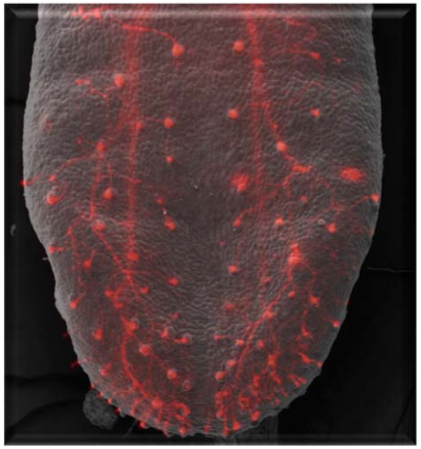
- Here, CO_2 significantly suppresses sweetness perception – although previous studies have found conflicting data
- Why?
  - Peripheral effect where CO_2 supresses gustatory response?
  - Higher cortical sweet-sour interaction?

Individual variation in response to carbonation

And Thermal Taster Status

Thermal Taster Status

Thermal tasters: individuals who perceive a '*phantom' taste* when the tongue is rapidly warmed or cooled (Cruz & Green 2000)

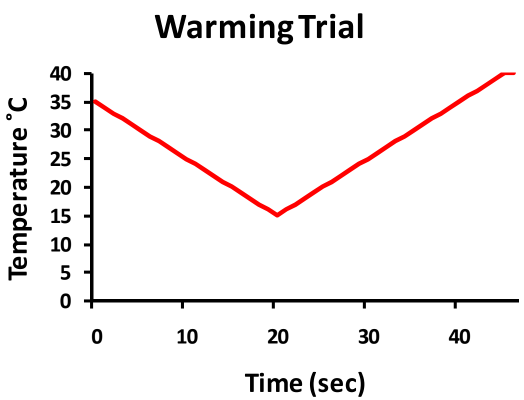


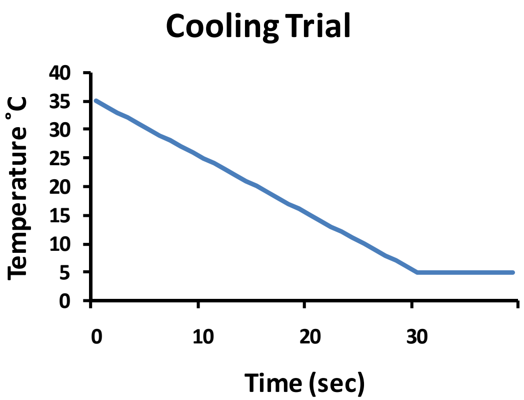
- Hypothesis: caused by cross wiring of taste and trigeminal nerves innervating fungiform papillae on tongue

- Thermal tasters have been shown to report a heightened response to oral sensations
  (Green & George 2004; Green 2005; Bajac and Pickering 2008; Pickering, Moyes et al 2010; Pickering, Bartolini et al 2010)

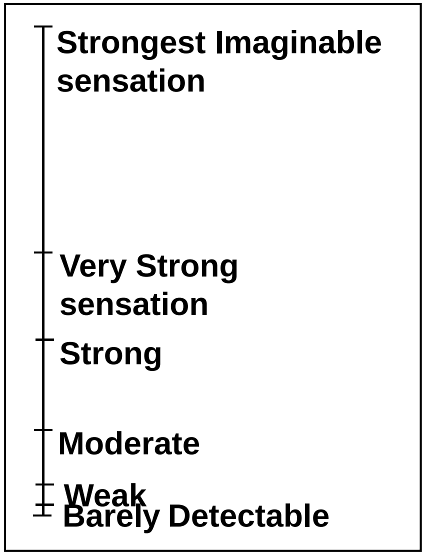
Thermal taster screening

- Temperature testing on tongue

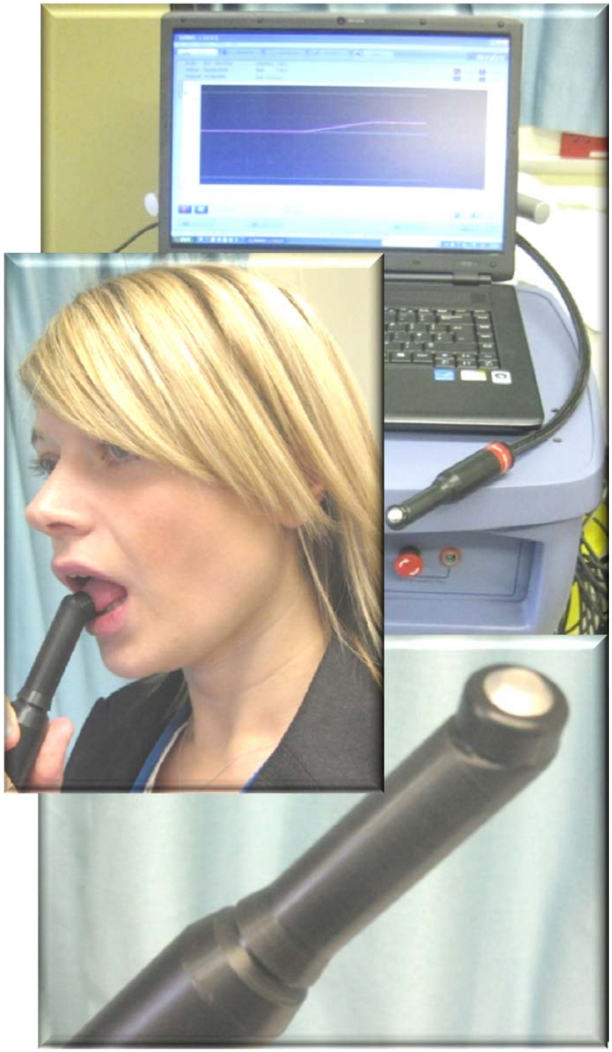




- Maximum temperature intensity and taste (if perceived) rated on gLMS
- Classed as Thermal Taster if a phantom taste was perceived (Thermal non Taster if no taste perceived)

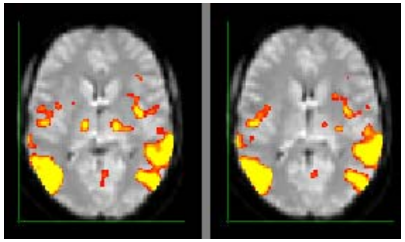


Medoc intra-oral probe



Individual variation: sensory and cortical response to carbonation

Objectives

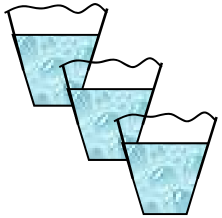


- Determine if cortical & sensory (discrimination/liking) response to CO_2 vary across Thermal Taster Status?

Stimuli

- 3 sweetened (30g/L dextrose) stimuli:

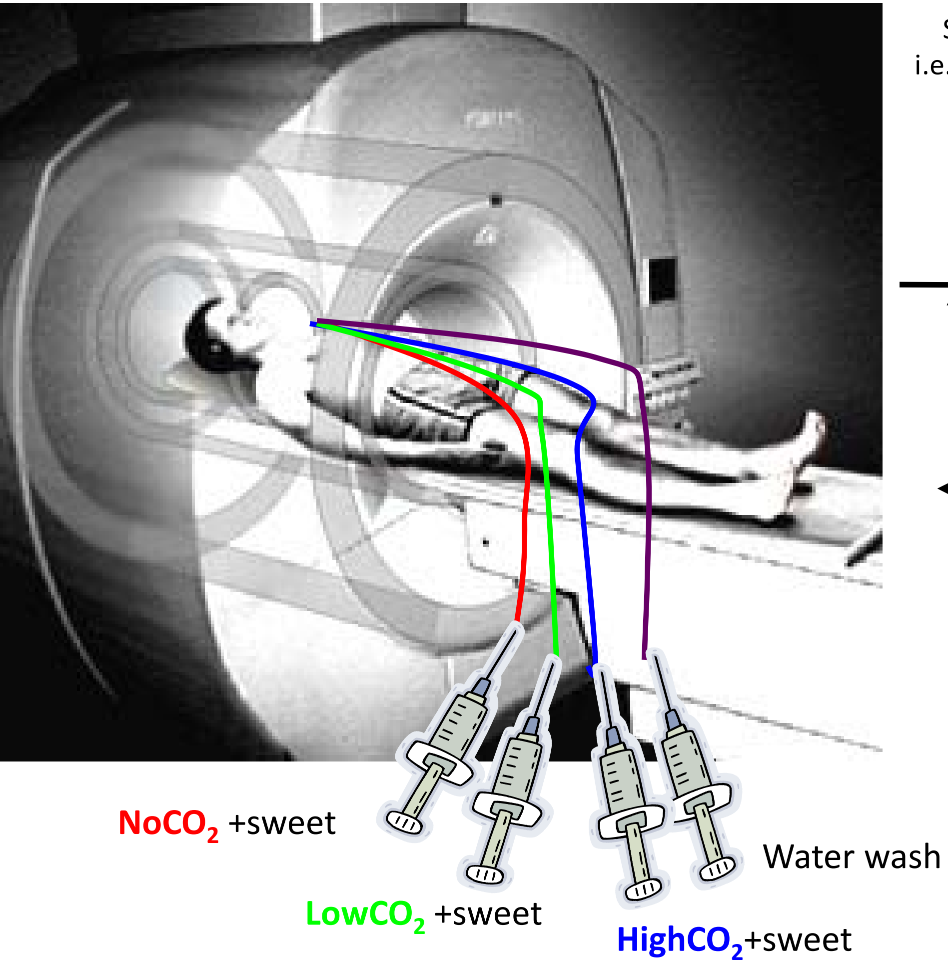
  NO CO_2, **LOWCO_2** (1 volume) & **HIGHCO_2** (2 volumes)

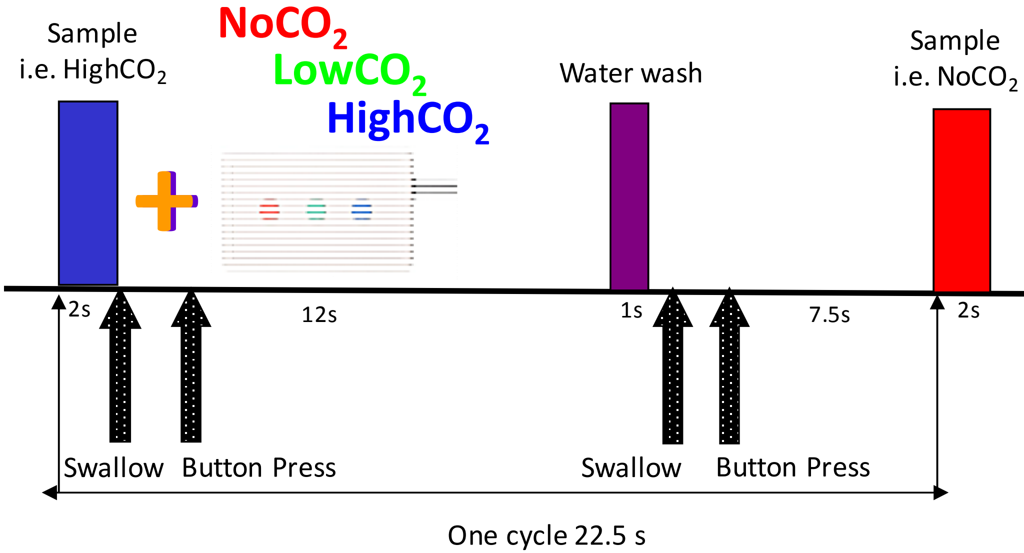


Methodology

- 12 thermal tasters (TTs) & 12 thermal non tasters (TnTs)
- fMRI brain scans (3T scanner) collected for each subject whilst consuming replicates of each stimulus.

fMRI stimuli and delivery



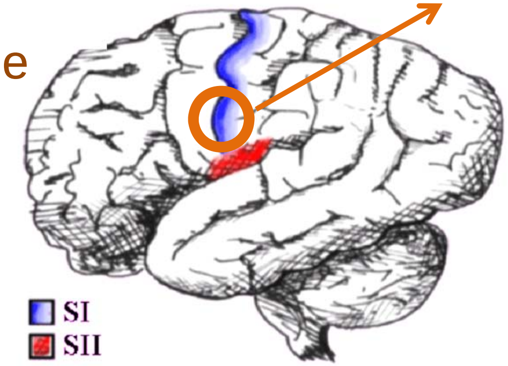


Samples ranked for preference outside the scanner

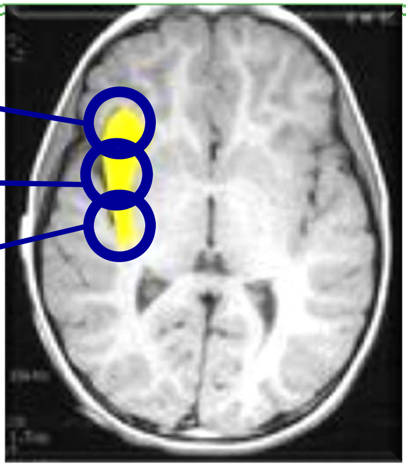
Areas of the brain

Somatosensory

- Temperature
- Tactile
- Pain



Primary (SI) **Secondary (SII)**



Insula

- Taste

Cingulate Cortex

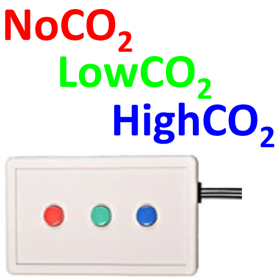
- Reward

Results

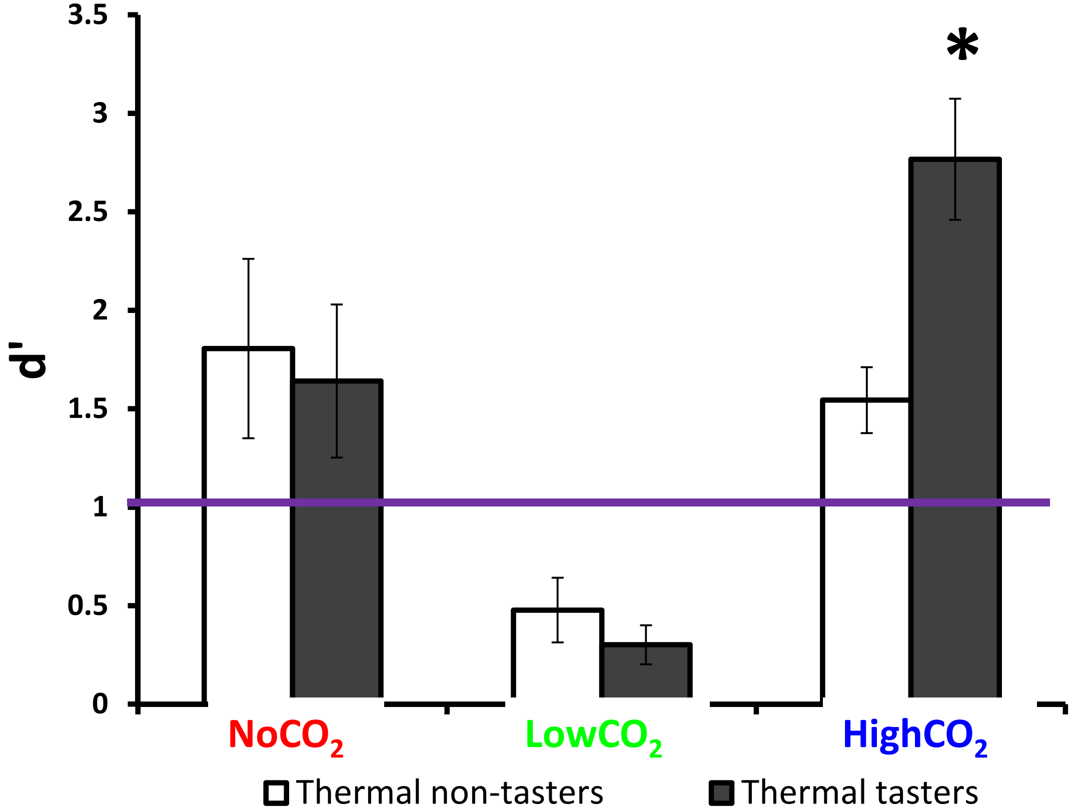
Sample discrimination

Thermal tasters were more able to identify the High CO_2 sample.

Do they have increased trigeminal sensitivity?



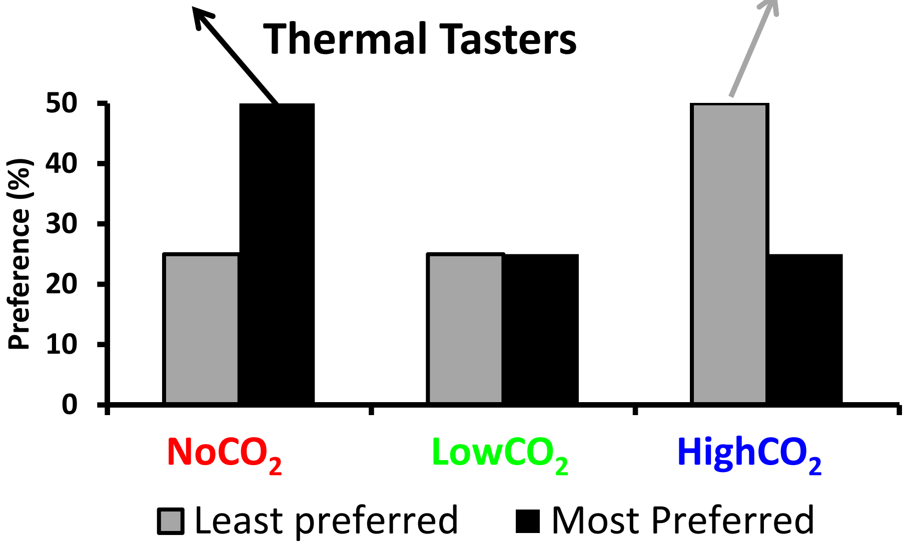
d' is a measure of sensitivity. A d' > 1 indicates an ability to discriminate from other samples

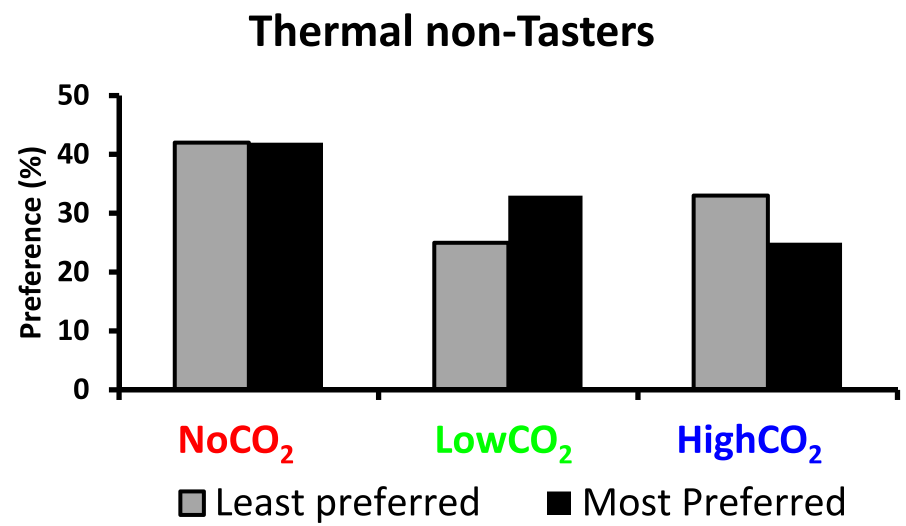


Sample preference

Most Preferred
No CO_2

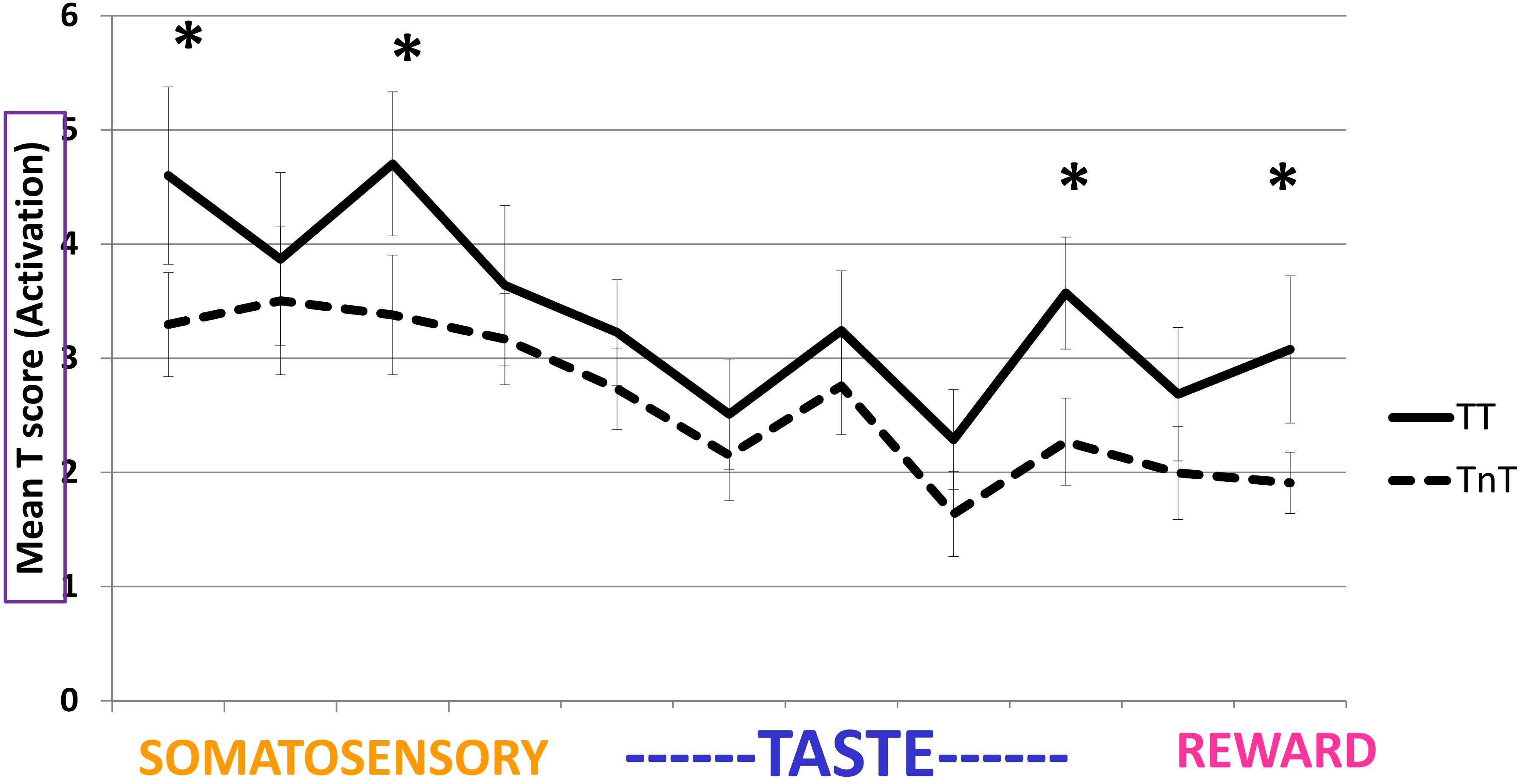
Least Preferred
High CO_2



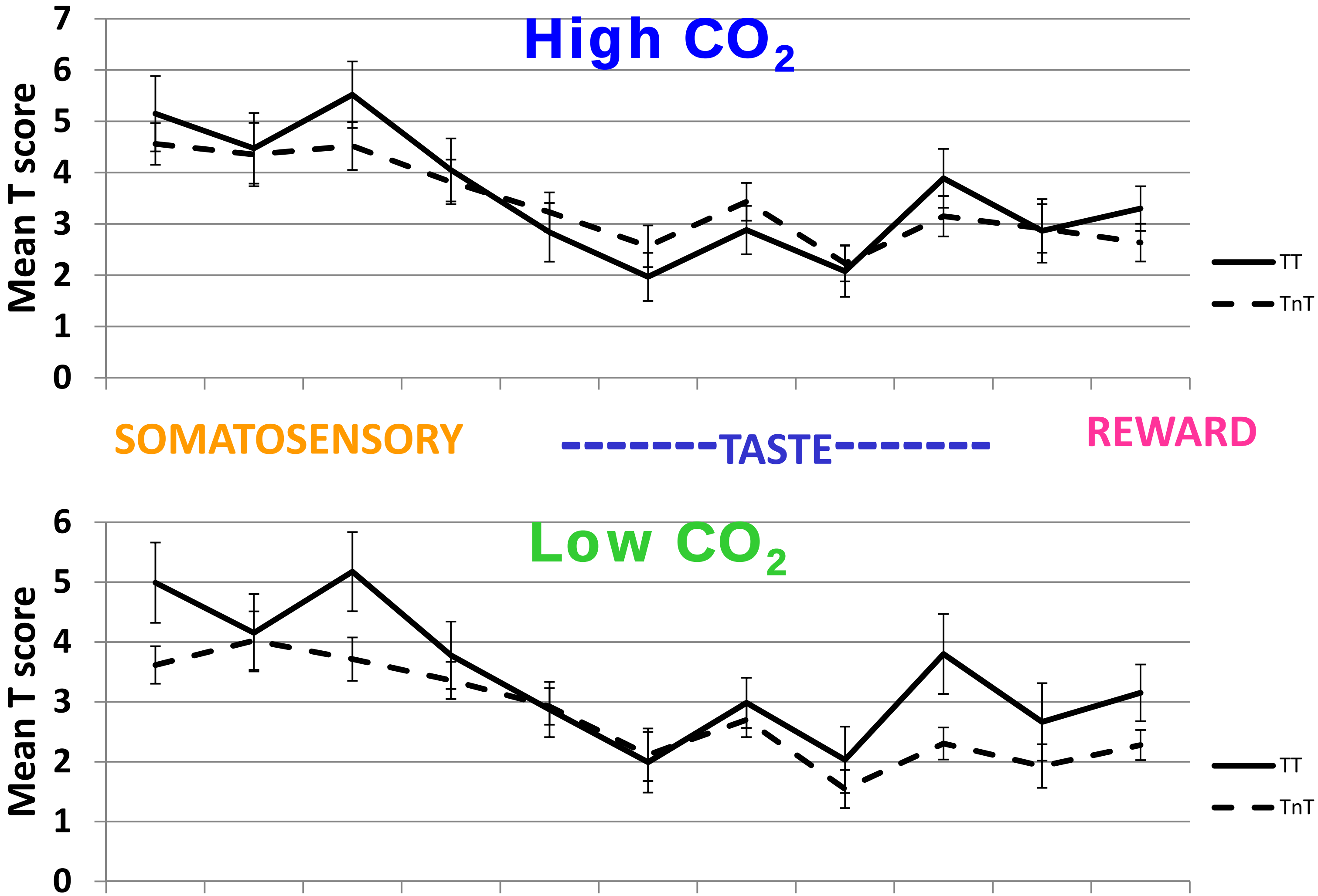


Thermal Tasters show a preference for less carbonated stimuli

Activation to uncarbonated stimuli



Activation to carbonated stimuli



Results summary

- Thermal tasters were better at identification of high CO_2 stimulus – are they more sensitive?

- Thermal Tasters showed an overall preference for uncarbonated stimuli - do they prefer less carbonated beer?

- Thermal Tasters show greater activation strength for equivalent stimuli but a reduced cortical response in taste areas to carbonated stimuli. Is the overall sensory experience of beer different for a thermal taster?

Overall conclusions

- CO_2 in beer influences sensory attributes beyond just the bubbles.
  - Sweetness and Bitterness: Effect depends on levels of other components such as hop acids and ethanol

- Thermal Taster Status impacts on perception of carbonated samples
  - TTs were more sensitive to carbonation and preferred less carbonated samples
  - Cortical activation is different in TTs, particularly in response to taste

- These findings have clear implications for the carbonated beverage industry in terms of product development and consumer preference insights.

Cheers!

Any Questions?