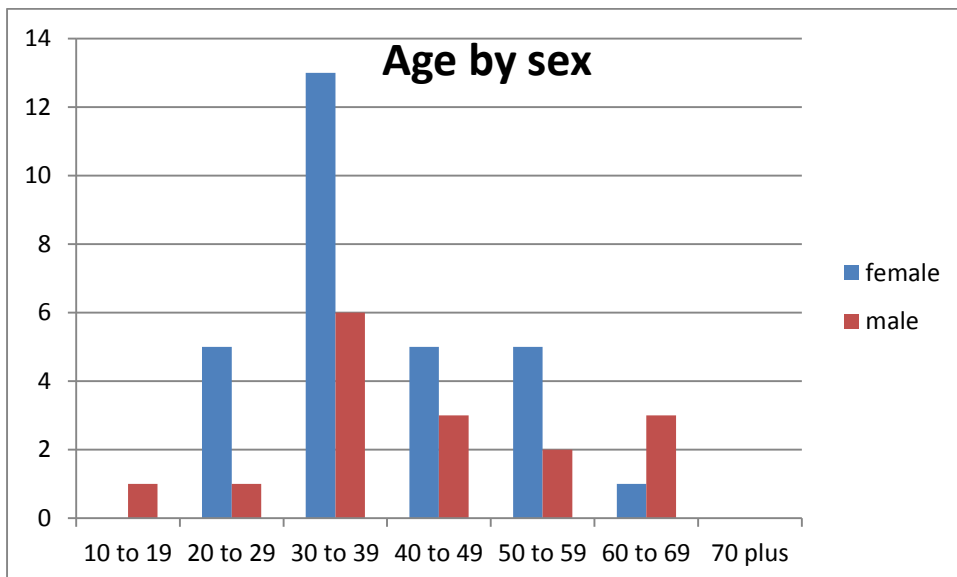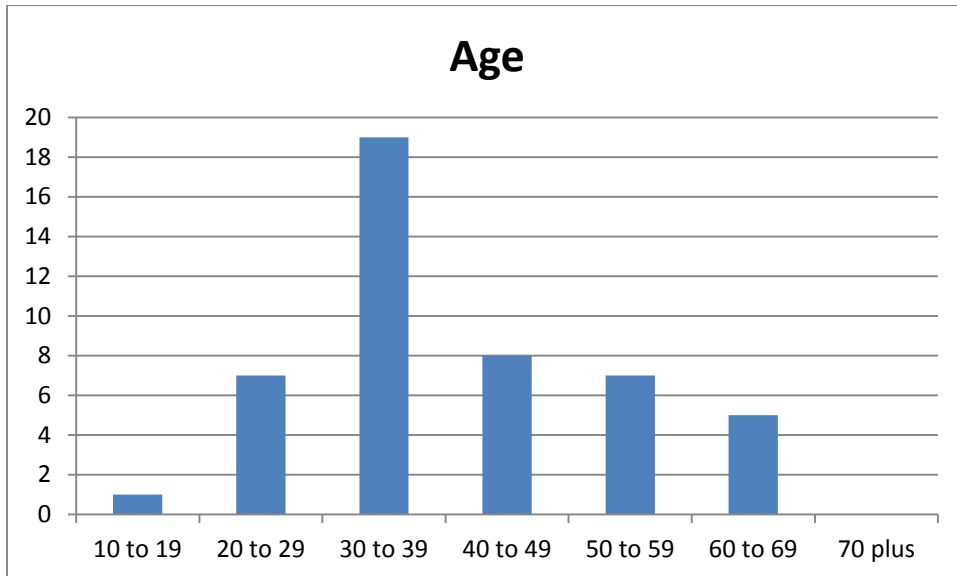**Preliminary exploratory data analysis of: The Proust Phenomenon: A Memory Network Experiment**

48 participants

16 male, 30 female, 2 no response (deleted from any analysis involving sex).

9 participants with sinus problems (4 female, 5 male).

Despite appearances non-parametric tests reveal that men and women don't statistically differ in their age (p>.2). This is good news it means subsequent sex differences can't just be attributed to an age difference and vice versa.

Experiment A: part I

For the most part I have only examined smells common to all tables as there are enough people (a large enough N) to run statistical tests on.

Familiarity & recognition of common smells

Because scores of familiarity and recognition didn't differ in relation to the specific smell I constructed a recall variable (factor) that examined both as a composite measure[1]. Recall did differ across smells:

	Recall	SEM*
Vanilla	4.645	.256
Cinnamon	6.056	.227
Lemon	6.282	.145
Cherry	4.868	.236

*standard error from the mean

I've also plotted this and pointed out the significant differences
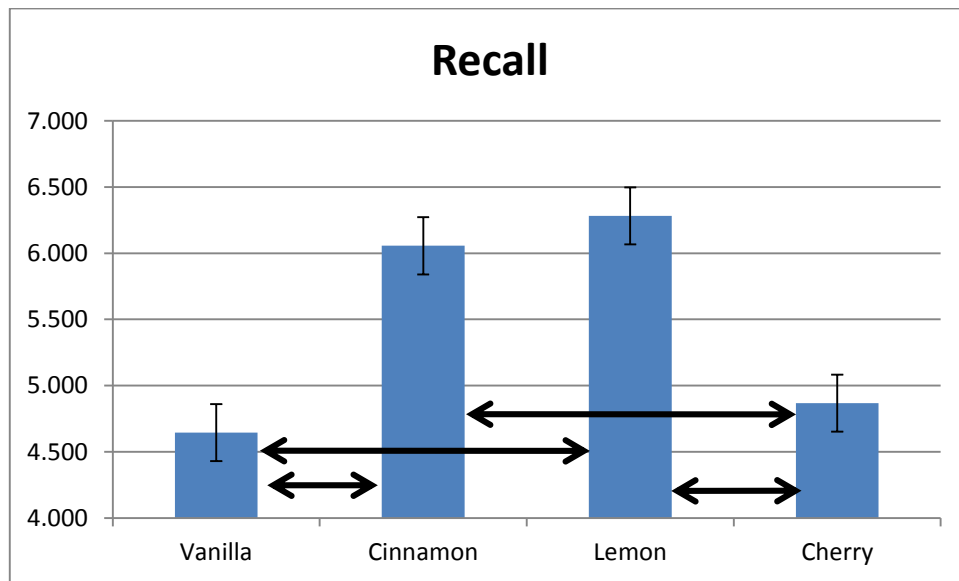
Arrows denote significant difference where $p < .01$[2].

So participants rated increased familiarity and recognition for cinnamon and lemon compared to cherry and vanilla – this was the same for both sexes.

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[1] 2(recall - familiarity/recognition) X 4(smell) X 2(sex) mixed ANOVA. Main effect of smell $F_{(3, 132)} = 16.47$, $p < 0.01$. Main effect of recall $F_{(1, 44)} = 23.94$, $p < 0.01$. No other effects (all F's < 3.0).

[2] Bonferroni corrected post-hoc comparisons.

Also people were more likely to rate all smells as more familiar (mean score = 5.71) than recognisable (mean score = 5.21). This might seem like a small difference but the statistical effect is very strong. It also makes sense – there's a psychological distinction between familiarity and recognition and it makes sense that any one given smell seems more familiar but not necessarily recognisable.

Interestingly – no effects of sex were observed, this is unusual for smell but maybe not for general measures of recall. There was also a relatively small male sample so this may contribute. I'll move on now to what I've called accuracy measures, these typically do have sex and age differences.

Accuracy measures of smell identification

I created a variable called accuracy of naming a smell by scoring correctly named smells as one and incorrectly named smells as zero. I was very liberal – citrus or lemon counted as correct when naming lemon, for example (maybe too liberal). While scoring I noticed that whole tables were often correct or wrong so I tested this statistically by looking at total accuracy (i.e., accuracy across all smells). Interestingly, table 7 performed significantly better than all other tables – it's unlikely that this is because table 7 was full of great smellers but probably because they discussed and labelled the smell amongst each other[3]. SO this is of some concern. Anyway I've pressed on with examining the 'accuracy measure' and left table 7 in for now.

 **Number of accurate responses for each individual smell:**
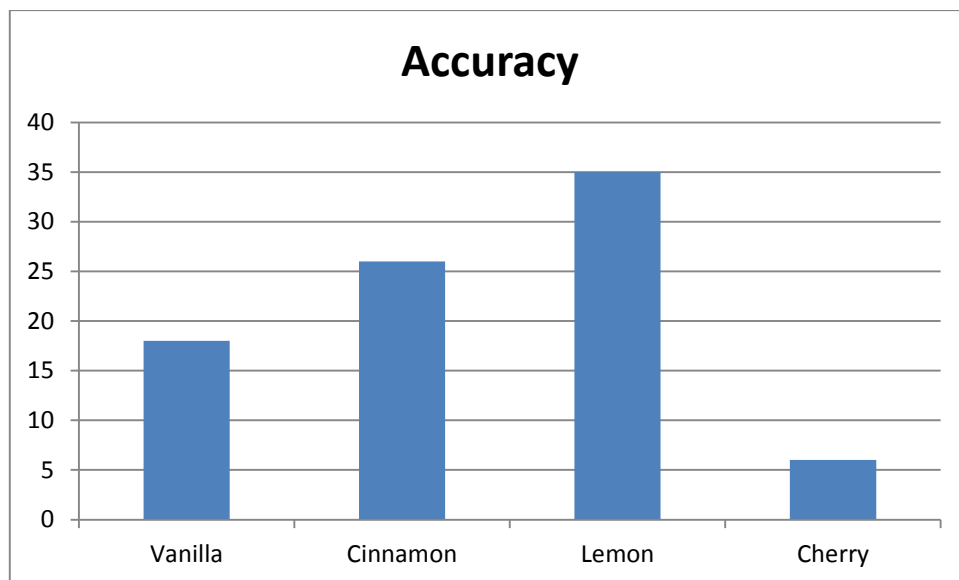
Interestingly, but anecdotally, the distribution of correct responses for each smell seems to follow the pattern of recall confidence described above. I'm not sure what statistics can be done on these as the data are non-parametric… Leigh may have some ideas. This anecdotal

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[3] One-way ANOVA with Table as a between subjects factor, pulled apart with LSD post-hoc tests.

observation suggests that people are good at identifying correctly whether they can correctly name and recall a smell.

Percentage of men and women who provided accurate name of smell for each smell.
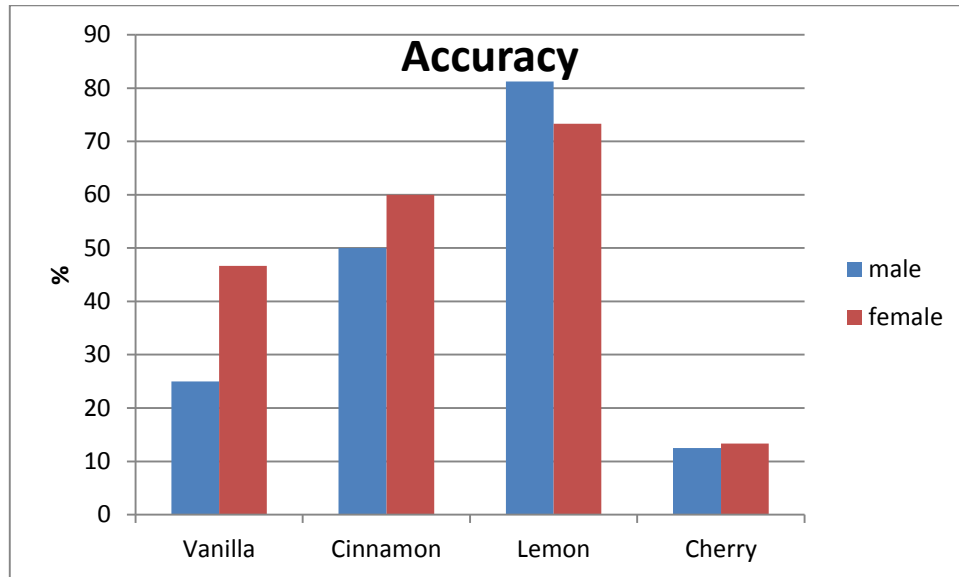

Experiment A: part II

I excluded 5 participants that only responded to the first two tins of smell that were variable between tables and focused the analysis on the remaining 43.
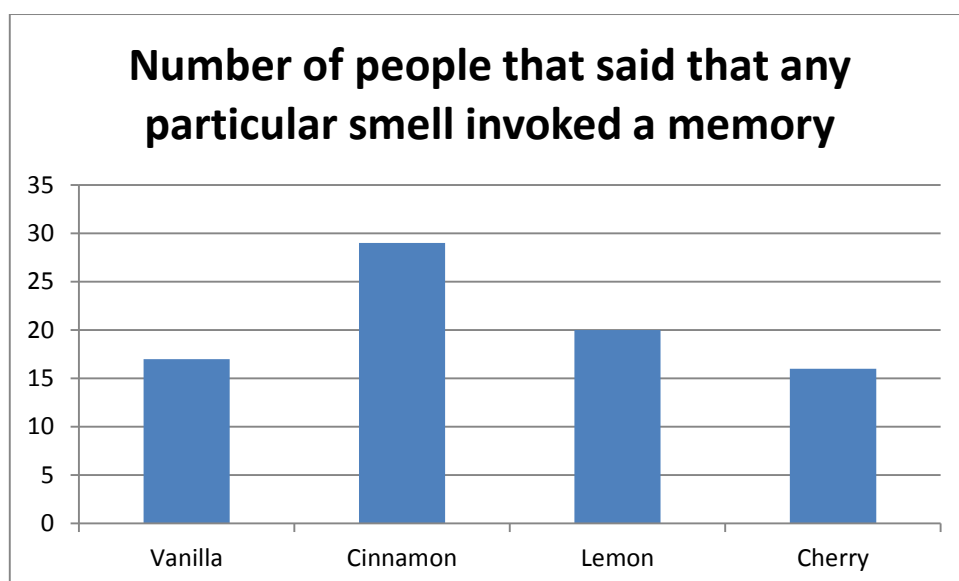
Next is an examination of the emotional and vividness ratings for the three smells chosen as eliciting a memory. It is hard to run any statistical tests on this data because people chose different smells.... I've done my best but I largely just describe the data.


Mean emotional and vividness ratings for smells that evoke a memory
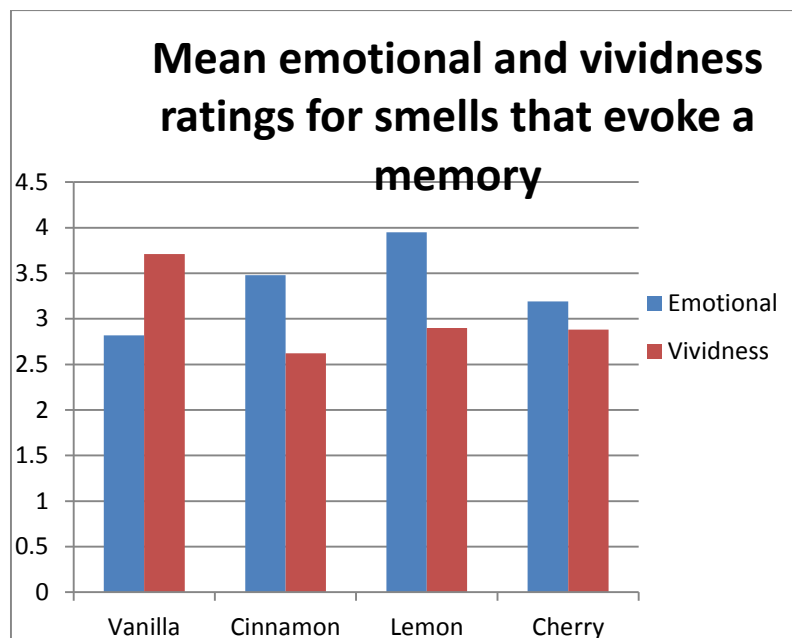
Interestingly 'how vivid' and 'how emotional' a smell was rated was highly correlated for all smells[4] except vanilla[5].That's to say that the more vivid a smell is perceived the more emotional it is with the exception of vanilla. This may be revealing of some specific property of vanilla as a smell.

I expected recall (familiarity and recognition ratings) to be positively associated with vividness and emotional ratings of the smell - this wasn't true. However, the inverse was true, in part, for cinnamon. Ratings for how emotional the smell was, was associated with how familiar and how recognisable the smell was. Specifically, the more familiar and recognisable participants rated cinnamon *the less* emotional the memory they said it evoked (see graph)[6].

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[4] Cinnamon – $r(29) = .65$, $p < .001$, Lemmon – $r(20) = .75$, $p<0.001$, Cherry – $r(16) = 0.58$, $p<.5$.
[5] Vanilla – $r(17) = 0.35$, $p< .15$
[6] Emotional ratings correlated with familiarity $r(29) = -.37$ $p< .05$ & recognisability $r(29) = -.51$, $p<.05$.
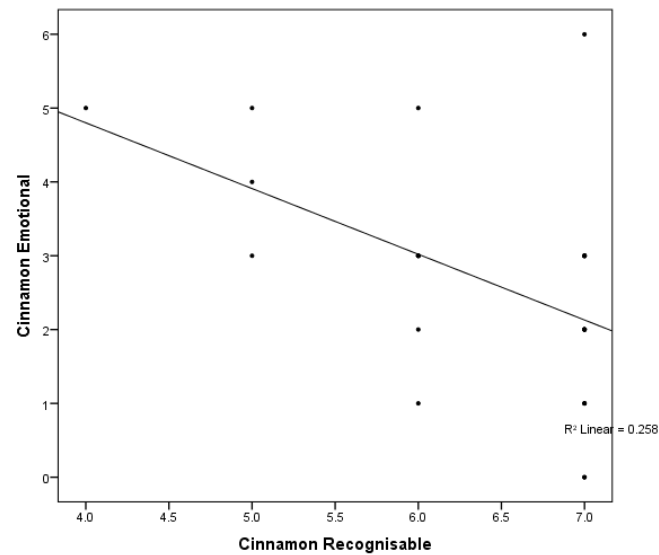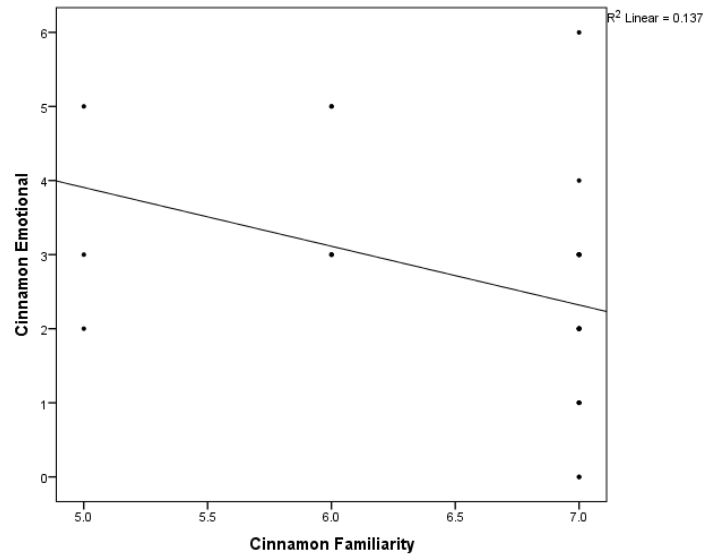
Initially I thought it might just be that cinnamon is associated with food and doesn't have much of an emotional content. However, Leigh correctly pointed out that so is Cherry and Lemon, so I'm a little stumped. It might be that cinnamon is also associated with an emotional response until named where it is identified as a benign non-emotional spice – not sure though. It is worth pointing out cinnamon is your least 'pure smell' – it strongly stimulates the trigeminal nerve and relies on somatosensory perceptual processes perhaps more than olfactory ones.

Experiment A: part III

First, ratings of intensity, recognisability and evocativeness were highly positively correlated for each smell[7]. This means they are probably measuring the same construct. [This is a little dodgy (statistically) but for this exploratory analysis I think I can get away with it – attempting to reduce the data reveals all three questions load heavily on to one component]. What is the one construct you're measuring? Not sure. Identification – maybe. Some kind of psychological impact the smell has after labelling. This is also complicated by the fact that these impressions are likely related to whether or not the participant correctly identified the odour in the first task – before labelling. I therefore looked at whether ratings of recognisability, intensity and evocativeness differed based on whether the participant correctly identified the smell to begin with[8] and largely they did (see graph).
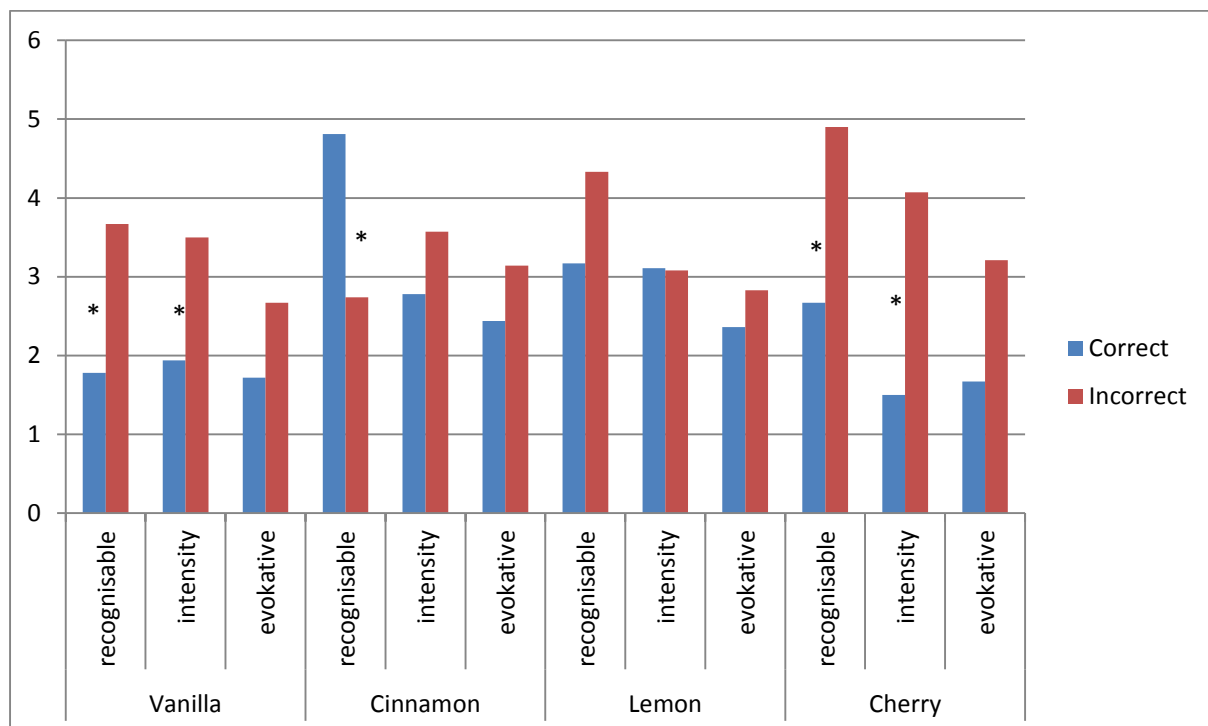
* denotes difference between rating between those who correctly identified the smell and those who didn't.

Vanilla and cherry both show that those who correctly identified the smell rated the smell after labelling as less recognisable and less intense compared to those who incorrectly labelled the smell to begin with. This makes sense – those who incorrectly identified the smell (or couldn't identify it) now find the smell more recognisable. Interestingly, those who incorrectly identified the smell (or couldn't identify it) find the smell more intense than those who could correctly identify the smell. This is true for vanilla and cherry only – the

[7] All r's > .60 all p's < .01.
[8] Independent sample t-tests.

hard to identify smells. For the more easily identifiable smells – cinnamon and lemon – this difference wasn't present.

I also examined the differences between the responses to the three questions (recognisable, intensity and evocativeness) in relation to each smell independent of previous identification[9].   Overall Cherry was rated highest in all questions and people rated smells as recognisable most, as evocative least and intense lies in between these.

Experiment B

First I looked for relationships within modality. Across all modalities how vivid, how emotional, how evocative and how specific the memory was, was highly positively correlated. So, in all modalities, the more vivid the memory was rated, the more emotional it was rated, the more evocative it was rated and the more specific the memory was rated. This leads me to think you were effectively asking someone – 'how strong is your memory in relation to this verbal/visual/olfactory/auditory label'.

I next explored the differences between questions across different modalities[10]. I initially did this including sex as a factor but nothing interesting happened so I removed it. There was an effect of the question asked, the modality and an interaction between these two factors[11]. Across all modalities the emotional ratings for the memory was the lowest compared to how vivid, how evocative and how specific the memory was[12] (see graph). This I imagine means that no evocation of a memory by simple presentation of any stimuli in one modality is enough to induce an emotional response. Emotional responses are usually evoked by either very specific stimuli or complex cross-modal stimuli, and often a mismatch with expectations. If you had presented the smell of sulphur dioxide – I think you would have gotten different responses!

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[9] 4X3 repeated measures ANOVA.

[10] 4(modality) X 4 (question) repeated measures ANOVA.

[11] Modality – $F_{(3, 135)} = 5.97$, $p< .01$, Question – $F_{(3, 135)} = 6.61$, $p<.001$. Interaction – $F_{(9, 405)} = 7.38$, $p< .001$.

[12] Bonferroni corrected comparisons

Ratings across modalities
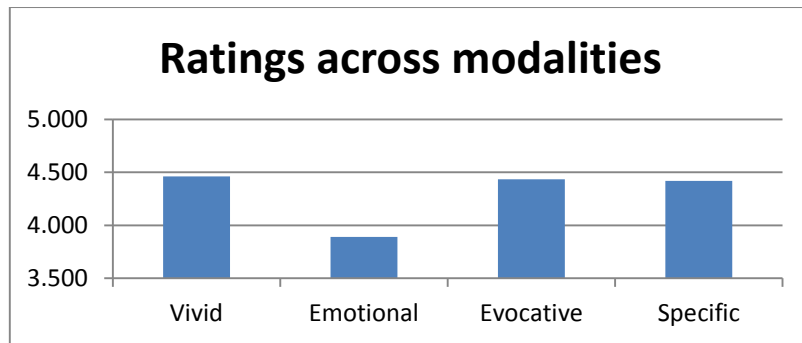
Across all questions the verbal label received the highest rating[13] compared to all other modalities. This likely reflects that words aren't really a sensory modality but enriched information with an explicit semantic concept; mere sensory perceptions can't compete!

Ratings across questions
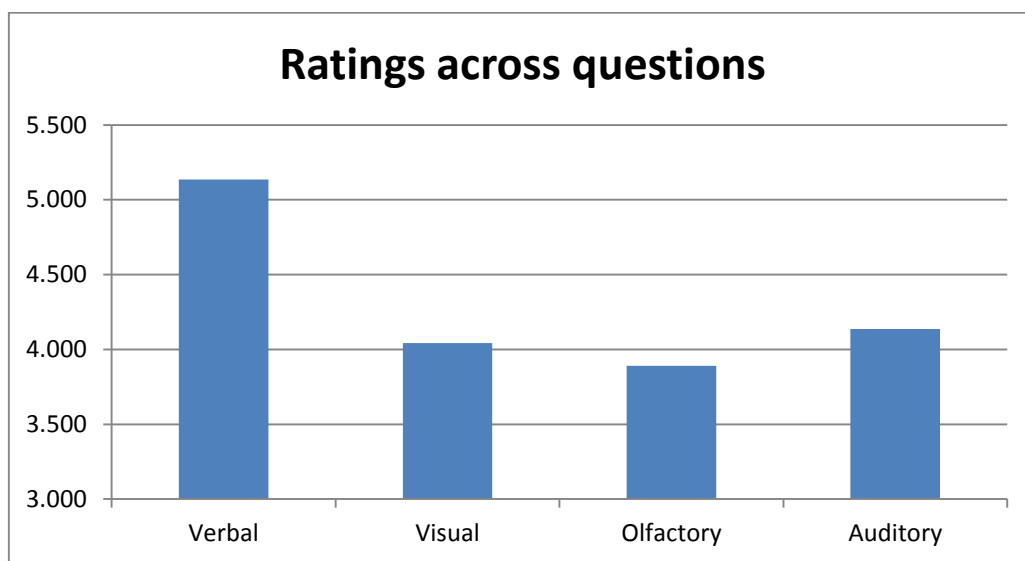
There's also a complex interaction but I can't really make heads or tails of it. I think subsequent tests might be useful but perhaps best guided by your questions about the data.

Summary

Of the four smells common to everyone we can lump cherry and vanilla together and cinnamon and lemon together. For the most part I imagine this is driven by how easily identifiable they are. Indeed, familiarity and recognition probably just mean 'can you name it?' This fits with smell research that suggests smell and language are closely associated – psychologically and at the level of the brain.

Emotionality and vividness are closely related among all smells with the exception of vanilla.

How familiar and how recognisable a smell is (I termed this 'recall') isn't associated with how emotional or vivid a smell is perceived to be. Except with cinnamon, in this case the

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[13] More bonferroni comparisons.

more one could recall cinnamon the less emotional it was rated – I'm not sure why this is. Perhaps, once identified cinnamon loses any emotional content. Leigh has also suggested that this could be some hedonic component related to recall and emotion. Tricky one.

After labelling the smells, questions about recognisability, intensity and evocativeness largely seemed to measure the same thing – probably 'does the smell match the label?' Once labelled only the hard to name smells (vanilla and cherry) were rated differently in intensity and recognisability based on whether they were previously correctly identified. Recognisability is expected but intensity is more interesting. A novel label in this case seems to add something to the olfactory percept.

For the complex smell – all stimuli evoked an emotional response least, of all the responses measured, and any kind of response was best elicited by a verbal stimuli. Pretty straight forward.