

# Does the strength of your sense of smell have a correlation with the strength of your short-term and long-term memory?

## INTRODUCTION

Our project is based on the relationship between memory and smell, we wanted to investigate whether the strength of one's ability to smell has a correlation with their short- and long-term memory strength. An event that greatly influenced this project topic was when one of our team members, Calum, recalled the time his grandfather was diagnosed with Alzheimer's disease. Scientists around the globe have strongly suggested that one of the very early indicators of Alzheimer's Disease is when the ability to smell deteriorates and Calum's grandfather suffered from this symptom.

Our aim is to conclude that if one's sense of smell is strong then their short-term and long-term memory is also strong. This led us to create three tests that would allow us to measure a participant's strength of smell and their short and long-term memory.

## KEY COMPONENTS

The sense of smell is the most complex and unique in structure and organisation. The main smell cells in the nose are specialised sensory cells, called olfactory sensory neurons. These are in a small patch of tissue high inside the nose. Each olfactory neuron has one odour receptor. Once the neurons detect the molecules an electrical signal is sent to the brain.

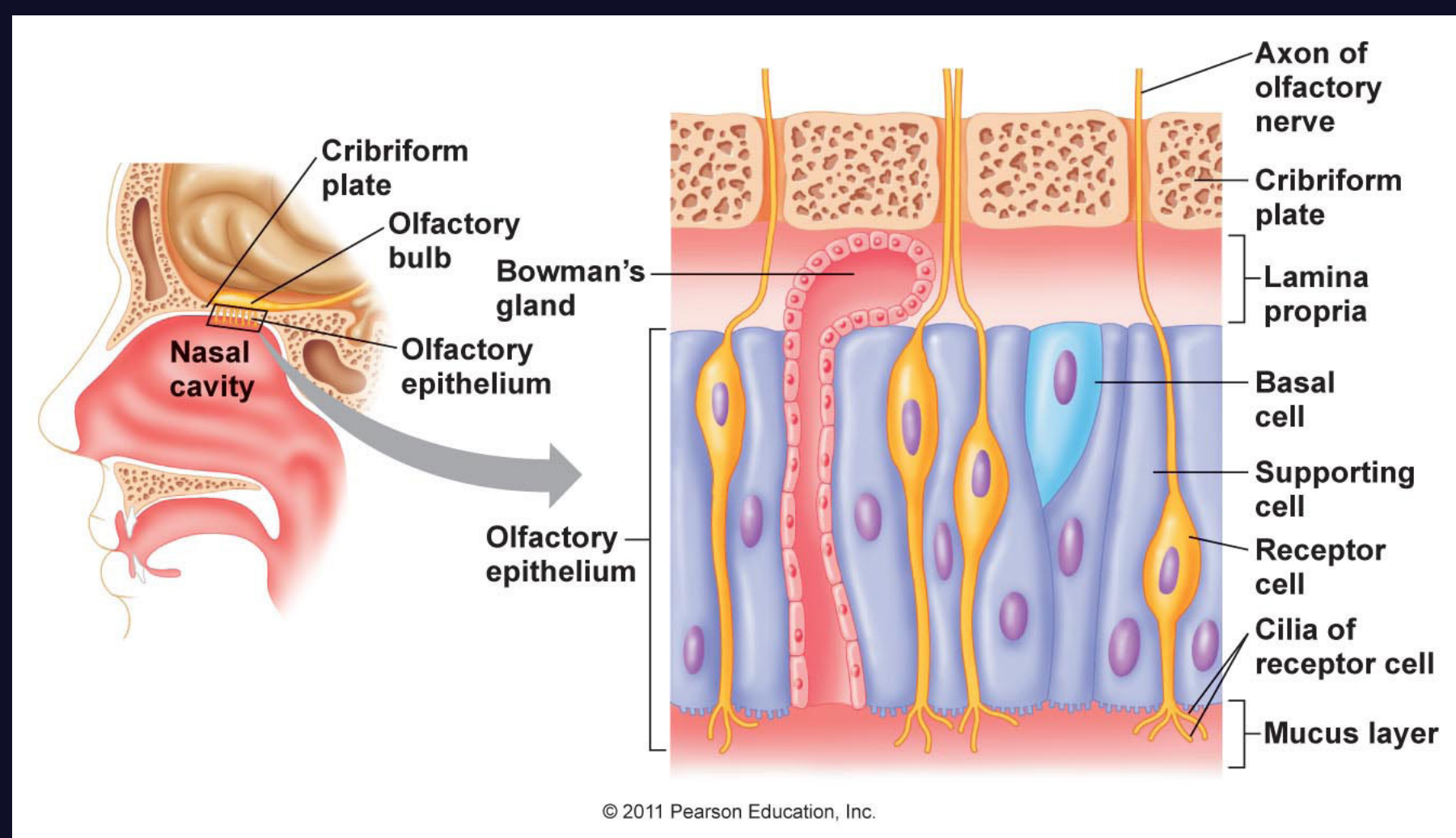


Figure 1: A cross section of the olfactory system

Long-term memory refers to the storage of information over an extended period of time. There are a number of different types of long-term memory, such as, declarative memory and visual memory, both of which we tested in our experiment. Declarative memory is the memory of factual information, general knowledge, data, and events. Visual memory is the ability to recognise and remember faces while also comprehending information. Information is transferred from short-term memory to long-term memory through the hippocampus. The hippocampus is located in the inner fold of the temporal lobe and is responsible for a human's long-term memory.

Short-term memory is the ability to temporarily hold information in your mind from the immediate past (e.g. a telephone number) it involves different psychological processes and neural sub-states than long-term memory (e.g. remembering what happened yesterday). Short-term memory is stored in the pre-frontal lobe as well as in the hippocampus.

## EXPERIMENTAL METHODS

Sample size = 121 Participants

To test the strength of the participants' sense of smell we chose 3 everyday scents - lemon, tea tree and lavender. To create a dilution scale we reduced the concentration of the original oil, from 100 % to 2%, 1%, 0.5%, 0.25%, 0.125%, 0.0625% for each scent. We held each test tube 20 cm away from the volunteer's nose and this was checked for each volunteer using a ruler.

To test the strength of the participants' long-term memory, we showed them a video of ten people each stating three facts about themselves. This was done at the beginning of the experiment and three months later the participants were tested to assess their ability to identify the people and remember the facts. This video included both faces and data in order to test a number of different types of long-term memory such as declarative memory, visual memory and episodic memory.

To test the strength of the participants' short term memory we showed them twenty words for two minutes after which they wrote down from memory on a blank page.

## RESULTS AND ANALYSIS

### LONG-TERM MEMORY

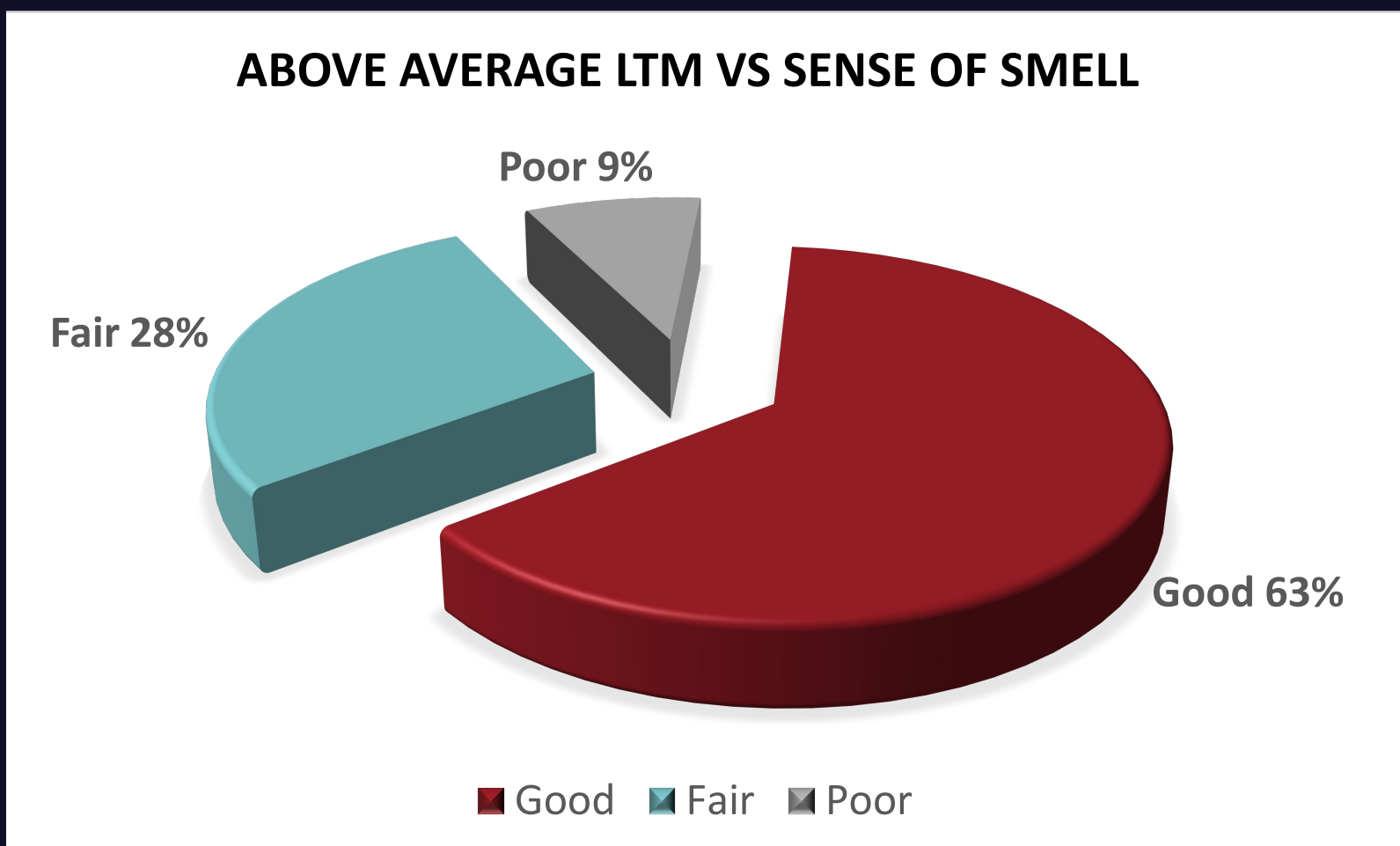


Figure 2: LTM vs smell for 57 above average participants

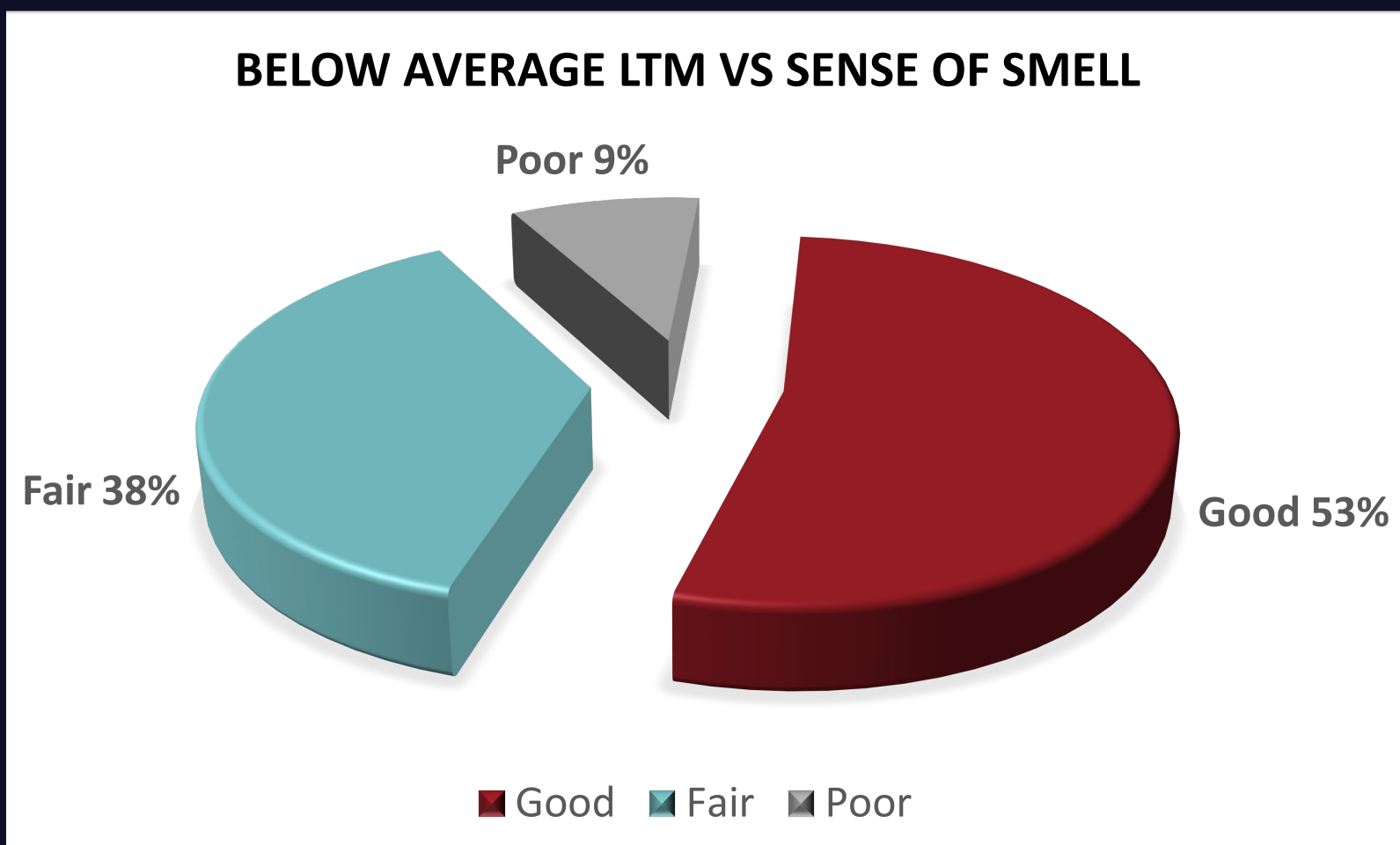


Figure 3: LTM vs smell for 64 below average participants

The mean score calculated for the long-term memory test was 26. This figure was used to subdivide the participants into above (57) and below (64) average categories which were then compared to their strength of sense of smell results.

The smell data was subdivided into good (2-4), fair (5-6) and poor (7-8). In the above average LTM category, 63% of the participants had a good sense of smell. In the below average LTM category, 53% had a good sense of smell. This indicates little to no significant difference between the above and below average LTM participants and the strength of their sense of smell.

This would indicate little to no correlation between sense of smell and long-term memory.

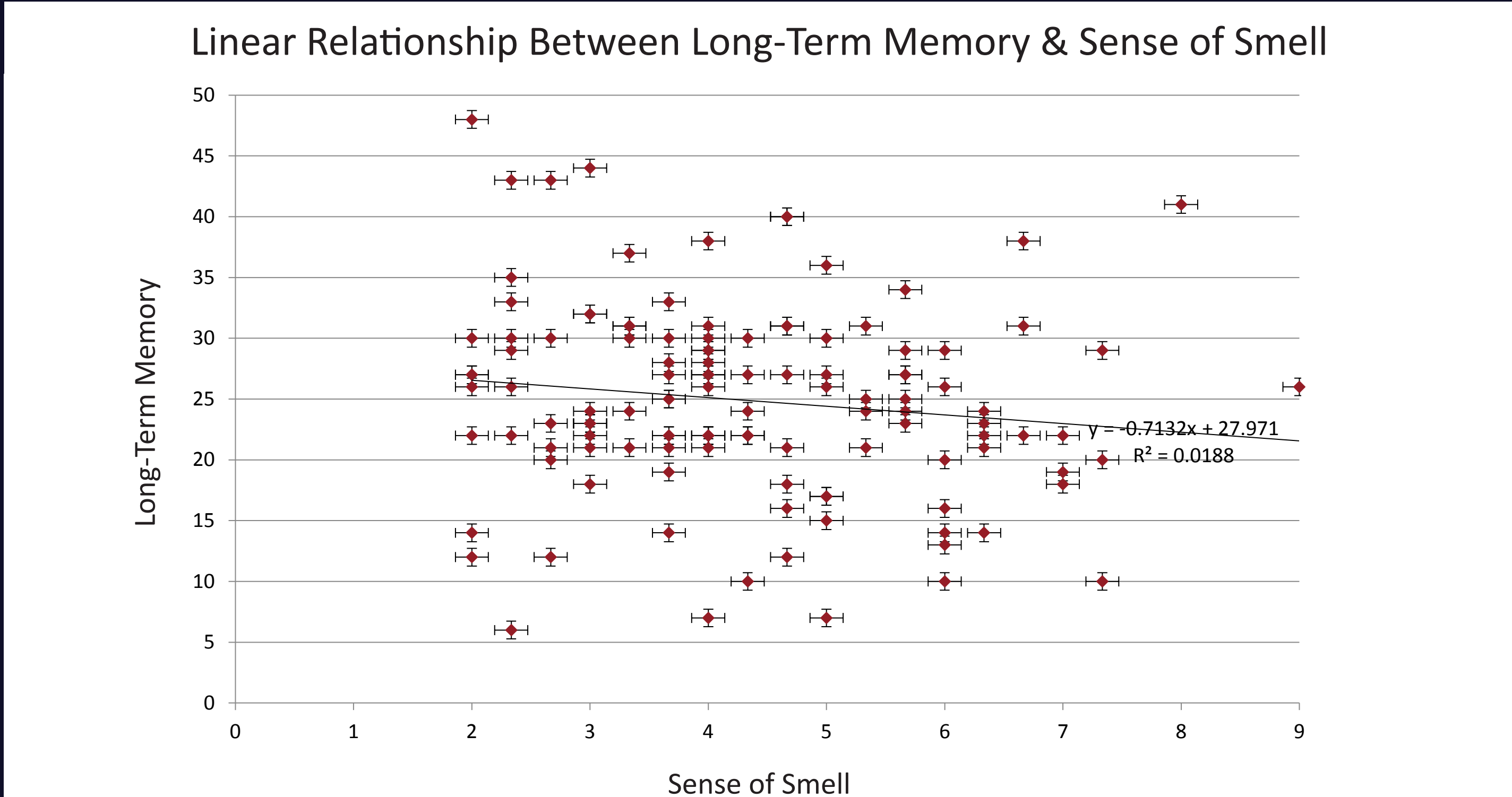


Figure 4: Scatter graph representing the correlation between LTM and strength of smell - error bars using standard error

As visible from the scatter-graph the data is very centralised and there is no clear positive or negative relationship. There is a very low  $R^2$  value reinforcing this. To analyse the correlation mathematically we used the Spearman rank-order correlation coefficient that was calculated for each of the 3 scents, taking reference to our long-term memory y values, it is evident that the y values are closer to 0 (i.e. smell 1: -0.1464, smell 2: -0.2031 and smell 3: -0.05351). This is a non-monotonic relationship. This indicates that there is no significant correlation between long-term memory strength and smell strength.

### SHORT-TERM MEMORY

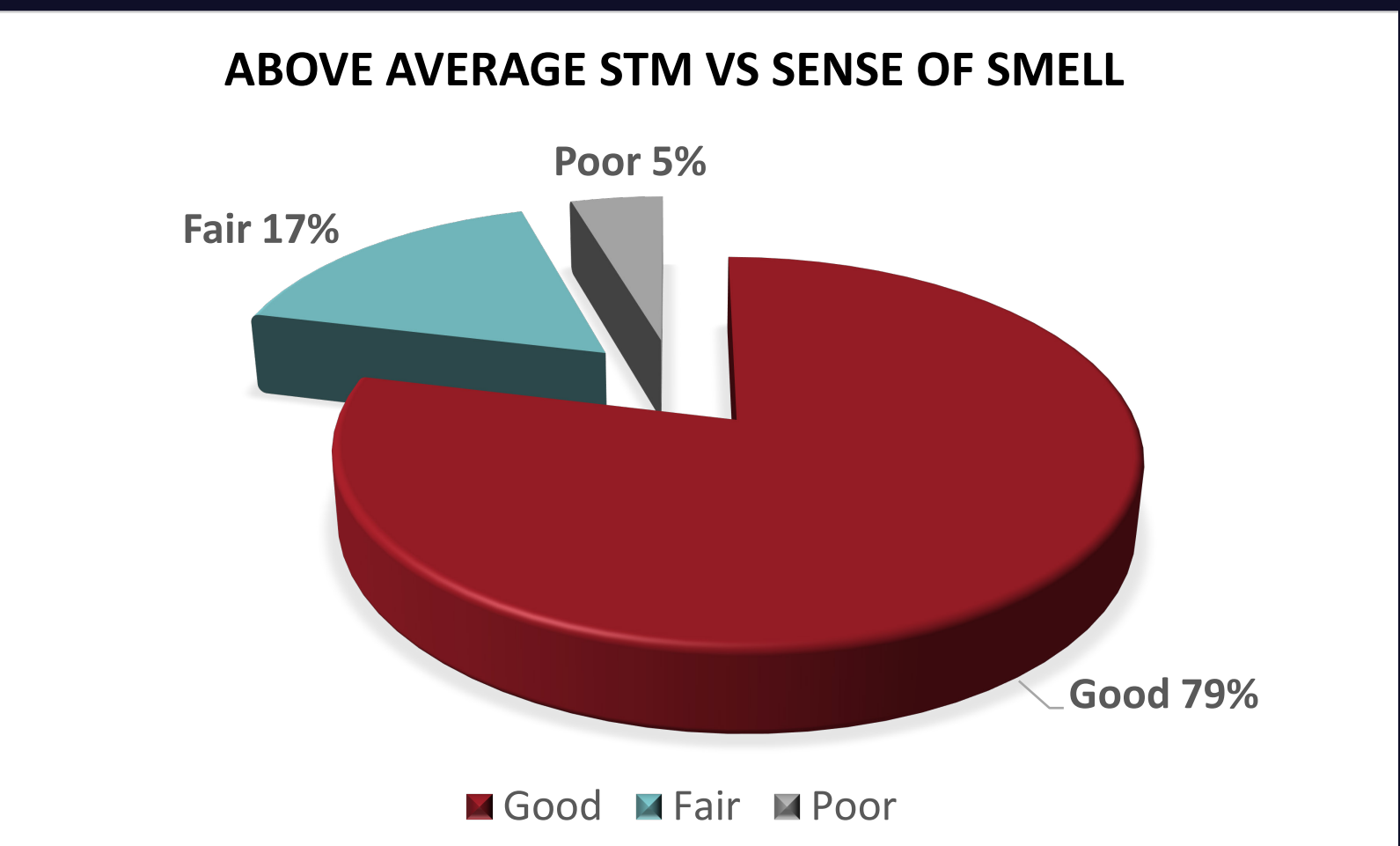


Figure 5: STM vs smell for 66 above average participants

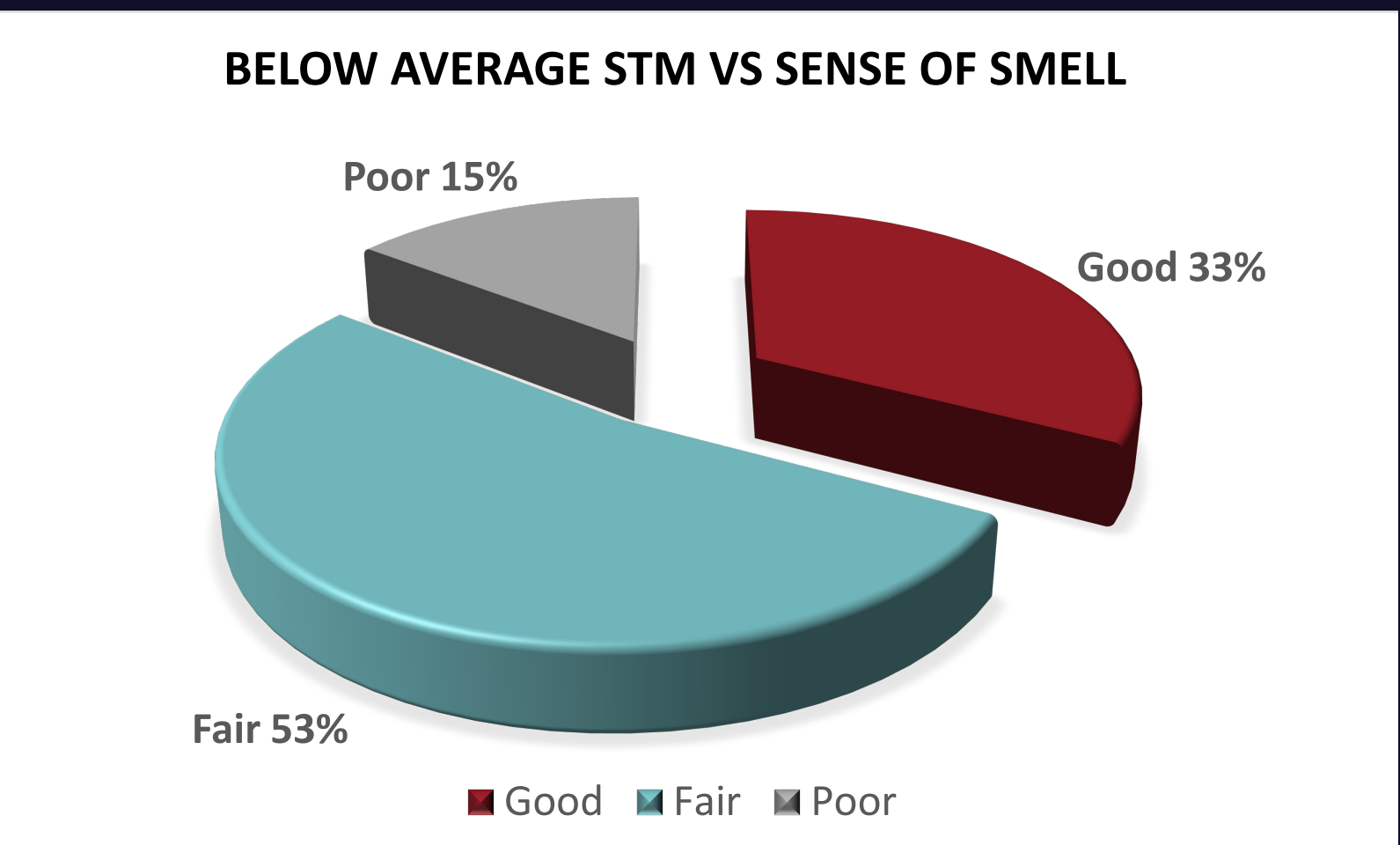


Figure 6: STM vs smell for 55 below average participants

The mean score calculated for the short term memory test was 37.66. This equated to 66 above average and 55 below average STM participants.

In the above average STM category, 79% of the participants had a good sense of smell compared to only 33% of the below average STM category. It became evident that there is a correlation between smell strength and the strength of short-term memory.

Using the Spearman test we can see that the short-term memory y values, are much closer to 1 (i.e. smell 1: -0.5107, smell 2: -0.5274 and smell 3: -0.4612). This supports our observation that there is a significant correlation between short-term memory strength and smell strength.

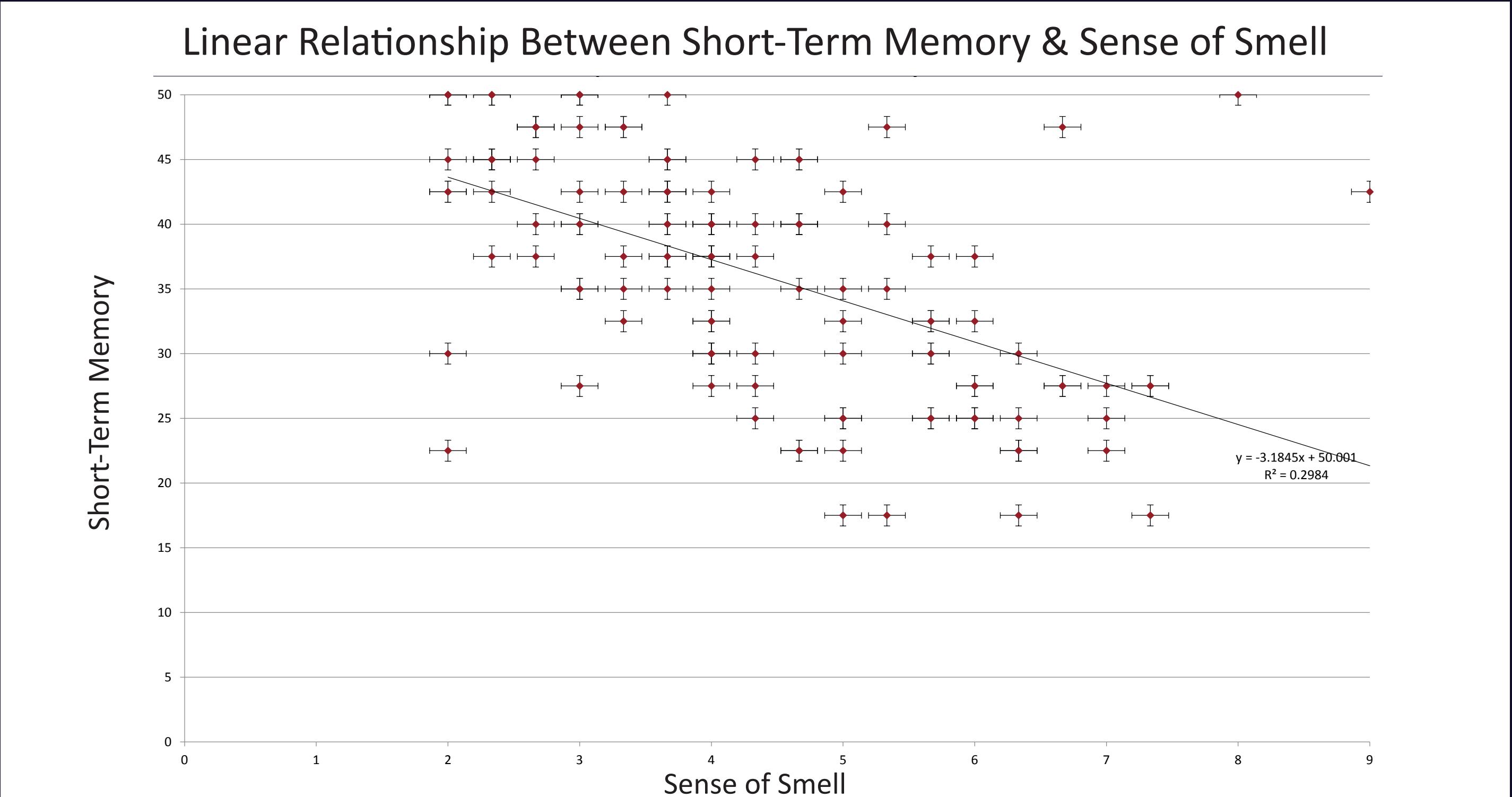


Figure 7: Scatter graph representing the correlation between STM and strength of smell - error bars using standard error

As visible from the scatter-graph, the main cluster of data can be seen between 50-30 in the short-term memory test and 2-4 on the smell test reflecting the correlation between a strong sense of smell and a strong short-term memory. The tail-end of the data can be seen between 15-20 in the short-term memory test and 7-8 on the smell test reflecting the correlation between a weak sense of smell and a weak short-term memory. This shows a moderate negative-linear relationship. This shows a monotonic relationship between the variables as long-term memory score increases, the sense of smell score decreases.

## CONCLUSION

Overall using a sample size of 121 participants we found that there is no statistical correlation between long-term memory and sense of smell. We did discover that there is a moderate correlation between the strength of a person's short-term memory and the strength of their sense of smell, which supports our initial hypothesis. Due to the fact that the prefrontal cortex is used in both smell identification, recognition and short-term memory formation, it is possible that there is a direct connection between smell strength and memory strength. This also connects back to the loss of smell that some patients experience with Alzheimer's disease. The correlation demonstrated in this experiment could indicate that through further research and refinement, this method could potentially be used as a diagnostic tool in the future.