frontiers FOR YOUNG MINDS

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WHY ARE WE SO SCENT-IMENTAL? STUDYING ODOR-LINKED MEMORIES

Angela-Faith Thomas [*†] ***and Megan H. Papesh*** [†]

New Mexico State University, Las Cruces, NM, United States

YOUNG REVIEWER:

DOO DOO

AGE: 9

Memories that are brought on by smells are called odor-linked memories. Odor-linked memories have a large impact on our lives. When these memories are positive, our physical well-being and emotional and mental states improve. Although we often look at pictures to remember the past, odors are actually better at helping us remember. Brain scans show that odors bring on strong memories because of the brain regions that process them. The group of brain areas that are best known for processing emotions, learning, and memory also process odors. When you smell something, to process the smell, your brain uses the same areas that it would use to process emotions and memories. This makes smells great at helping us remember emotional memories! Understanding the effects of odor-linked memories can help us use them to positively affect our daily lives, in both the short-term and the long-term.

Are there particular smells that always bring you joy? When you smell certain things, such as your mother's perfume or your favorite

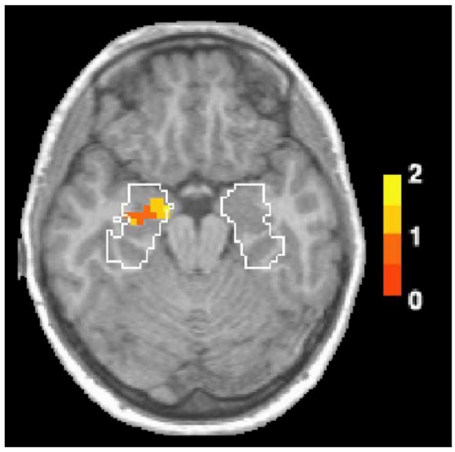

Figure 1

Figure 1

An fMRI scan showing the difference in brain activity for odor-linked and picture-linked memories. This image shows a scan of the brain from the top of someone's head, as if you were looking down at them from above. The white outline shows the parts of the brain that include the amygdala and hippocampus. The colors show how big the difference in brain activity was when people had memories in response to odors and pictures, with yellow showing the biggest difference. In this study, odors caused more brain activity than pictures [Image credit: [3]].

meal, those smells can bring up pleasant memories. These are called odor-linked memories because the memories are brought on by smells (odors). The experience that odor-linked memories cause is called the **Proust effect**. This name came about because the author Marcel Proust wrote in his book, *Swann's Way,* that the smell of a pastry he dipped in his tea brought on a rush of joy associated with his childhood. This claim made researchers curious to know whether there was a scientific explanation for Mr. Proust's experience.

PROUST EFFECT

The experience that is brought on by memories that are odor-linked, or associated with smells

WHAT IS THE CONNECTION BETWEEN SMELLS AND MEMORY?

Olfaction is just a fancy word for our sense of smell. Even though the connection between olfaction and memory is rarely thought about [1], it is actually very important. Odor-linked memories can be extremely powerful. In the laboratory, researchers ask participants to smell different odors and see what sorts of memories come to mind. The researchers then ask follow-up questions about each memory, such as whether it is clear vs. fuzzy or emotional vs. boring. It turns out that olfactory cues (smells or odors) are more effective at triggering clear and emotional memories than visual cues, such as images or photographs [2]. In fact, older adults can remember much older memories with a smell than with pictures or words [3]. So, if Mr. Proust saw a picture of his favorite pastry and the tea that he dipped it in, he might not have had such a strong experience connecting him to his childhood memories.

OLFACTION

The sense of smell. The adjective form, olfactory, means related to the sense of smell.

Researchers can use brain scans called **functional magnetic resonance imaging** (**fMRI**) to measure brain activity while people perform mental tasks. Because fMRI looks at how the brain functions [4], it can help researchers see which parts of the brain are more (or less) involved while people remember the past in response to odors or pictures. Do odor-linked memories cause different brain activation

FUNCTIONAL MAGNETIC RESONANCE IMAGING (FMRI)

A technique for measuring brain activity as people do mental tasks. fMRI can show which areas of the brain help process different types of thoughts.

Figure 2

The amygdala and hippocampus are located in the temporal lobes, with one on each side of the brain. This image shows the left side of the brain.

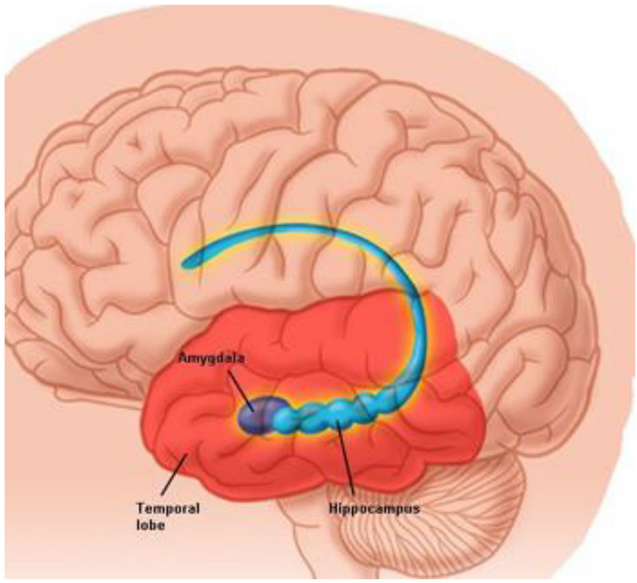

Figure 2

than picture-linked memories? Yes! fMRI evidence shows that the areas of the brain that process emotions are more active when people have odor-linked memories than memories brought on by pictures (Figure 1) [5].

Years of research helped us to understand that the emotional processing areas in the brain—the same areas activated by odors—include the **amygdala** and the **hippocampus**, which are located in the **temporal lobes** (Figure 2). The temporal lobes are under your skull near your left and right temples. The hippocampus is a seahorse-shaped brain area that is involved with **associative learning**, which is learning that occurs when you connect two separate events together. Odor-linked memory relies on associative learning because we *associate* (or link) the odor that we smell with the time(s) in our lives when we previously smelled it. As you can see in Figure 2, the amygdala and the hippocampus are really close together, which makes it easy for us to learn and remember emotional memories.

How do smells get to the brain, though? After entering the nose and passing through the **olfactory bulb** (Figure 3), smell information is sent to the amygdala and hippocampus. Olfaction is the only sense that gets processed in this brain area. Therefore, smell is the sense most strongly linked to brain areas that are involved in emotion, learning, and memory. Thanks to fMRI scans, we now have evidence to explain why the smell of freshly cut grass takes us back to a previous summer in our memories, or why Mr. Proust so clearly remembered his childhood just from smelling a pastry. Smelling the grass or a pastry activates the brain areas responsible for emotions and memories!

AMYGDALA

(sounds like "uh-mig-duh-luh") A part of the brain involved with processing emotional memories and experiences.

HIPPOCAMPUS

A part of the brain involved with learning, especially associative learning.

TEMPORAL LOBES

The parts of the brain that the hippocampus and amygdala are found in. This brain area is involved in processing emotions.

ASSOCIATIVE LEARNING

Learning that occurs when you connect two separate events or things together. For example, linking the smell of coffee to spending time with your grandparent.

OLFACTORY BULB

The part of the brain that receives information about smells.

Figure 3

Smell is sent through the olfactory bulb (yellow) to the amygdala and hippocampus areas (orange).

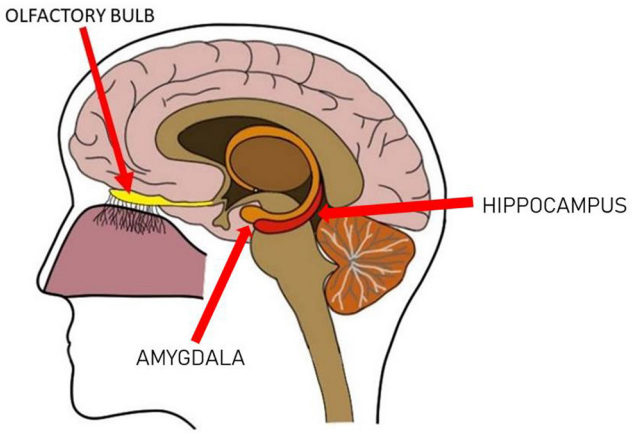

Figure 3

MENTAL AND PHYSICAL BENEFITS OF ODOR-LINKED MEMORIES

Odor-linked memories are special because they can do more than just transport us back to a different time in our lives. They can improve our health as well. It might seem surprising that our sense of smell can have such a positive impact on our well-being, but it is true! Researchers have found that odor-linked memories can actually be more positive than memories that are brought on by any other senses [1]. Pleasant memories put us in good moods, and being in a good mood helps to reduce stress. Stress can present itself in our bodies as inflammation (swelling, redness), which is a sign doctors look for in many different diseases [1]. Therefore, when odor-linked memories reduce our stress levels, we relax, and our physical health improves.

In addition to improving our physical health, odor-linked memories can improve our mental health. Mental health benefits of these memories include boosts to self-esteem, improved social interactions, and a sense of optimism (a sunny outlook). Odor-linked memories have also been shown to inspire self-confidence and motivation, and even to help adults quit smoking cigarettes! When smokers had pleasant odor-linked memories, they said that their cigarette cravings were reduced [1].

WHAT ELSE IS THERE TO KNOW?

Our lives are affected by the smells around us in big ways. We know that certain odors can actually improve our lives in the long run, by making us healthier. You can even use what you know about odors and memory to help you in school. Because we know that odor is so strongly linked to memory, if you smell the same odor when you study for and take a test, you have a better chance of remembering what you studied! For example, if you use peppermint lip balm while studying,

you should put on that same lip balm before your test. The smell of peppermint can help you remember what you studied because of associative memory. Researchers proved this using the smell of chocolate [6]! Just be sure not to use the same lip balm smell for multiple classes, so your brain can remember the right class!

What we have discovered about odor-linked memories is important, but there is still so much more to learn. Because positive memories can help lower stress, they also help improve mood and can help people change unwanted behaviors, like smoking. This means that the effects of odor-linked memories could be used in therapy and counseling, to help improve people's lives in both the short- and long-term. In conclusion, there are many effects of odor-linked memories, but we are not done studying all the ways they affect our lives just yet. It is a good thing Mr. Proust dipped that pastry into his tea…otherwise, we might not be aware of all of the positive impacts that odor-linked memories can have!

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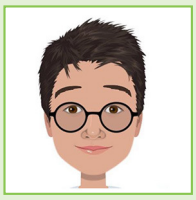

DOO DOO, AGE: 9

Doo doo is a very happy and curious boy. All his teachers complain he asks too much and that his questions are very complex. Doo doo loves Math and Science. During the COVID-19 pandemic, Doo doo hacked the first online game posted by the teacher, so he could effortlessly win. Doo doo has one brother who is his main volunteer participating in his experiments, although they are illegal, since they were not approved by the local ethics committee. Thus, he was punished by the local authorities and since then, permission to use his brother is required.

AUTHORS

ANGELA-FAITH THOMAS

Angela-Faith Thomas is recent graduate from New Mexico State University. She is a proud psychology instructor at Clovis Community College in New Mexico. She teaches students about topics in psychology including how the brain develops in infants, children, and adults. For fun, she enjoys playing with her cat, Jack, going to the movie theater, and hanging out with friends. *thomasa@clovis.edu

MEGAN H. PAPESH

Megan H. Papesh started her career in Psychology at Louisiana State University and is currently an Assistant Professor at New Mexico State University. Her laboratory investigates the brain and behavior in many domains, including human memory, face perception, visual search, and attention. She has won several teaching and research awards, including the Rising Star award from the Association for Psychological Science. In her free time, she enjoys spoiling her dog and going for hikes or bike rides.

†These authors have contributed equally to this work