

but now as a nonsmoker find it offensive? Or maybe you disliked cigarette smoke as a child, but it became a scent marker for your father and it now elicits wistful and pleasant connotations. Intrinsic to the fact that we form associations to odors that determine our hedonic responses to them is that an association is a type of memory. An association can be vague and you may only *feel* that a certain smell is good or bad, with no specific recollection in mind, but it can also bring forth complex and intense personal memories. The association that made the scent of rose unpleasant for the woman who first experienced it at her mother's funeral is also a memory of her mother's funeral every time she smells it. And more than any of our other sensory experiences, smell is exceptional in its ability to conjure emotional memories and viscerally transport us in time and place.

 CHAPTER 3

SCENTS OF TIME

Wherever I am in the world, all I need is the smell of eucalyptus to recover that lost world of Adroque, which today no doubt exists only in my memory.

—JORGE LUIS BORGES

One day my cousin Amanda visited some friends whom she had not seen in a long time. The trip involved a considerable drive and it was decided that Amanda would stay the night. In return for her friend's hospitality, my cousin insisted on doing the dishes after dinner. As she bent over the soapy water and began the mundane task of scrubbing, Amanda was suddenly overwhelmed by inexplicable emotion. As if out of nowhere a bullet had hit her—so intense were her feelings that she found herself weeping. For several minutes her head hung over the sink as tears streamed down her face; she felt ridiculous, confused, and overcome with a strange nostalgic sadness all at once. Her friend watched, stunned and concerned; "*What's wrong? What's wrong?*" she kept asking. Suddenly, Amanda

looked up, turned to her friend, and said: "It's my grandmother. It's the smell of the dish soap. . . . I can see her perfectly. Standing in her kitchen and I'm helping her do the dishes the last Thanksgiving we all spent together. I'm right back there with her. I can't believe how much I feel her now. I miss her so much." My cousin continued to talk to her friend about her memories of our grandmother for the rest of the evening.

Has anything like this ever happened to you? If not with the scent of a certain soap, then with a special perfume, the aroma of school-floor varnish, the dusty odor from an old book, or some other distinctive scent? Although uncommon compared with other memory experiences, almost everyone I have ever met has experienced a startling and poignant memory that was triggered by a particular smell. And everyone who has ever talked to me about their scent-evoked memories has been fascinated and curious about this experience.

Throughout history, poets and philosophers ranging from Aristotle to Borges and Nabokov have pondered and extolled the wonders of memories triggered by scent. The most frequently cited example, probably because it is the most detailed, is the one given by Marcel Proust at the beginning of his seven-volume opus on memory. In the first chapter of *Swann's Way*, Proust recounts an episode where the aroma arising from a madeleine biscuit soaked with linden tea brings back a stunning long-forgotten recollection:

No sooner had the warm liquid, and the crumbs with it, touched my palate than a shudder ran through my whole body, and I stopped, intent upon the extraordinary changes

that were taking place. An exquisite pleasure had invaded my senses, but individual, detached with no suggestion of its origin. . . . Whence could it have come to me, this all powerful joy? I was conscious that it was connected with the taste of the tea and cake but that it infinitely transcended those savors.¹

From the fame of this description, these redolent memories are often dubbed "Proustian memories" or an example of the "Proust phenomenon." Proustian memories are typified as emotionally vivid, sudden, autobiographical recollections triggered by a scent. Odors have also earned a reputation as being the "best" cues—reminders—to uncovering our past. But are odors really the best cues to memory? And if so, how are they better than or different from any other cues at eliciting recollections?

THE BEST CUES TO MEMORY

In scrutinizing Amanda's and Proust's memory descriptions you may notice several similar features. First, pure emotion is the most immediate and central experience in these recollective episodes, and the content of the memory—what happened, who was there, where it was—becomes filled in only later. Another striking feature is that these memories are sudden and unexpected. We are usually startled that scents are capable of unleashing such powerful feelings and recollections because we generally ignore our sense of smell.

Most memories of our personal past are triggered in the same basic way. A feature of the original event is encountered

and the event to which it was connected tumbles back. With Proustian memories, the feature that triggers the recollection is a scent. In Amanda's case we can trace the process as follows: Amanda had been very close to our grandmother who had died some years before. The dish soap that our grandmother used was uncommon, and Amanda had not smelled it since the last time she washed the dishes with Grandma. When Amanda unexpectedly came across the scent of this specific dish soap, the particular memory that was tied to it, our grandmother, was pulled out of the sink and into her consciousness. For Proust, we can presume a similar sequence of psychological events. Proust had not enjoyed the flavor of linden (lime flower) tea with madeleine biscuits since his childhood summer with his aunt, and then when many years later this mixture reached his palate, the memory to which it was linked erupted. These sequences show that a specific scent is the triggering cue to a significant past moment, but the question still remains: are odors actually *better* at triggering recall than things we might hear, see, feel, or taste?

Despite our inherent intrigue with scent-triggered memories, this phenomenon has been barely touched by science. The first "empirical" investigation of scent-evoked memories was reported in 1935 by Donald Laird, who summarized the work of a Mr. Harvey Fitzgerald at Colgate University and published it in the journal *Scientific Monthly*.² Fitzgerald interviewed 254 "men and women of eminence," including writers, doctors, and clergymen, and asked them to retrospectively describe what their scent-evoked memories were like. One woman reported a scent memory experience as follows:

On the train once, in the midst of happy conditions, I suddenly felt discouraged, awkward, unhappy. As soon as I recognized the perfume used by a fellow traveler, I saw very vividly a large dancing class, a French dancing master, and felt again my girlish dismay at his attitude toward my poor attempts to learn the steps he was trying to teach me. As soon as the memory picture came I knew why I had suddenly felt unhappy, and, of course, came back to normal. This experience occurred some fifteen or twenty years after the last time I had seen the dancing master.

Further attesting to the claim that odors are especially effective memory cues, one of the interviewees, a midwestern bishop, remarked that "smell is sure some automatic reminder." An overall summary of these descriptions led Laird to conclude that scent-evoked memories are markedly vivid and emotional, and that smells often trigger memories of long-ago events. The problem, however, is that this study does not go beyond being a compilation of anecdotes itself, nor does it address the comparison between scent and other memory cues.

Fifty years later an attempt was made to bring scent-evoked memories into the laboratory. In 1984, David Rubin and his colleagues Elisabeth Groth and Debra Goldsmith at Duke University conducted a study on autobiographical memory where they compared memories elicited by items presented either verbally, as photographs, or as odors.³ If a memory was triggered by an item, in any of the sensory forms, the participant was asked to rate his or her memory for the qualities of vividness

and emotionality, and for how often the person had thought of or talked about the memory prior to the experiment. Rubín and his colleagues found that memories elicited by items presented as odors were reported as *thought of* and *talked about* less often than memories elicited by items presented as photographs or words. In other words, scent-evoked memories tended to be of rarely relived events. But their findings did not substantiate the conviction that scent-evoked memories are more vivid or possess any other exceptional qualities, or that they are in any way "better" than memories triggered by visual or verbal cues.

THE EMOTIONAL DISTINCTIVENESS OF SCENT-EVOKED MEMORY

In 1990, I began to chase the question of whether and how odors might be the best memory cues, and ever since then I have been investigating the nature of scent-evoked memories with a variety of techniques.

My first challenge in this endeavor was to decipher what people meant when they talked about a "good" memory, or "best" memory cue. Typically we think of a "good" memory as being an accurate memory, a vivid and correct recollection of an event as it actually took place. But memory is more than just an accurate mental presentation of the past. In addition to the facts, like remembering where Grandma lived, memories have a personal, subjective, and emotional dimension.

Recollections of our past are always accompanied by a feeling, which can range from a vague nostalgia to poignant and intense emotion. Because of this dimensionality, I parsed memory

into two components in order to study it: its *objective accuracy*, who was there, what they were wearing, what someone said; and its *emotional quality*, the feelings and evocations that arise with the return of a past experience.

To test the differences between scent-evoked memories and other types of memory, I developed a procedure similar to that used by Rubín and his colleagues and compared memories triggered by a cue presented as a smell with the same item presented in other sensory forms. For example, the recollection stimulated by the *smell* of popcorn would be compared against the memories evoked by the *sight* of popcorn, the *sound* of popcorn popping, the *feel* of popcorn kernels, or simply the word *popcorn*.

What I found in these experiments is that, in terms of their accuracy, detail, and vividness, our recollections triggered by scents are just as good as our memories elicited by seeing, hearing, or touching an item—but no more so.⁴ Yet our memories triggered by odors are distinctive in one important way: their emotionality. We list more emotions, rate our emotions as having greater intensity, report our memories as being more emotionally laden, and state that we feel more strongly a sense of being back in the original time and place when a scent elicits the past than when that same event is triggered in any other way. I have also found that the amygdala, the wellspring of emotion in our brain, is more highly activated when a person recalls a memory by the scent of a perfume than when a person recalls the same memory as a result of seeing that perfume's bottle, or when he or she sees or smells a nonmeaningful perfume. So scent-evoked memories are *different* from other types

of memory experiences. They are uniquely emotional and evocative—in our minds and in our brains.

CAPRICIOUS EMOTION

A memory conjured by an aroma will always feel emotionally intense, but the emotions experienced with that memory are not fixed. A certain scent may always remind you of the same person or moment and always be accompanied by a rush of feelings, but though the content of that memory will stay the same over a lifetime, the sentiments carried with that reminiscence may not.

Suppose that when you were sixteen you were completely infatuated by a popular girl in your class—let's call her "Nancy"—and to your astonished delight she actually said yes when you invited her to your high school dance. Gleeefully, you soon found yourself Nancy's boyfriend and whenever you were with her you noticed that she wore a lovely, distinctive perfume, one you would later come to know as Chanel No. 5. During those first blissful months, whenever you stumbled upon Nancy's scent you became suffused with passionate diversion. Then, after several months of heavenly dating, one night at a large party with all your jealous friends in attendance, Nancy unceremoniously dumps you. Your agony, humiliation, and anger are insurmountable. Now when the scent of Chanel No. 5 comes into your nasal view, terrible emotions come racing with it, a million miles from the blissful feelings that just days ago accompanied her fragrance. Fast-forward fifteen years into the future when you are happily living with your long-term partner, confident and contented; one day on

your way to work a woman passes you on the street wearing Chanel No. 5, and you find yourself in a laughing reverie. You remember Nancy all right, but instead of bliss or humiliation, a very different emotion is brought with that reminiscence. Now the forgiving brush of nostalgia has painted your feelings with humor and wisdom.

This vignette shows how the emotions that come with your memory of Nancy, though always strong, will not always be the same; they depend on what Nancy means to you at the time you are remembering her. The emotions that accompany specific memories change as a function of what the event means to you at the time you are remembering it. This emotional instability is not restricted to scent-evoked recollections, but the intensely emotional nature of scent memories makes them an especially revealing display of this effect.

Despite experiences like the Nancy story, scents are no better than other kinds of memory triggers in terms of the accuracy of information they elicit, but they are uniquely emotionally involving. I believe the distinctive and intense emotionality of scent-evoked memories offers a critical insight into why odors are regarded as the "best" memory cues. It is *because* of their intense emotional evocativeness. The emotional potency of odor-evoked memory leads to the false impression that these memories are especially true, and that odors are superior reminders of our past experiences.

Scent-evoked memories provide an excellent illustration of the persuasion of emotion and also a cautionary reminder. The confidence that one's recollections are accurate, which is so hard to resist when memories are colored by emotion, is

similar to what often emerges on the witness stand. Eyewitnesses tend to be doggedly confident that their recollections are correct. Unfortunately, research shows that their memories are often quite mistaken. However, the misconstrual of emotional intensity for accuracy may not be the complete explanation for why scents have earned the reputation as superior reminders. There is another feature of scent-evoked memories that Proust alluded to which may truly make odors better than other memory triggers. The Canadian writer Anne Mullens recently told me about an event in her life that vividly captures this special quality.

MEMORIES LOST AND MEMORIES REGAINED

At the age of nineteen Anne was touring a veterinary college with some friends when they wandered into an empty room with a large drainage hole in the middle of the floor. Despite the barrenness of the room, Anne found herself riveted in place as soon as she entered. A scent emanating from the hole, an odd mixture of what Anne described as animal blood, sawdust, and cleaning fluid, released the floodgates on a long-forgotten event—the memory of being six years old and smelling a very similar concoction during a tour of a slaughterhouse in a remote Newfoundland village, where her father was the visiting doctor for the summer. According to Anne, “smelling the odor was like pressing play on a lost movie in my head.” In telling me this story, Anne laughingly recalled that her friends thought she was having a seizure because “I could not move from the room and was staring off into space with my mouth

wide open as if being fed this memory from out of the blue.” Anne’s voice quickened as she launched into the rest of her memory.

I recalled being six in a pig slaughterhouse in the hamlet of St. Anthony, at the northern tip of Newfoundland. Since my dad, the visiting doctor, was the local dignitary, they showed us all the sites, including this slaughterhouse. This chunk of memory that came back included the whitewash-painted wall, the gray cement floor and the white wood pillars, and a table with a big sink against a wall. The wall had some blood splatter on it.

After the tour we went to a family’s home—the full-time doctor’s house—and sat in their living room. I can see the lighting of it and the very formal look—green velvet chesterfield, chintz chairs, walnut coffee table, and side tables. Very English and formal for a small fishing village. We were served tea and I remember lemon pound cake and rosebud china and that the woman, Mrs. Thomas, was dressed in a nice floral dress. I think I was wearing a floral dress, but I have lots of memories of a favorite dress, the strawberry dress (white with red strawberries), and I can’t be certain if I was indeed wearing it, as it is in a lot of memories and not unique.

Awestruck by having such an exceptionally vivid lost piece of her past thrust back into her life, Anne immediately telephoned her mother to verify that her memory was real. To

Anne's delight, her mother confirmed that they did tour the local slaughterhouse during that summer in northern Newfoundland, and that after the tour they had all gone to the home of the Thomases, the local full-time doctor. But she could not confirm any other details that Anne remembered of that day, because she could not remember them herself. Nor could Anne's three sisters. Anne laments that she cannot judge the accuracy of her memory, since no one else can remember it well enough to corroborate her recollection. But that does not diminish the fact that this memory felt extremely real and was "... a truly phenomenal experience which has fascinated me for years."

This anecdote captures a special dimension of the Proust phenomenon, the ability of odors to reawaken lost memories. Is it possible that odors have the ability to trigger memories that might otherwise be forever forgotten, that we would never recover if not for stumbling upon the "right" aroma? This question has not yet been directly tested, but that this could be so is supported by two well-studied psychological phenomena: distinctiveness and interference.

A distinctive object stands out from the background either because of its rarity in time, type, or both; when something is distinctive, we pay more attention to it. A particular smell may be encountered just once in your lifetime, or only in tandem with a very specific event, and so becomes forever linked to that single event; visual or verbal versions of the same cue, however, are much more likely to be repeatedly encountered and as such lose their distinctiveness and meaning. Proust noted this in the following passage:

The sight of the little madeleine had recalled nothing to my mind before I tasted it, perhaps because I had so often seen such things in the interval, without tasting them, on the trays in pastry-cooks' windows, that their image had dissociated itself from those Combray days to take its place among others more recent.⁵

The same phenomenon occurred with my cousin Amanda. The distinctive smell of a particular brand of dish soap was the trigger to remembering our grandmother, because no other dish soap smelled like it. In contrast, *seeing* various dish soap bottles or *hearing* brand names—including the type used by our grandmother—were impotent at evoking our grandmother because Amanda had encountered facsimiles of these sensations so many times before.

Another factor that allows odors to remain faithful memory cues is the comparatively low likelihood of encountering them. In Anne's case, that strange brew of animal blood, sawdust, and cleaning fluid was only experienced during her childhood trip to the slaughterhouse. Similarly, Proust must not have dipped a madeleine biscuit into linden tea in the years intervening between his summer as a youth in Combray and when he wrote his famous recollection in his late thirties.* Indeed

*I am assuming that Proust was in his late thirties when he had his famous scent-evoked memory, because *Swann's Way*, where the quote appears, was first published in 1912 when Proust was forty-one, and it is reported that he began work on *The Remembrance of Things Past* (*Swann's Way* is the first volume) in 1909.

the more uncommon the scent, the more likely that it will be associated with a unique episode from our past. How often is a deeply significant memory revived by the smell of coffee?

Not only are odors less frequently encountered than visual or auditory cues, but when an association is made to a scent, it is actually much harder to undo and reassociate it to another experience than it is for visual and auditory items to be reconnected and associated. In other words, the first association made to an odor *interferes* with the formation of any subsequent associations. A familiar example is the experience of "learned taste aversions." Coincidentally becoming ill after eating pepperoni pizza led to my severe aversion to the smell of pepperoni that persisted for a very long time and was extremely hard to unlearn, even when I knew that pepperoni was never to blame for my nausea.

Resistance to being overwritten and the high distinctiveness of certain scents can combine to make odors faithfully and directly tied to particular events like no other cue, and thus the unique key to unlocking a special memory. Even though this may be the feature of scent-evoked memory that makes odors "better" memory cues, their emotionality is still their most extraordinary feature. I have often wondered, if a scent unleashed a memory that otherwise would have been relegated to the memory dustbin, would that memory be more emotional than if some very distinctive sight or sound reawakened the same event? My guess is yes. When an aroma triggers recall, you are caught in a wave of emotion and evocation like no other. It is not the "long-forgottenness," but rather the unique connection between olfaction, emotion, and memory that makes scent-evoked memories so special.

TRAUMATIC MEMORIES

The spellbinding rush of emotion and transport to another time and place when a scent returns you to a lost love, a childhood event, or even washing dishes can make the past appear more powerful than the present. But not all memories released by aromas are of lost summer days or old lovers; odors can also trigger memories that are severely traumatic in nature.

There is a psychological disorder defined by traumatic memories, called *posttraumatic stress disorder (PTSD)*.^{*} When individuals with PTSD experience the memory of their trauma, they can become as emotionally overwrought as they were during the original harrowing episode. To the victim, a PTSD flashback of rape can feel as bad as the rape itself. In PTSD, memories are triggered by a cue that reminds the person of the trauma. For example, walking by a parking lot could trigger the memory of being raped in a parking lot, but scents are the most insidious and vicious reminders. The intensely emotional nature of odor-evoked memories and their unique neurological links with emotional processing mean that when a scent triggers a PTSD flashback, these episodes recapitulate a complete reliving of the devastating event.

^{*}A person with PTSD is plagued by the experience of recurrent memories of a traumatic event. Rape, fire, car crashes, and war are common traumatic events that lead to developing PTSD. Not everyone who undergoes a traumatic event will develop PTSD; personality and other predisposing factors interact to determine whether PTSD will be established.

Another reason why scents are so menacing for victims of PTSD is because they have no way to prepare or protect themselves from a sudden attack. Unlike visual cues, which can be intentionally avoided—*don't walk by any parking lots*—odors are invisible and can manifest almost anywhere. The scent of the specific cologne worn by the rapist could "appear" while the recovering victim is innocently walking down a street, sitting in a restaurant or a movie theater, or in myriad other unexpected places, and more than any other reminder can bring on a sudden and unexpected attack with paralyzing power. Aromas connected to PTSD can also make once normal activities impossible. Sometimes called the *barbecue effect*, the aroma of meat on the grill can trigger horrific memories of burned bodies and make summer cookouts impossible for firefighters, rescue workers, or war veterans for years afterward.

Not only are scents the worst triggers for PTSD flashbacks, but they are also the hardest to treat. I have had calls from psychiatrists and clinicians who are at their wit's end about how to deal with the scent trigger to trauma with their PTSD patients. While it is possible to modify one's life by avoiding parking lots, how can one avoid encountering an offending smell without becoming a complete recluse?

In such cases, I suggest to therapists that they employ a variant of the standard technique for treating fear and phobias called *systematic desensitization*. Systematic desensitization works by exposing the traumatized person to very mild facsimiles of the scary stimulus, then gradually moving to greater and more realistic exposures, and often to the real thing in the end. At each stage of exposure the patient is taught relaxation tech-

niques to use while being exposed to the frightening object or cue. In the case of a woman suffering from PTSD who was raped in a parking lot, an example treatment for the visual stimulus of a parking lot could be dealt with in a series of steps from very mild exposures, such as an architect's drawing of a parking lot to finally being taken to the parking lot where the rape occurred. Sounds associated to the trauma, like slamming car doors, could be dealt with in a similar way. But how does a therapist deal with the fear triggered by the rapist's smell?

Theoretically, smells should be able to be dealt with using systematic desensitization just like visual and auditory cues, but there are several difficulties. First, how do you come up with a mild facsimile for an odor? If the victim recognized the smell of her rapist as Old Spice, treatment could begin by talking about Old Spice, then seeing Old Spice bottles, working up to having the patient smell Old Spice. But visual and verbal versions of an odor memory cue do not have anywhere near the emotional potency of the odor cue itself. So although the concept of Old Spice might become neutralized, this will likely not translate into a neutral response to the scent of Old Spice. Second, the fact that scents inherently become more tightly glued to emotional associations than any other type of sensory cue, desensitizing—that is, unlearning—emotional associations to the real fragrance will be very difficult. Nevertheless, progressing through various sensory forms of a cologne and working up to repeated presentations of the real scent while using relaxation techniques and positive associations should at least be somewhat effective.

There is some evidence that using scent to treat PTSD patients is indeed helpful. Skip Rizzo, a psychologist at the

University of Southern California who treats Iraq war veterans suffering from PTSD, has recently begun incorporating smells into his therapy and has found that the addition of these scents makes treatment more successful. Dr. Rizzo uses a virtual reality video-game technique as a form of systematic desensitization. To make the video game more realistic, a range of odors, such as diesel, gunpowder, and garbage are emitted during various scenes to make the war veterans feel more like they are really back in Iraq. This more realistic immersion into the original traumatic episode makes overcoming the destructive nature of their memories more possible. As you will see later, scents are being used in many imaginative ways to make visual experiences more real.

A COLLECTIVE PTSD: THE SCENT OF 9/11

October 30, 2001, was a beautiful fall day in Brooklyn, and Nathaniel was distracted by thoughts of work as he entered the subway on his way uptown. As the train neared the Chambers Street station, in lower Manhattan, his mind suddenly flashed and froze on the present. It was *that* odor. A rush of panic pulsed through him, and looking around it was clear that the other passengers were similarly transfixed. *That* very distinctive odor, which lingered in "the zone" for months after 9/11, was known to almost all who experienced the collapse of the World Trade Centers firsthand, and whenever it was reencountered it served as an instant reminder of that day. Talk of the strange powers of the scent elicited by the destroyed

World Trade Centers led scientists Pam Dalton and George Preti, from the Monell Chemical Senses Center in Philadelphia, to analyze the air that permeated Ground Zero to see if anything unusual could be discovered. It turned out that the scent of Ground Zero comprised a complex and unique mixture of chemicals that smelled rubbery, bitter, and sweet at the same time. But, unlike the New Yorkers who lived through 9/11 firsthand and whose immediate response to this aroma was terror and grief, the Philadelphian researchers had no emotional responses to it at all. To Dalton and Preti, the aroma was merely strange—not bad and not good—yet the only difference between the Monell scientists and the New Yorkers was their past experiences with *that* scent. For the New Yorkers, the first time they had encountered this odor was a terrifying and traumatic world event, but to the Monell scientists this scent was merely associated with an interesting experiment. The response of the New Yorkers versus the Philadelphians epitomizes how the emotions associated to an odor will determine how that odor is later perceived and experienced.

SCENTSATIONAL MEMORY

If odors are such potent cues to memory, can they also help us remember? Could fragrances help you perform better on a test, or be used systematically to help you be better at recalling any sort of information you wished to? According to Simon Chu, an

olfaction researcher at the University of Liverpool, Chinese culture has long been wise to the assistance of aroma in the retelling of stories. A Chinese tradition practiced for centuries was to pass around a small pot of spice or incense when generations gathered to share oral histories. Later when family members wanted to remember a story in detail, the same scent was passed around again.

The idea that odors might be used to enhance memory is supported by a well-established psychological phenomenon called *context-dependent memory*. When you are in the same context, place, or mind-set that you were in when you learned something, you remember that information better. It turns out that the key aspect of the context that helps you remember is how you *feel* when you are there.* Since odor is the sense most related to emotion, it would follow that odors would be the most effective cue to enhance memory. The idea that odors could be used as context cues has certainly occurred to people before me, and several researchers have already shown that scenting a room with a particular aroma and having that same aroma present during a test can sometimes improve memory—but not always. I was curious why odors were effective memory boosters only some of the time and so I conducted a series of experiments from which I discovered several things.

First, I found that in order for an ambient scent to facilitate memory, it has to be distinctive or unfamiliar—to stand out

*The discovery that one's feelings are the most important cue for context-dependent memory is credited to Eric Eich, a professor of psychology at the University of British Columbia.

from the background so that your attention will be drawn to it, even if you don't intentionally focus on it.⁶ You would likely ignore the scent of cleaning solution if you smelled it in a laboratory, but your nose and mind would prick up if a sterile laboratory were fragrant with peppermint or butterscotch. The second thing I discovered is that emotion is a fundamental factor in this effect.

Learning and memory are two sides of the same coin. In order to remember something you must already have learned it, and an emotional context makes events more memorable. If I told you a boring story, you would be less likely to recall the details of it than if I told you a story with the same essential content but where an emotional charge was added to its meaning. Which story would you remember better: (1) A young blond-haired boy wearing a blue shirt crossed the parking lot and got into his mother's SUV; or (2) A young blond-haired boy wearing a blue shirt was struck by a speeding motorcycle as he crossed the parking lot toward his mother's SUV? I am sure you will agree that the latter is more memorable.

Considering the power of emotion to intensify memory in general and the particularly privileged connection between our sense of smell, emotion, and memory, I wondered whether a heightened emotional state experienced while an odor was present would hyperactivate the neural underpinnings of emotion, scent, and memory, thereby causing an odor and an event to become superglued together.

To test this theory, I conducted two experiments with forty-eight and forty students, respectively, in which an unfamiliar fragrance was present in a room while people *learned* a random

list of sixteen words such as *ring* or *horse*.⁷ The students were not aware that I would later test them for their memory of these words. Nevertheless, the procedure was geared to help them learn (and hence remember) the words by having them come up with an event that had happened to them for each word in the list. One week later, at the test session of the experiment, the participants were then quizzed for their memory of the sixteen words. The number of words that were correctly remembered was the measure of memory; the more effective any available memory cue was, the more words would be recalled.

The key to these studies was that one group was in an anxious mood during the learning session of the experiment and also had an ambient aroma available as a potential memory aid. To induce anxiety I took advantage of the fact that I was at a university and exploited a naturally occurring anxiety-provoking event—exams. The participants in the “anxiety” group were anxious because the experiment took place one hour before a midterm exam. Students who were in the “normal” mood condition—experiencing no strong emotions of any kind—took part in the experiment in the hour before a regular class. When memory for the word list was tested one week later, it was before a regular class, and everyone self-rated as being in a normal mood.*

*It should be noted that students self-selected to be in this experiment and the most exam-anxious students undoubtedly did not volunteer. Nevertheless, the mood of the students was measured in each condition of the experiment, and students who participated in the hour before their midterm were significantly more anxious than the students in any other group.

The results showed that students in the group who learned the list of words in the hour before their midterm exam and who had the same ambient odor present during both the learning and test sessions remembered more words than students in any other group. They remembered more words than students who had experienced the odor in room air both times but were always in a normal mood, and strikingly, better than the group of students who were anxious during the learning session but did not have an odor cue available during the test session.* In fact, students who were merely anxious during the learning session did quite poorly, presumably because they were distracted by their upcoming exam and not paying much attention to the word list. The reason this is noteworthy is because emotion usually intensifies learning, but it wasn't helpful for the random word list when an odor cue wasn't there. However, if an odor cue was available and a heightened state of emotional arousal experienced, in spite of distraction, the students were able to remember even irrelevant information well.

There is a useful take-home message from this research, especially for students, but also for anyone who is trying to learn or memorize information. If you are anxious or emotionally worked up while studying material that you will later have to remember, it would be a good idea to have an unusual or unfamiliar fragrance with you that you can also take to your

*A context-dependent memory effect was also seen in this study. The participants who experienced an ambient odor both times remembered more words than participants in the two groups who did not have an odor cue available at both learning and test.

test. This is a perfect way to cheat without cheating. Before you rush to find a suitable scent for your next memory-challenging situation, however, there are two things you need to know.

Your first concern is with a physiological feature of our sense of smell called *odor adaptation*, the fact that after about fifteen minutes of smelling a particular aroma you effectively no longer perceive the scent. An example you may be familiar with is the unfortunate disappearance of aroma that occurs in scrumptious-smelling environments, like a bakery or flower shop. When you first walk into a busy bakery, the delicious aromas of sweet baked goods engulf you, but after waiting in line, by the time you are ready to buy your cake, the heady bakery aroma seems gone. Another frustrating situation you may be familiar with is if you have ever tried to willfully conjure a lost love or poignant childhood moment by fiercely sniffing an old cologne bottle or sticking your head inside a cedar trunk. The more you keep inhaling to relive those lost moments, the more both the scent and the memory you are desperately trying to recapture fade further away.

In these scenarios a physiological phenomenon has occurred inside your nose. When your odor receptors have been bombarded with particular molecules for a certain length of time, they cease responding to those specific chemicals. This physiological effect can be undone relatively quickly by simply removing yourself from the proximity of those odoriferous molecules. After several minutes of standing outside the bakery or leaving the old cologne bottle, you will be able to return to those aromas and smell them again with full pleasure.

One way to prolong the effect of smelling a scent before adaptation kicks in is to dispense an odor intermittently. Rather

than having the air freshener on constantly, bursts of air freshener alternated with no scent will draw out the time before your receptors get saturated and prolong your appreciation of the minty pine aroma in your car. In the case of studying, sniffing an odor sporadically throughout your study session, rather than constantly, will increase the time it remains useful.

The second idea in using aromas as memory aids is more practical. Smell a different fragrance for the different topics you are trying to learn. If you are studying for a calculus exam and a driver's license test, be careful to use different scents for each of these topics and to not get them mixed up. If you use the same scent for both, you might find yourself thinking of speed limits when you should be remembering rates for asymptotes.

REMEMBERING ODORS

Memory can restore to life everything except smells.

—VLADIMIR NABOKOV (*MARY*)

Ironically, though odors are exceptional triggers of memory, it is extremely difficult, if not impossible, to summon up the memory of an odor itself. You can remember what a crackling fire sounds like, or what the house you grew up in looked like, but can you truly conjure up the smell of your old camping tent? Or even chocolate chip cookies?

Research into our ability to remember odors was pioneered by Trygg Engen, who was briefly mentioned in the previous chapter.

Born in Oslo, Norway, Trygg came to the United States in 1948 and spent his professional career at Brown University. Among Trygg's major findings is that our ability to remember odors is very long lasting and that the first association made to a scent is very hard to undo. Yet, in spite of Trygg's groundbreaking work, research into our ability to remember odors is pierced with an impeding conundrum: how do you study the ability to remember odors? This is a problem because of another central question in the psychology of smell: can we recall, that is, imagine, fragrances? We may be able to recognize fragrances—you can recognize the scent of the white-and-red candy from the restaurant as peppermint—but can you truly capture the *scent image* of a peppermint in your mind's nose when the candy isn't there?

I once conducted a survey with 140 college students in which I asked them to try to conjure various physical sensations, such as visualizing a car, hearing an alarm clock, feeling satin, tasting a lemon, or smelling chocolate, and found that the reported ability to conjure the aroma of chocolate was weak and considerably worse than the ability to conjure any other kind of sensory image. Other researchers have also failed to find evidence for olfactory imagery, but there are still those who argue that odor imagery is equivalent to imagery in our other senses. Professional perfumers, wine tasters, and chefs tend to be especially convinced of their odor imagery prowess. But whether they can truly image scents, or whether they are any better than the average person, has never been tested.

The most compelling data supporting imagery with our other senses come from neuroimaging studies, which show that the same areas of the brain are active during imagining and

perceiving a particular sensation; for example, seeing pumpkin pie and visualizing pumpkin pie light up the same regions of the visual cortex. This neurobiological overlap between imagining and true sensation has been well documented for vision and hearing, but the same is not true for perceiving and imaging odors. The parts of the brain involved in actually smelling pumpkin pie do not overlap neatly with the parts of the brain that are active when you imagine the aroma of pumpkin pie.

Another place to look for imagery is in dreams. Research on dreaming has shown that dreams containing scent experiences are extremely rare, much rarer than dreams containing any other form of sensation. We also cannot smell while we are asleep. That is, you really do *wake up and smell the coffee*, and not the other way around. In a study I recently carried out with Mary Carskadon, a world-renowned sleep expert at Brown University, we found that during deep and dreaming sleep,* even very strong and trigeminally activating odors such as peppermint and the harsh smell pyridine could not awaken sleepers or produce brain wave changes that were indicative of arousal.† None of our other senses are cut off so completely while we sleep. We do not currently understand why or how olfaction shuts down while we sleep. But one possibility is that because

*Deep sleep is slow wave stage 3 and 4 sleep. Dreaming sleep is rapid eye movement (REM) sleep. For more details, see Carskadon, M., & Herz, R.S. (2004). Minimal olfactory perception during sleep: Why odor alarms will not work for humans. *Sleep*, 27, 402-405.

†EEG (electroencephalogram) recordings were measured as an indication of neural arousal.

our sense of smell relies so heavily on interpreting context and paying attention and because this level of awareness is shut off while we sleep, this may be why our noses become ineffectual detectors when we are in this altered state.

For most people it seems that the sensation of re-creating the image of an aroma is derived from related perceptions and memories. Remembering what a turkey looks like, browned and gleaming, as it emerges from the oven, the warmth of the kitchen; a mood of happy satisfaction; and the anticipation of the savory flavors all conjure the *feeling* of smelling turkey at Thanksgiving. But our mind's nose is most likely not experiencing turkey the way we experience it when it is really being carved in front of us.

I believe the reason why we are so poor at imaging odors compared to other sensations is because we do not need abstract odor images to survive. We use smell to tell us what to approach and what to avoid when we come across an item in question—*this food is good and this one is bad*. We don't use odors to construct maps or abstract schemas of our world. Animals, like rodents, who rely predominantly on their sense of smell to negotiate the world, likely do think in smell, and certainly some of our primate ancestors did as well. But for modern humans, vision and hearing-language are the sensory information sources we use to construct abstract representations to make sense of and survive in the world. Because we don't rely on odor images in this way, this ability has not been specially selected for and hence has become weak. However, because selection processes are variable, certain individuals may still possess our ancestral imagery ability, and true odor imagers may be among us. Furthermore, because learning is such a central component of our

sense of smell, it may be possible that with training or repeated experience one might be able to develop the ability to create sensory odor images. Some perfumers and chefs could be telling the truth and may indeed have acquired true sensory representations for the aromatics used in their craft.

Our memories make us who we are. Without memory we are at sea in a constant jumble of the present, lost from a world context and, most important, from ourselves. We do not know where we have been nor can we remember where we are going. Losing one's sense of smell does not destroy our memory, but it diminishes and alters it. The poignant and wistful feelings of nostalgia, the ability to conjure lost loves and certain long-forgotten events, are gone without a sense of smell. Jessica Ross complained that she no longer knew why she used to enjoy taking walks after the rain or visiting certain places. She said that without her sense of smell she felt disconnected from herself and other people. Ultimately she divulged that she thought a part of her was now missing, and that her sense of self and overall well-being were irrevocably damaged.