

Preventing Pediatric Vehicular Heatstrokes: Overcoming Prospective Memory Failure



The Sofia Foundation for Children's Safety was founded in 2017 to help prevent the avoidable tragedy of pediatric vehicular heatstroke.

ABSTRACT

This paper seeks to increase awareness and prevent the avoidable occurrence of children dying from hyperthermia when caregivers unknowingly leave them in a vehicle. Pediatric vehicular heatstroke (PVH) is frequently a result of prospective memory (PM) failure – or failure to forget to do things in the future, rather than neglectful caregiving. Parents who have inadvertently left a child in a car often report experiences of 'false memories' where they vividly remember dropping the child off as they intended.

In this paper, we will explain how PM failures, false memories, and other contributing factors can lead to pediatric vehicular heatstroke. Since the vast majority of PVH tragedies happen to caring and attentive parents, this paper argues that all caregivers should take safety precautions to prevent hot car deaths. *The Bag in the Back* campaign has been developed to offer guidelines and strategies for preventing PVH. This campaign will be reviewed and can be used by pediatricians, daycare providers, and others to mobilize caregivers to take action in preventing PVH deaths and injuries.

INTRODUCTION

Pediatric vehicular heatstroke (PVH) is one of the leading causes of non-traffic, non-crash vehicular child fatalities in the United States.¹ The incidence has increased dramatically since car seats were moved to the back seat, which prevents air bag injuries but removes the visual reminder that a child is in the car.² On average, there are 38 PVH fatalities in young children in stationary vehicles in the U.S. each year, for a total of 742 child fatalities on record between 1998–2017 and thousands of non-fatal injuries.³ Just over half of the children involved in these hot car fatalities were unknowingly left by a parent or other caregiver.

Throughout the COVID-19 pandemic, the number of child fatalities due to vehicle hyperthermia has been the lowest since 1998, with a particularly large decline in children who were unknowingly left behind in cars (62% less compared to previous years).⁴ Experts have proposed multiple explanations for the sudden drop in PVH figures; the global and nation-wide lockdowns of 2020 changed patterns of our daily routines; people stayed stationary and were driving 14% less which significantly contributed to the annual decrease in PVH deaths in the United States.⁵ However, despite these

figures being at an all-time low, researchers predict that once COVID restrictions are lifted and the economy returns, people will return to their prepandemic routines – such as driving to work or school – and PVH fatalities will increase. Therefore, there is now a sense of urgency for health-care professionals, parents, caregivers and legislators to recognize this type of motor vehicle injury and fatality in both public and private discourse and further invest in the prevention of PVH deaths.⁶

A major barrier to preventing these avoidable deaths is the public's misunderstanding of how common memory failures, rather than neglectful parenting, lead to most instances of PVH. Even very loving and well intentioned parents can mistakenly leave a child behind in a car.

*The Bag in the Back*⁷ campaign is designed to educate parents, caregivers, doctors, and the general public about PVH. The campaign seeks to explain how prospective memory failures, the development of false memories of drop-off, and other contributing factors make it possible for caregivers to unknowingly leave a child in the car. The Bag in the Back campaign offers suggestions for how physicians and daycare providers can talk with parents about preventing PVH.

THE SCIENCE BEHIND VEHICULAR HEATSTROKES

Pediatric vehicular heatstroke is a particular risk in geographical locations with prolonged periods of hot weather.⁸ However, PVH has occurred in almost all states including those in the far north, where an outdoor temperature in the mid-60s is sufficient to heat the car to over 110 degrees.^{9,10}

Studies have found that on days when temperatures exceed 86 °F, the temperature inside a vehicle can quickly reach 134 to 154 °F. On average, in the first 10 minutes of being left in the sun the temperature inside a vehicle rises by 19 degrees. In a 60-minute period, it can rise more than 40 degrees. When the outside temperature is 90 °F, a child left in a vehicle can die in as little as 10 minutes.

Two factors make children more prone to hyperthermia than adults: children have a greater surface area to body mass ratio than adults and their thermoregulation is less efficient than that of adults. A child's body heat rises three to five times faster than an adult's and a child's organs begin to shut down when the child's temperature reaches 104 °F.¹¹ Fatal body temperature for a child is 107 °F. Even though PVH death is still relatively rare, other problems, such as vital organ damage and brain swelling can occur quickly, resulting in significant morbidity.

WHAT IS PROSPECTIVE MEMORY FAILURE?

Researchers and scientists have long studied how memory is formed, stored, and recalled. In neuropsychology, memory has been broadly divided into two categories; retrospective memory (RM) and prospective memory (PR).¹² Retrospective memory is the memory we store of people, times, contexts, words and events encountered or experienced in the past. In contrast, prospective memory involves remembering something or remembering to do something after a delay, such as stopping by the pharmacy on the way home from work. Both of these memory formations are linked, though when people are asked to think or describe memory loss in their own lives, they commonly refer to and think about retrospective memories - such as forgetting someone's address, phone number, or other facts. Although most people tend to think of memory failure in terms of RM failure, multiple studies indicate that the most common memory failures in everyday life are errors in prospective memory.¹³

On an 80 degree day



<https://www.noheatstroke.org/NSC-Hot-cars-report.pdf>

The distinctive feature of prospective memory failure is an error in the use of stored information to plan and execute an action set to take place in the future.¹⁴ Prospective memory failures are fairly common and the human mind experiences various PM-related memory errors and disruptions on a daily basis. Some common examples of PM failures include planning to call a friend at lunchtime but instead going straight to the cafeteria as you normally would; not remembering to take your medication prior to going to bed because you had to stop to clean up a spill; and not interrupting an otherwise routine drive home to stop at the grocery store as you had planned.

Errors in multitasking, ongoing habitual activity (being on 'autopilot'), and the absence of a reminder cue (e.g., seeing a child in the rearview mirror, a drop-off reminder from a phone, or a sound of a child on the back seat) often contribute to PM failures. Successful performance of prospective memory requires multiple cognitive operations including forming, organizing and initiating a plan; retaining the memory of the intention over a delay period; performing the intention at the right time; and then remembering that the intended action took place. The essence of a PM failure therefore is the loss of awareness to 'remember to remember' at just the right time.¹⁵ Most prospective memory failures are relatively harmless or minor annoyances, but it is crucial to increase awareness as these memory failures can create hazardous conditions.

The vast majority of parents do not understand that a common prospective memory failure could result in inadvertently leaving a child in a hot car. However, over twenty-five percent of U.S. parents with children under three years of age acknowledge that at some point, they have lost awareness of the presence of a child in the back seat of the car.¹⁶ While driving a child, it is common for parents to think about other people and situations, especially when their child is quiet or sleeping. In the case of PVH, as thoughts shift during the drive, a prospective memory failure can lead the parent to forget the planned action of dropping off their child.

Parents or caregivers whose children have suffered from PVH often report changes in their normal routine on the day of the PVH event. Such changes include taking a new route to work, getting an unexpected phone call, or not normally being the one to drop off the child. These routine changes can cause inattention blindness (i.e., not perceiving something that is in plain sight) and trigger a memory failure that leads to the parent losing hold of the original plan. This scientific anomaly of PM failure also explains why parents who have unknowingly left a child in the car often go about their routine activities after the memory failure - at that point, the habit memory has suppressed the prospective

memory.¹⁷ When the brain creates a 'false memory,' parents are oblivious to the fact that their child has been left in a hot car.

QUICK FACTS

- Research shows that 60% of adults have experienced different types of memory distortions
- A vast majority of the parents aren't taking action to prevent leaving a child unknowingly in the car
- Over 50% PVH fatalities happened to children unknowingly left by a parent or a caregiver
- Pediatric vehicular heatstroke is one of the leading causes of nontraffic non-crash child fatalities in the United States

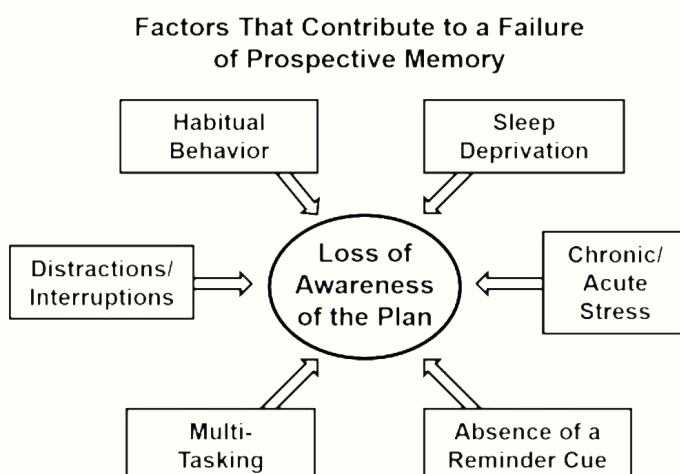
FALSE MEMORIES

False memories have intrigued cognitive psychologists for nearly a century. Multiple studies show that the creation of false memories is very common in associative memory tests in both clinical and non-clinical environments.

In a clinical environment, the Deese¹⁸-Roediger¹⁹-McDermott²⁰ (DRM) paradigm is most commonly used when studying false memories. In this approach, people are given a list of words that share a common theme such as 'school' (e.g. desk, education, locker, learning, recess, etc.). The list, however, lacks a word that is common and semantically related to the theme, such as 'teacher.' When people are queried as to which words were on the list, a high percentage of people falsely 'recall' that the word 'teacher' was on the list. Hence, the assumption that 'teacher' was on the list becomes a false memory.²¹ Based on some reports in similarly conducted studies, up to 70% of the participants will recall or recognize the 'false' word with the same probability as the words which actually appeared in the middle of the study list.²²

In a non-clinical setting, false memories have been reported in multiple and various settings. For example, a person who realizes at lunchtime that they do not have their lunch bag at work even though they can clearly picture themselves grabbing it off the kitchen counter at home has created a false memory. A person who imagines sending a quick email to a friend and then later when the friend asks why there was no reply, feels puzzled because they clearly 'remember' sending it. In a survey conducted in 2018 by the Sofia Foundation, 93% of adults report having had these types of false memory formations at some point in their lives.²³ Although most people have experienced the strange feeling of a false memory, many do not realize how this common phenomenon can put them and their children at risk.

An individual is at particular risk for developing false memories around the location of their child when their normal routine changes, when the order of performing a task changes, or when the task gets interrupted by something that does not usually happen. Even simple interruptions such as a road accident, a phone call, or an unusual stop can cause a person's brain to lose hold of a planned action (e.g. drop-off at daycare). Afterward, it is extremely easy for the brain to check off the missing step as completed because the imagined event is mistaken for an actual event. In terms of PVH, parents and caretakers have universally reported being certain they had taken the child to the target location, typically home or daycare. The DRM paradigm helps to clinically explain how these false memories can occur and that we all are vulnerable to them.



Diamond D. M. (2019)

MULTITASKING AND DISTRACTION AS CONTRIBUTING FACTORS

In the field of neurobiology, PM failures are often identified when the brain structures are in a mode of competing with each other. Trying to focus on more than one task at a time is commonly referred to as multitasking. However, multitasking is a myth.²⁴ In reality, the human brain is not capable of performing two tasks at the same time. Instead, the brain handles tasks sequentially, switching between one task and another.²⁵ In extreme examples, multitasking and changes in habitual patterns contribute to catastrophic memory errors, as the brain can lose its awareness rapidly.²⁶

In a 2003 study, researchers noted that PM failures were most likely to occur in times of transition, typically when a person leaves one environment to go to another (e.g. when leaving from home to go to work).²⁷ This study reported that PM failures were at their highest rate of occurrence when people were 'preoccupied' with another action or focused on various different environmental factors.

These findings are consistent with the literature demonstrating that stress, distractions and interruptions, as well as simply processing ongoing yet intervening events, are all potential causes for errors in prospective memory. One study shows that even mild distractions contribute to memory failures.²⁸ Forgetting one's intentions in a demanding situation can happen in a matter of seconds, and a person's awareness of an intention can be lost in response to a distracting stimulus.²⁹

EFFECTS OF SLEEP DEPRIVATION ON PROSPECTIVE MEMORY

Multiple studies in the field of human health have shown that sleep loss impacts basic elements of cognitive function. Not getting an adequate amount of sleep increases failures to carry out intended actions, which may have severe consequences to safety-critical situations.³⁰ Reports show that particular elements of cognitive function, such as the experience of attention – selectively concentrating on a discrete aspect of information – deteriorate as a result of sleep deprivation. Ultimately failures in attention can lead to a loss of awareness of future intentions.

Sleep loss and the associated complex memory processing errors can increase the occurrence of false memories. When a person is sleep-deprived the brain's ability to form accurate and real associations deteriorates and instead the mind 'fills in gaps' with the

information it retrieves from similar situations in the past.³¹ Differentiating false formation of memories and natural associative processes is, therefore, not always easy, especially when fatigued.



<https://www.noheatstroke.org/NSC-Hot-cars-report.pdf>

THE ROLE OF EDUCATION AND INFORMATION

The Bag in the Back campaign is designed to raise awareness of how prospective memory failures can lead to PVH. The campaign's primary goal is to provide a comprehensive but targeted approach to inform and educate the general public about PVH. When parents and caregivers realize they are at risk of experiencing a catastrophic memory failure, they are more likely to take preventive measures to make sure they do not experience a memory failure that results in them inadvertently leaving a child in the car.

By providing accurate and up-to-date information, the campaign hopes to reduce stigma around prospective memory failure and childcare, and to provide a safe space for parents and caretakers to discuss the topic of PVH without judgement.

Parents look to experts for guidance on safety practices, especially in areas where they may not be well-informed. Because there are many misconceptions (e.g., “I could never forget my child because she is my highest priority.”), it is particularly important for safety information about PVH to be included as part of a prenatal workshops, postpartum education, and well visits in the pediatrician's office.

HOW TO TALK ABOUT PVH WITH PARENTS?

Parents can be educated about PVH. It is well documented that we are all at a high risk of vulnerability to memory errors and studies show that a high percentage of parents, both in the United States and elsewhere, report incidences where they have lost awareness of children in the back seat of their cars. Previous research confirms that the leading cause of death for children left unattended in motor vehicles is stroke and hyperthermia.³²

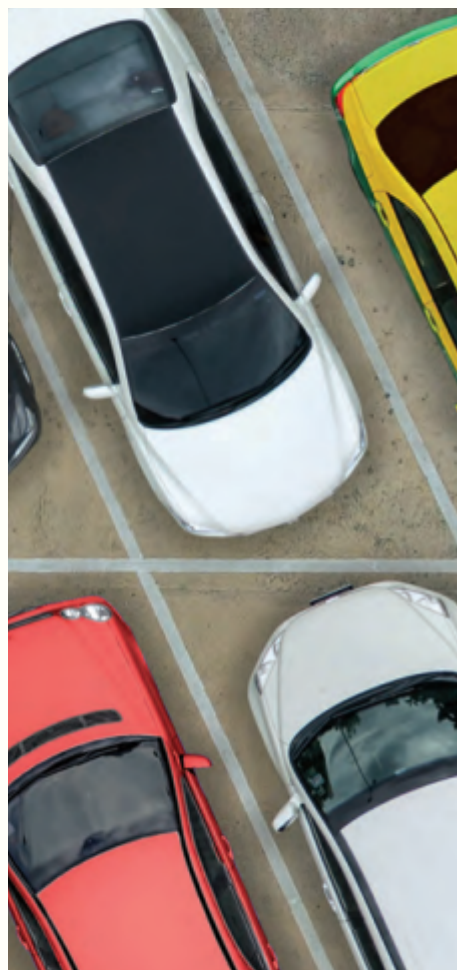
Because the role of common memory failures are misunderstood, there is often great outrage from the public when a child is inadvertently left to die in a hot car. The occurrence of PVH is seen as a result of negligence and parents and/or caretakers may be charged criminally.³³ This often leads to perpetuating the myth that PVH only happens to ‘bad’ parents. As a result, this topic is highly stigmatized and parents, believing they are good parents, are not likely to adopt essential safety practices that could prevent them leaving a child unknowingly in the car. A strong education program can be a way of successfully disseminating information about PVH. If parents hear from trusted sources that PVH is a real risk and that it can be prevented by taking simple precautions, PVH deaths could be prevented.

HOW DOES THE CAMPAIGN WORK?

The Bag in the Back campaign promotes a simple but smart way to avoid a preventable tragedy, encouraging parents and caregivers to develop a habit of putting a bag or a personal item in the back seat so that every time they leave their vehicle, they are forced to open the back door to retrieve the item. In the event that a parent has lost awareness of the child through a PM failure, they are likely to see the child when they access the back seat.

WHO IS THE TARGET AUDIENCE?

Ultimately The Bag in the Back campaign is targeting parents and caregivers of 0–12 year-old-children. However, the campaign recognizes the difficulties in getting the message to such a wide audience. Parents have reported that knowledge about PVH through public service announcements and public health campaigns is not reaching them adequately.³⁴ Caregivers and parents would benefit from this information coming through more personal channels. Therefore, this paper is aimed toward healthcare providers, childcare practitioners and daycare providers who routinely share important safety information with parents. Additionally, PVH prevention measures in the workplace could be implemented through an employer's health and safety program and/or their employee wellness programs.³⁵



<https://www.noheatstroke.org/NSC-Hot-cars-report.pdf>

CONCLUSION

In 2019, 53 children in the U.S. died in a hot car.³⁶ Though during the global COVID-19 pandemic the numbers of PVH fatalities decreased by about 38% in 2020, the long term patterns of these tragedies stayed alarmingly similar; most pediatric vehicular heatstrokes occurred in the southern United States and most happened because parents either unknowingly or knowingly left their children in stationary vehicles.³⁷ During this time, PVH was not linked to memory loss as frequently as in previous years, primarily because the patterns of daily-routines changed; frequent driving decreased and schools and daycares were closed.³⁸ However, as COVID-19 vaccines are now available out and the pandemic lockdown restrictions have dissipated, it's crucial to get out the message that all vehicle hyperthermia is preventable and all parents are at risk of forming false memories that could lead them to inadvertently leaving a child in a stationary vehicle.

Countless studies have shown that the human brain is capable of memory failures, including skipping planned actions and creating false memories. A caregiver can easily believe their child is safe at school, home or daycare when they have, in fact, been left in the back seat of a parked vehicle. Stress, sleep deprivation, distraction and habit memory are very capable of overriding short-term memory and forming associations with correlating and semantically close-related events. These stress-related memory loss incidents are particularly expected to increase now that home restrictions have been lifted. By sharing stories and having a platform to discuss these issues, awareness can lead to the adoption of life-saving practices. The Bag in the Back Program is a simple and efficient way forward and can prevent countless tragedies in the future.

RESOURCES

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3. <https://www.noheatstroke.org/NSC-Hot-cars-report.pdf>
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23. Appendix 1
24. <https://health.clevelandclinic.org/science-clear-multi-tasking-doesnt-work/>
25. <https://www.noheatstroke.org/NSC-Hot-cars-report.pdf>
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ADDITIONAL RESOURCES

- National Safety Council
nsc.org/heatstroke
- National Highway Traffic Safety Administration:
nhtsa.gov/heatstroke
- San Jose State University
[NoHeatstroke.org](https://www.sjsu.edu/noheatstroke.org)
- American Academy of Pediatrics
[HealthyChildren.org](https://www.aap.org/healthychildren.org)
- Safe Kids Worldwide
safekids.org/take-action-preventheatstroke
- KidsandCars.org
[kidsandcars.org/how-kids-gethurt/heat-stroke](https://www.kidsandcars.org/how-kids-gethurt/heat-stroke)
- Rayrayspledge.com
[rayrayspledge.com/Ray-Ray-s-Call-to-Action](https://www.rayrayspledge.com/Ray-Ray-s-Call-to-Action)
- Road to Zero
[nsc.org/RoadtoZero](https://www.roadtozero.org)

APPENDIX 1.

	All				Child 3 years or younger		
	Base	# Yes	% Yes		Base	# Yes	% Yes
Told someone something	949	590	62%		512	318	62%
Taken your vitamins or medication	949	480	51%		512	257	50%
Locked your house	949	474	50%		512	240	47%
Sent an email / called someone	949	430	45%		512	219	43%
Put food in the refrigerator	949	391	41%		512	218	43%
Paid a bill	949	391	41%		512	191	37%
Brought your lunch, computer or something else you needed for work	949	365	38%		512	193	38%
Turned off the oven, a burner, the iron or other fire hazard	949	347	37%		512	169	33%
Closed the garage door	949	340	36%		512	177	35%
Removed your keys from the car	949	297	31%		512	155	30%
Removed food from the microwave	949	262	28%		512	154	30%
Removed groceries from the car	949	198	21%		512	92	18%
Locked your desk / office	949	119	13%		512	63	12%
Set the alarm on your house	949	117	12%		512	53	10%
Picked up or dropped off your child	949	37	4%		512	15	3%
Removed your child from the car	949	21	2%		512	12	2%
Removed your pet from the car	949	8	1%		512	3	1%
No, none of these	949	71	7%		512	37	7%