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When a child dies of heatstroke after a parent or caretaker unknowingly leaves the child in a car: How does it happen and is it a crime?

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Abstract

It is commonly reported that in the course of a drive, a parent or caretaker loses awareness of the presence of a child in the back seat of the car. Upon arriving at the destination, the driver exits the car and unknowingly leaves the child in the car. This incomprehensible lapse of memory exposes forgotten children to hazards, including death from heatstroke. More than 400 children in the past 20 years have suffered from heatstroke after being unknowingly forgotten in cars. How can loving and attentive parents, with no evidence of substance abuse or an organic brain disorder, have a catastrophic lapse of memory that places a child's welfare in jeopardy? This article addresses this question at multiple levels of analysis. First, it is concluded that the loss of awareness of a child in a car is a failure of a type of memory referred to as prospective memory (PM), that is, failure to remember to execute a plan in the future. Second, factors that increase the likelihood that PM will fail are identified. Third, research on the neurobiology of PM and PM-related memory failures are reviewed, including a discussion of how competition between brain structures contributes to a failure of PM. Finally, the issue of whether a failure of PM that results in harm to a child qualifies as a criminal offence is discussed. Overall, this neuropsychological perspective on how catastrophic memory errors occur should be of value to the scientific community, the public and law-enforcement agencies.

Keywords

Forensic psychiatry, memory failure, neurobiology of memory, prospective memory, *mens rea*, neuropsychology of memory

Prologue: A case study

Lyn and Jarrett Balfour shared the responsibility of taking their nine-month-old son, Bryce, to day care; either Lyn or Jarrett would take Bryce to day care as a part of each one's drive to work. On the morning of 30 March 2007, Jarrett's car was unavailable, so Lyn modified her normal routine to work to include driving Jarrett to day care. Other aspects of the drive were different as well. First, Bryce had always been placed in a car seat behind the passenger's seat. However, on this day, Jarrett placed a new car seat in the regular location, and he moved Bryce's old car seat to a new position, behind the driver. Bryce was placed in the old car seat, which was positioned behind the driver for the first time. Second, Lyn routinely placed Bryce's change bag on the front passenger seat when she took Bryce to day care. However, because Jarrett sat in the front seat that morning, the change bag was placed on the rear floor, out of Lyn's view. Third, soon after Lyn dropped Jarrett at work, her drive was interrupted by two important phone calls: the first from a family member in need of her assistance, and the second involving an urgent problem at work that required her immediate attention. Once Lyn had successfully dealt with the family and work crises, she returned to what seemed to be the only task at hand: to continue her drive to work. At this stage, Lyn had lost awareness that Bryce, sleeping soundly behind her, was in the car.

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It is also important to note that the night before, Lyn had cared for a neighbour's baby until 1:00am, and then Bryce woken her at 3:00am. She spent hours caring for Bryce, which left her sleep deprived that day. Thus, without Bryce in the passenger-side car seat or the change bag in the front seat, and with Bryce sleeping quietly behind her, Lyn did not have the typical visual and auditory cues that could have alerted her to Bryce's presence in the car.

Lyn arrived at work, exited the car and prepared for the demands of her job, unaware Bryce was still in her car. During her day at work, Lyn frequently looked at a picture of Bryce on her desk and was confident she had taken him to the day-care provider that morning. This was, in fact, a false memory, as later that day Lyn was horrified to discover that Bryce was still in her car. Bryce was found unconscious, with a body temperature of at least 42°C (108°F). His cause of death was determined to be heatstroke from spending the entire day in a hot car.

In *Balfour* v. *Commonwealth of Virginia*, Lyn was initially charged with felony child neglect and second-degree murder. This charge was later reduced to involuntary manslaughter. A conviction in this case carried a maximum penalty of 10 years in prison. On 25 January 2008, at the conclusion of an emotionally charged trial, Lyn Balfour was found not guilty of all charges.

Introduction

The tragic loss of Bryce Balfour's life represents an epidemic of children who have died or suffered organ damage from heatstroke when parents or caretakers have left them in a car that has become intolerably hot in response to heat exposure. It has been estimated that more than 400 children in the USA and other countries[1,2] have been harmed after being forgotten in cars.[3–5] The high incidence of harm to children in hot cars has been linked to the installation of air bags in the front seat of vehicles in the 1990s, when drivers were first compelled to place small children in the back seat where they would not be harmed by air-bag deployment.

In this viewpoint, I address the issue of how loving and attentive parents and caretakers – with no evidence of neglect, substance abuse or an organic brain disorder – can have a catastrophic lapse of memory that results in harm to their children. First, I describe how the loss of awareness of a child in a car is a failure of a category of memory referred to as prospective memory (PM). Second, I identify factors that affect the likelihood that a PM failure will occur. Third, I provide a model that illustrates why the incidence of heatstroke-induced harm is relatively rare, despite the finding that a high percentage of parents report having lost awareness of children in cars. Fourth, I review the neurobiological basis of PM and how brain structures may interact to cause a PM failure. Finally, I formulate an opinion as to whether a memory failure that puts a child in harm's way qualifies as a criminal offence. In summary, the goal of this viewpoint is to provide a cognitive and neurobiological perspective on how catastrophic memory errors occur, which should be of value to the public and law-enforcement agencies.

Types of memory: Focus on retrospective and prospective memory

Memory may be categorised broadly into two types: retrospective memory (RM) and PM.[6] The essence of RM was described by William James who, in 1890, wrote that emotional experiences leave 'a scar upon the cerebral tissues'.[7] In a sense, all events from one's past – neutral as well as emotional – may leave the neural equivalent of a 'scar' upon the brain. RM therefore involves the processing, storage and retrieval of information from past experiences.

RM can be divided into explicit and implicit forms. Explicit RM involves conscious cognitive effort at the storage and retrieval phases of memory processing.[8,9] Remembering detailed information and events, such as a phone number, a spouse's birthday and what was served for breakfast today, are all examples of explicit RM. Implicit RM, by contrast, involves subconsciously processed information.[10] One form of implicit RM, which is relevant to this viewpoint, is habit memory.[11,12] Habit memories are formed slowly in response to acquired perceptual and motor skills that develop largely outside of one's awareness of the learning process. Examples of habit memory are maintaining one's balance while riding a bike, driving a car and refined skills in sports (e.g. how to hit a tennis ball properly).

PM is the second general category of memory. PM is an extension of RM in that it involves the use of stored information to plan and then execute an action which will take place in the future.[13–15] Successful performance of PM requires multiple cognitive operations, including: forming, organising and initiating the 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.

PM takes place repeatedly on a daily basis. Examples of PM on a typical day may include plans to return a phone call to a colleague after lunch, to take medication prior to going to bed or to interrupt the routine drive home to stop at a pharmacy to pick up medication. As simple as the example of stopping at the pharmacy may appear, successful completion of this task involves the coordination of multiple explicit and implicit RM components. To begin, the person needs to take into consideration past experiences to plan the modified route. The drive itself involves implicit RM, beginning with habitual (automated) actions involved in the mechanics of operating a car (unlock the door, attach the seat belt, push the ignition button, etc.). The act of driving along a well-travelled route can be an automated process, enabling the driver to drift into an 'autopilot' mode. The great benefit of the 'autopilot' mode is that it frees cognitive resources for the driver to multi-task, that is, listen to the radio, remember events of one's past and discuss future plans with the passengers, all with minimal conscious effort to drive on a well-travelled route.[16]

The critical juncture of the drive takes place as the driver approaches the pharmacy. At that moment, the memory to interrupt the routine drive to stop at the pharmacy may be active because the driver has maintained a persistent effort to keep the intention in mind throughout the drive to pick up the medication.[13–15] However, as is more often the case, when awareness of an intention is temporarily lost, the memory needs to be reactivated by a cue, such as time (e.g. go to the store at 5:00 pm),[17] a PM-specific sensory cue (e.g. receiving a phone call during the drive with a reminder to stop at the pharmacy)[18,19] or an activity (e.g. a sneeze may remind the driver to pick up cold medication). If, however, the task is not maintained constantly in the driver's awareness or the memory is not reactivated by an intention-specific cue, then PM is likely to fail.[20]

Characterisation and causes of memory failures

When people are queried about their memory, they commonly focus on RM-type forgetting of facts and details, such as a phone number or someone's name, but research indicates that the most common memory errors in everyday life are PM failures.[14,21–23] Although most memory failures are minor annoyances, memory failures involving PM can create potentially hazardous conditions, such as when a person leaves home and forgets to shut off the oven or to close the garage door. Confirmed PM-related memory errors have been shown to contribute to hazardous medical-care conditions, such as when surgeons forget to retrieve surgical tools in a body cavity[14,24,25] and when medication is dispensed incorrectly by pharmacists.[26]

PM errors have also been committed when pilots have failed to remember to interrupt their ongoing cockpit activity to begin their descent,[27] causing them to overshoot the airport destination. Far worse than missing the airport, serious incidents and even catastrophic outcomes with a loss of lives have been caused by attention and memory errors by air-traffic controllers,[27] airline mechanics and pilots.[14]

A surprising and potentially hazardous form of PM failure is the well-documented finding that security guards, police officers and detectives have left their loaded guns in public bathrooms.[28] To understand how this can happen, I conducted an interview with a Tampa detective that left his gun in a bathroom at a movie theatre.[29] He disclosed to me that just as he had completed his use of the toilet, he was distracted by his son calling to him to hurry because the movie was about to begin. At the moment in which his attention was diverted to his son, he lost awareness of his gun, which was directly in front of him on the toilet-roll dispenser; he then exited the bathroom, leaving his weapon behind. A child later picked up the gun and delivered it to his parent, averting a potential catastrophe had the child fired the gun. This example of a potentially catastrophic PM failure illustrates how rapidly, in a matter of seconds, a person's awareness of an intention can be lost in response to a distracting stimulus.

The most frequently reported occurrence of a catastrophic PM failure is the primary topic of this viewpoint. Just as a detective can forget his weapon in a public bathroom and a pilot can forget to set the wing flaps properly prior to take-off, a parent or caretaker can forget a child in a car, which puts the child at risk of harm from heatstroke.

Why does memory fail in general, and specifically, why does PM fail, especially when the consequences of a PM failure are so dire? Figure 1 illustrates six primary factors that contribute to the core feature of a PM failure, which is the loss of awareness of the plan to interrupt ongoing activity to perform the target action.

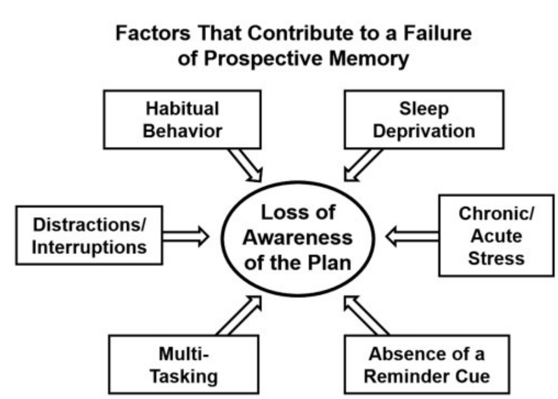

Figure 1. Factors that contribute to a failure of prospective memory (PM). The core feature common to all PM failures is the loss of awareness of an intended action.

That is, from the time of the formulation of the plan to its expected time of execution, these six factors contribute to an individual losing awareness of the intention to complete the plan. The essence of a PM failure therefore is the loss of awareness to 'remember to remember' at just the right time.[21,30]

Two of the six factors in Figure 1 – sleep deprivation and chronic stress – provide a global detrimental influence on PM.[31–33] The other factors represent acute conditions during the PM delay that influence its outcomes. In one study, investigators 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). This study reported that PM failures were at their highest rate of occurrence when people were in a state of 'high arousal' or were 'preoccupied' with another action.[34] These findings are consistent with the literature demonstrating that stress,[35] distractions and interruptions,[36] as well as simply processing ongoing intervening events,[37] are all potent detrimental influences on PM. Experimental research under controlled conditions has demonstrated that even mild distractions can impair PM rapidly in less than a minute.[38]

Two factors that often occur in conjunction with a PM failure are ongoing habitual activity ('autopilot' mode) and the absence of an explicit reminder cue. Habitual activity can trigger a form of inattentional blindness, such that the awareness of the intention is lost because a person's attention is focused on other features of the environment.[16] This phenomenon was first described in 1890 by William James, who noted that 'habit diminishes the conscious attention with which our acts are performed'.[7] Once inattentional blindness develops, the ongoing habit can dominate one's awareness,[39] which impairs attention to the task that deviates from the habit.[40] With one's awareness focused on the routine, awareness of the plan to interrupt the habit may occur only in response to a highly salient and unique reminder cue,[41] such as the child vocalising, seeing the child's change bag in the car or a phone call from the day-care provider asking about the child.

Relation of children forgotten in cars to false-memory research

There is a vexing component of children forgotten in cars that commonly provokes outrage from the public and may influence law-enforcement officers to charge parents and caretakers with crimes, ranging from child neglect to murder. Parents and caretakers who forget children in cars may go about their daily routine, for many hours at home or at work, as the child dies from heatstroke. The question that is commonly asked is that someone may forget a child for a brief period of time, but how does someone forget a child in a car all day or even overnight in some cases?

Parents and caretakers have universally reported being certain they had taken the child to the target location, typically home or day care. False memories such as this one have intrigued cognitive psychologists for nearly a century.[42] Researchers have studied different categories of false memories, including fabricating and implantation of memories of events that did not happen, such as childhood experiences, or distorting real experiences to reduce their accuracy.[42–45] The category of false memory most relevant to parents forgetting children in cars is when an event assumed to have taken place becomes stored as a very real – but false – memory. This phenomenon was first studied by Deese[46] and then extended by Roediger and McDermott,[47] in an approach which is referred to as the Deese–Roediger–McDermott (DRM) false-memory paradigm.[48] In this approach, people study a list of words that share a common theme such as medical care (e.g. nurse, hospital, surgery, medication, etc.). The list, however, lacks a word that is common and semantically related to the theme, such as 'doctor', which people assume had been included in the list. At some time later, when people are queried as to which words were on the list, a high percentage of people falsely 'recall' that the word 'doctor' was on the list. Hence, the assumption that 'doctor' was on the list becomes a false memory, in which people report with high confidence that 'doctor' was on the list when in fact it was not.

The authors of the original DRM study were so taken by the strength of the false memories formed that they stated '...the illusion of remembering events that never happened can occur quite readily' and further noted 'the fact that people may say they vividly remember details surrounding an event cannot, by itself, be taken as convincing evidence that the event actually occurred'. The DRM paradigm mimics the false memories of parents who forget children in cars because the driver's assumption that he or she took the child to day care becomes a false but seemingly very real memory.

It is notable that DRM false memories can be quite durable, lasting for many hours and even overnight.[49] Thus, once a false memory is formed, it is as durable as a real memory, a finding that may help us to understand how a person can leave a child in a car for many hours, all the while being certain that the child was at the intended location.

Relation of Reason's 'Swiss cheese' model to cases in which children have been forgotten in cars

Reason developed a 'Swiss cheese' model[50] based on protective barriers, such as alarms, physical barriers and automatic shutdowns, which reduce the likelihood that a hazardous workplace situation will develop into a tragedy. According to Reason, the barriers should be impenetrable to human error, but they have flaws, depicted as holes in slices of Swiss cheese, which are continually opening, shutting and shifting their location. The presence of holes in any one 'slice' (one flawed protective barrier) does not normally cause a hazardous outcome, but when the holes in many layers momentarily line up, an improbable trajectory from potential hazard to tragedy can pass through all of the protective barriers.

I have applied Reason's model to the conditions that influence whether a forgotten child is retrieved safely or is harmed by heatstroke based on experimental research and my service as an expert witness in civil and criminal cases. As illustrated in Figure 2, the trajectory from a potentially hazardous condition to heatstroke-induced harm begins with findings of a survey in which approximately 25% of parents of young children reported they had forgotten (lost awareness of) a child in their car at some time during a drive.[51] This loss of awareness may develop spontaneously, as a matter of a time-related PM failure,[52] or may be a more active process, triggered by a stimulus that directs the driver's attention away from the child, such as an emotional experience. The attentional narrowing that occurs with strong emotion, also referred to as 'tunnel vision', was described in a seminal paper by Easterbrook in 1959[53] and has been replicated in more contemporary research.[54–58] In a related cognitive process, referred to as 'inattentional blindness' and 'attentional capture',[59,60] a person's awareness of a salient cue – in this case, the child – may be lost as other salient cues in the environment attract a person's attention. Therefore, the 'Swiss cheese' model of forgotten children in cars typically begins with the driver's loss of awareness of the presence of the child in the car.

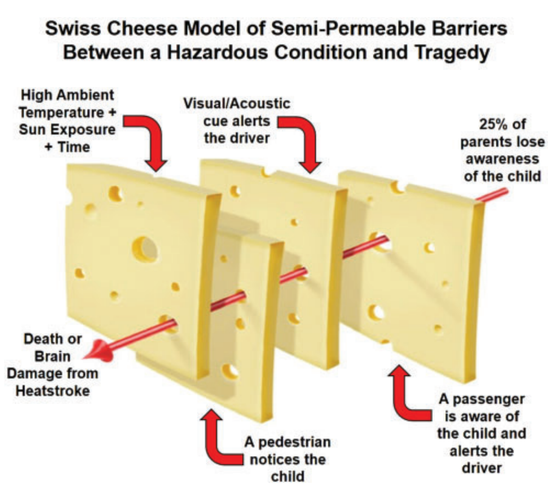

Figure 2. 'Swiss cheese' model of semi-permeable barriers that stand between a hazardous condition (loss of awareness of a child in the car) from developing into a tragedy (heatstroke). Only the trajectory that passes through a hole in each of the protective barriers results in tragedy.

The first protective barrier after a driver loses awareness of a child is that a passenger alerts the driver to the presence of the child in the car. This barrier is potentially a significant factor, as most reported cases involve drivers who were alone when children were forgotten in cars. However, even when the driver is not alone, the presence of a passenger in the car may not be a sufficient barrier to avoid a child from being forgotten because the driver and the passenger both lose awareness of the child in the car. For example, in three cases in which I have served as an expert witness (*Poole* v *Director of Public Prosecutions*, Victoria, Australia [2014]; *Ives* v *State of Texas* [2015] and *Lillie* v *State of Florida* [2017]), a child died of heatstroke after being forgotten in a car in which the driver, as well as a sole passenger, both lost awareness of the presence of the child in the car.

The second barrier is that a cue (typically visual or auditory) alerts the driver to the child's presence. I have received numerous reports from parents alerted to their child's presence when they heard the child make a sound or they happen to look in the back seat to 'discover' their child in the car. A person may also be alerted to the child in the car by a phone call from the day-care provider asking why the child hadn't arrived at day care as scheduled. This barrier fails when there is an absence of a sensory cue alerting the parent or caretaker to the child's presence in the car.

When the first two within-car barriers fail and a child is forgotten in a car, there is a third layer of protection. In cases in which I have served as an expert witness (e.g. *Gruen* v *State of New Jersey* [2017], *Steinhart* v *State of Iowa Child Protective Services* [2015]), as well as numerous other cases which have been reported in the media, pedestrians have noticed a child alone in a hot car. In these instances, the pedestrians may intervene by calling the police and/or breaking into the car to free the child. This barrier is most likely to be present when the car is parked in a high pedestrian traffic area such as a shopping centre. This condition often saves a child from harm but may result in the driver being charged with child neglect or abandonment.

Even when the trajectory from potential hazard to harm passes through the first three barriers, a forgotten child in a car may remain unharmed if environmental conditions are not conducive towards producing heatstroke.[61,62] That is, under conditions in which the internal temperature of the car does not rise sufficiently to cause harm (e.g. in cool weather), the car is parked in covered parking or the duration of exposure is brief, the child may remain unharmed in the car for many hours. It is only when environmental conditions produce an intolerably hot (or cold) environment for a prolonged period of time that a child may be harmed by extreme ambient temperature.

In sum, Reason's 'Swiss cheese' model has value towards understanding why it is relatively common that drivers report having forgotten children in cars, but death or organ damage from heatstroke is quite rare. It is only in the extraordinarily rare circumstance in which a trajectory from a potentially hazardous condition passes unimpeded through all protective barriers that a child suffers from heatstroke.

Neurobiology of RM and PM failures

The expression of normal, healthy brain functioning involves the capacity to process and store information from one's past (RM) and to use that information in the present to make plans for the future (PM). A memory failure, in the absence of pharmacological influences or an organic disorder, also reflects the expression of a normal, healthy brain, even when that memory failure results in a tragic outcome. It is of value therefore to understand how normal brain functioning can result in catastrophic memory errors.

As noted previously, PM is a complex form of memory that involves multiple cognitive operations, beginning with forming and organising a plan based on past experiences (RM), determining when and how to execute the plan, performing the intention at just the right time in the future and then remembering that the intention has been accomplished. With such a complex, multi-component cognitive process, it is a challenge to model the different neural systems that enable PM to occur. It is therefore understandable that neural models of PM have been complex, involving numerous brain structures that cooperate as well as compete with each other. Recent reviews provide a reference source for research in this area.[63–68]

Although numerous brain structures are involved in PM, the neural systems that are of most value towards understanding PM and PM failures are the frontal and parietal cortices (F/PC) and the hippocampus (HC). A vast literature has demonstrated that F/PC functioning underlies strategising, planning for the future and maintaining a representation of an intention,[64,69–71] and that the HC is necessary for the formation of conscious memories.[72,73] A person without a functioning F/PC would have great difficulty in planning and strategising about the future and in multi-tasking.[74] Damage to the HC, by contrast, would result in a person who appears to be normal, in that intellect, communication and personality would be unaffected. However, without a HC, a person would be unable to form and retrieve all recently processed memories of explicit (conscious) experiences.

Although people with damage to the HC are incapable of forming explicit memories, they can acquire perceptual and motor skills at a normal rate, despite a complete lack of awareness that the learning has taken place.[12] This observation was first reported in a patient (H.M.) with surgical removal of his HC bilaterally.[75] Although the surgery rendered H.M. incapable of forming new conscious (i.e. declarative/explicit) memories, he subconsciously learned perceptual and motor skills at a normal rate, a finding that has been replicated repeatedly over the ensuing decades.[76] The research beginning with H.M. has been extended to animal studies[77,78] to demonstrate conclusively that there are separate and distinct brain memory systems for conscious (explicit) versus subconscious (habit) memory processing.[79] The neural structure that processes subconscious – particularly skill and habit – memories is a set of primitive nuclei, referred to as the basal ganglia (BG).[80,81]

The sequence and brain structures involved in successful and unsuccessful PM is in Figure 3 (adapted from McDaniel and Einstein[67]). PM begins as a plan, generated by the F/PC system, to accomplish an intention in the future. The F/PC works with the HC to use stored memories and to process new information in order to create a representation of the intention.[68] In the example of a drive that inconsistently includes a child, the F/PC would generate the plan to include a stopover at the day care, and the HC would store the information that the child is in the car today, perhaps unlike other days. The literature indicates therefore that the F/PC subserves the planning component of the drive and the maintenance of the intention in memory, and the HC provides the complementary function to store the memory of the child's presence in the car and to reactivate that memory at the appropriate time.[82]

During the delay between the formation and execution of the plan, there is a form of competition between the conscious (F/PC and HC) brain memory systems to process the PM and the subconscious (BG) brain memory system to enable someone to accomplish a routine action automatically as if in an 'autopilot' mode. Brain-imaging studies have demonstrated that this competitive process can involve the simultaneous activation of the BG and reduced activation of the HC,[83–85] which is enhanced by stress.[86] Mechanistic

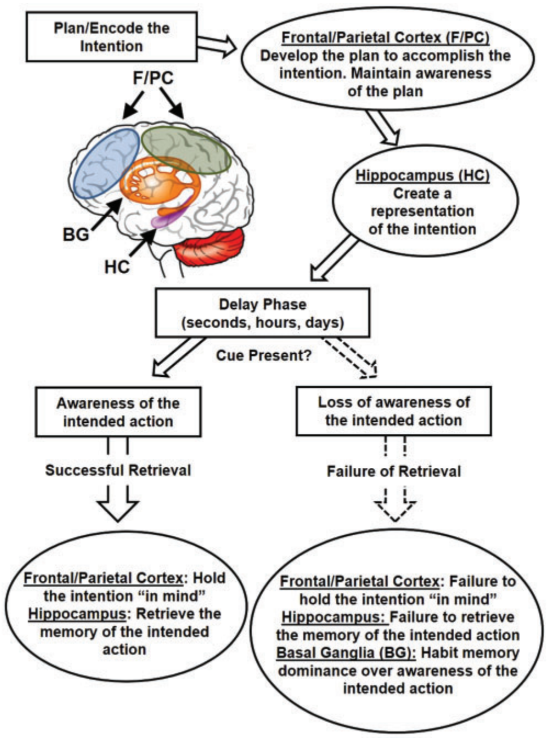

Figure 3. Neurobiological model of successful and unsuccessful PM. PM is initiated and maintained by the frontal cortex (shaded in blue) in conjunction with the parietal cortex (shaded in green). The conjoint action of the frontal and parietal cortices is indicated as the F/PC. The hippocampus (HC) works with the F/PC to generate a representation of the plan based on prior experience (retrospective memory). The HC needs to be reactivated at the right time, usually by a reminder cue or activity, for PM to be successful. If basal ganglia (BG) activation during habitual activity occurs, awareness of the intention may be lost. In this case, failure of PM retrieval is likely to occur unless a salient, PM-specific cue reactivates the F/PC and HC neural system.

studies in rodents have also identified competitive interactions between these two brain systems under conditions of habit versus novel learning conditions.[85,87,88] These findings support the hypothesis that under conditions of stress or habitual behaviour, the BG may interfere with one's awareness of an intended action, leading a driver to lose awareness of the child in the car and to follow a commonly driven route.

Research indicates that when the intended action should occur, a cue can reactivate the F/PC+HC system in the neural equivalent of 'booting' the conscious memory system. If that 'booting' of the F/PC+HC system occurs, then there is a reactivation of the target memory, with successful retrieval of the memory of the intention. If, however, there is a loss of awareness of the task in conjunction with an absence of an alerting cue, then there is a strong likelihood of a failure to retrieve the memory of the intention.

PM failure, and therefore the failure of the F/PC + HC system, is common because keeping an intention in mind, for even less than a minute,[38] is adversely affected by multiple competing factors. The passage of time, distraction, multi-tasking and stress all exert an adverse effect on F/FC[89] and HC functioning[90] while promoting subconscious, habit-based (BG) memory processing,[91] as well as an inherent competition between the BG and F/PC + HC memory systems.[85,87,88]

With the BG guiding behaviour, the driver can perform a habitual behaviour (i.e. to drive a well-established route) and the F/PC can perform its multi-tasking function (i.e. to enable the driver to listen to the radio, have a discussion with passengers and plan for the future), all with minimal cognitive effort. However, as the F/PC multi-tasks and the BG guides habitual behaviour, the driver may lose awareness of the presence of the child in the car. With this loss of awareness of the child in the car, the plan to stop at the day care is lost as well.

Therefore, when the driver arrives at the routine destination, he or she exits the car having lost awareness that the child remains in the car. The driver's assumption that the child has been taken to day care becomes a false memory, which provides the driver with the false sense of security that the child is in a safe location. The driver then conducts routine activity at the destination for as much as an entire day or an entire evening, completely unaware that the child remains in the car. This hypothesis explains how parents and caretakers may return to their car after being away for many hours and are horrified when they discover their child had died in the car during their absence.

Unknowingly and unintentionally leaving a child in a car: Is it a crime?

A subset of parents and caretakers who have unintentionally and unknowingly left a child in a car have been prosecuted for crimes which range from child neglect to murder. In this situation, the Latin dictum '*actus non facit reum nisi mens sit rea*' is relevant, meaning 'the act does not make a person guilty unless the mind is also guilty' or put more simply, a criminal act requires a knowing 'guilty mind' (*mens rea*). Components of the 'voluntary act requirement' in the USA Model Penal Code (MPC), Section 2.01, relevant to *mens rea* include: 'a person is not guilty of an offense unless he acted purposely, knowingly, recklessly or negligently'.

The *mens rea* requirement of criminal law negates prosecution of individuals if they are limited in their capacity to be aware that their actions could harm another person. Neuroscience research has been of great value in this regard by expanding our understanding of conditions that influence the accountability of individuals who have committed violent acts. A vast literature has incorporated impaired or insufficient functioning of brain structures, such as the frontal cortex, amygdala and HC, produced by early life trauma,[92,93] brain dysfunction,[94] immature brain development[95] or intense emotion,[96] as mitigating factors in limiting offender accountability in violent acts.

Also relevant to the *mens rea* component of the law is that people have not been found to be legally responsible for committing harm to others when they are in an unconscious state. *Massachusetts* v *Tirrell* (1846) was the first case to determine that an individual cannot be criminally responsible for acts committed while unconscious, in this case killing a person while the defendant was in a somnambulism (sleep-walking) state. The *mens rea* defence has been used successfully in numerous contemporary cases when an individual in a somnambulism state caused harm to another (see Denno[97] for a review). Courts have also held that other forms of an unconscious state (also referred to as automaticism) constitute a defence to a criminal charge,[97] such as harm caused by an individual in the midst of an epileptic seizure[97] or harm caused by an individual who fell asleep while driving.[98]

The issue of offender accountability was summarised succinctly in California jury instructions, which described the defence of 'automatism' as: 'A person who commits what would be a criminal act, while unconscious, is not guilty of a crime'.[97] It is in this context that the neuroscience research I have reviewed is relevant. There is incontrovertible evidence that there are independent levels of conscious and non-conscious processing which occur simultaneously by different brain structures. Whereas the F/PC+HC system processes conscious, planned and strategic actions, other structures, such as the BG, function at a subconscious level, enabling well-established routines to occur automatically, with minimal conscious awareness. Moreover, it is a well-established finding that these brain systems appear to compete against each other for access to conscious awareness, which includes the BG habit-based subconscious system, which exerts a powerful influence on awareness and behaviour.

In cases I have reviewed when people unknowingly left children in a car, there is strong support for the hypothesis that they were guided by their BG, which was focused on accomplishing a habitual action. Brain-imaging research reveals that HC neural activity, which maintains the memory of the child's presence in the car, is reduced in a task in which BG activity is dominant. Thus, at the moment in which the driver exits the car, the HC cellular activity that had processed the memory of the presence of the child in the car would be reduced below the level of conscious awareness. Moreover, in a process which is not well understood, the brain creates a false memory that the child has been taken to the planned destination (home or day care). Therefore, upon exiting the car, the driver has not left the child (or children) in the car purposely, knowingly, recklessly, negligently and certainly not with malice. Rather, the person's actions reflect the dynamics and imperfection of human brain functioning in a complex multitasking situation, which underlies the failure of PM.

My opinion expressed in this viewpoint is that absence of *mens rea* directly applies to cases in which parents and caretakers, unknowingly and unintentionally, leave a child in a car. A similar opinion was expressed by the Court of Appeals of the State of Texas in their reversal of the conviction of Wakesha Ives of criminal negligence after she had forgotten her child in her car.[99] The court determined that 'Because the evidence does not rise to the level of some serious blameworthiness, we reverse the conviction...'. Therefore, when we take into account that a criminal act requires an individual to be fully aware that his or her action could cause harm, when a child dies of heatstroke in a hot car, it is a public-health issue and a tragedy, but it is not a crime.

Epilogue

The combination of detrimental factors which led Lyn Balfour to leave Bryce in her car that day were covered extensively in a *Washington Post* Pulitzer Prize–winning feature entitled 'Fatal Distraction'[100] and were also called the 'Perfect Storm' in a local news story.[101] Her case had many PM-impairing factors which coexisted, seemingly conspiring against her from maintaining awareness of Bryce's presence in her car: she was sleep-deprived, stressed by urgent phone calls during her drive and deprived of regular cues, for example the change bag which had always served as a reminder that Bryce was in the car. Her case serves as a template to understand the multitude of factors that contribute to why children can be forgotten in cars.

It is important to emphasise that with more than 400 children dying in hot cars as a result of a PM failure over the past 20 years, as well as other conditions in which children may die as a result of human error, each case is different; each case needs to be evaluated based on the unique circumstances that led to a loss of awareness by the caretaker of the child's presence in the car. A PM failure may occur with only a small subset of the perfect storm of events that Lyn Balfour experienced. Indeed, as little as a single factor in Figure 1, for example a habit-based drive that only intermittently includes taking the child to day care, has sufficed for people to lose awareness of a child in a car.

Finally, human error involving an impairment of memory and attention with catastrophic outcomes can take on many different forms (e.g. airline pilot error, critical care setting, medication adherence, children and dogs[102] forgotten in hot cars). Therefore, while the primary purpose of this viewpoint is to address how and why children are forgotten in cars, this analysis of human errors can provide guidance as to how people may unknowingly make a catastrophic error which can unintentionally result in harm to others.

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