THE UNIVERSITY *of* EDINBURGH

ON THE FALLIBILITY OF HUMAN MEMORY FOR FUTURE ACTIONS

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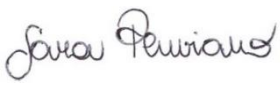
Declaration

I hereby declare that this thesis is of my own composition and that it contains no material previously submitted for the award of any other degree. The work reported in this thesis has been executed by myself, except where due acknowledgment is made in the text.

Sara Pluviano



Abstract

Human memory is a system that is inherently fallible and prone to distortion, and our memory for future actions is no exception. Prospective memory is defined either as remembering to carry out a task at a particular moment in the future or as the timely execution of a previously formed intention. For a variety of reasons, one may miss this prearranged moment and thus fail to fulfill an intention. This thesis focuses on the factors that may affect the fulfilment of a delayed intention and contribute to prospective memory failures.

As the rather scant literature on the effect of stress on prospective memory functioning has produced contradictory findings, Part One of this Thesis investigates the role of stress in prospective memory failures in a strict sense, namely forgetting to carry out intended actions at the appointed time and place. One study involving healthy participants examines the disruptive effect of daily stress on prospective memory functioning and explores the moderating role of individual factors in modulating the harmful consequences associated with stress in everyday life. Another study carried out with healthcare workers investigates how work stress and burnout may contribute to forgetting clinical tasks, which may result in potential adverse events jeopardizing patient safety.

Besides stress, misremembering future intentions may also arise from the lingering effect of misinformation on our memory, attitudes, and behaviors. Part Two of this Thesis, encompassing 6 experiments on healthy participants, shows how inaccurate and invalid information survive despite sophisticated correction attempts, influencing memory and reported future intentions.

Overall, the results of the studies presented in this Thesis prove the fallibility of our memory for future actions. Various techniques to reduce the risks associated with memory failures are discussed.

Riassunto

La memoria umana è un sistema intrinsecamente imperfetto ed incline ad errori, e la memoria per le azioni da svolgere nel futuro non fa eccezione. La memoria prospettica è definita come il ricordare di portare a termine un compito in un particolare momento nel futuro o l'esecuzione puntuale di un'intenzione formulata precedentemente. Per diversi motivi, una persona può dimenticare questo momento prestabilito e quindi non ricordarsi di portare a termine un'intenzione. Questa Tesi si concentra sui fattori che possono influenzare l'esecuzione di un'intenzione futura e contribuire ad errori di memoria prospettica.

Poiché i pochi lavori esistenti in letteratura riguardo l'effetto dello stress sulla memoria prospettica hanno riportato risultati contradditori, la Prima Parte di questa Tesi indaga il ruolo dello stress negli errori di memoria prospettica intesi in senso stretto, ovvero come il dimenticarsi di eseguire azioni prestabilite al tempo e nel luogo opportuni. Uno studio che coinvolge partecipanti sani esamina l'effetto negativo dello stress quotidiano sul funzionamento della memoria prospettica ed esplora il ruolo di moderazione di alcuni fattori individuali nel modulare le conseguenze negative associate allo stress nella vita quotidiana. Un altro studio condotto sugli operatori sanitari indaga come lo stress lavorativo e il burnout possono contribuire a dimenticare compiti lavorativi, cosa che può produrre possibili eventi avversi che mettono in pericolo la salute del paziente.

Oltre allo stress, ricordare in maniera non corretta intenzioni future può derivare dall'effetto persistente della disinformazione sulla nostra memoria, sui nostri atteggiamenti e comportamenti. La Seconda Parte di questa Tesi, che contiene 6 esperimenti condotti su partecipanti sani, mostra come la credenza in informazioni errate ed invalidate possa persistere nonostante tentativi sofisticati di correzione di queste informazioni, influenzando la nostra memoria e le future intenzioni.

Complessivamente, i risultati degli studi presentati in questa Tesi dimostrano la fallacia della nostra memoria per le azioni da svolgere nel futuro. Vengono discusse diverse tecniche finalizzate a ridurre i rischi associati con gli errori di memoria.

Lay Summary

Consider when you forgot to do something you clearly "told yourself" you needed to remember at a particular time, such as going to a doctor's appointment, or on a particular occasion, such as congratulating a friend soon after his PhD viva. Or when you thought you would recall the details of a situation, an event or a conversation perfectly well, and then found out you remembered them differently from the way they really were. In these cases, your brain was tricking you. Decades of work in psychology have shown that our memory regularly fails us; we have to expect our memory to be extremely prone to errors and be aware that our faulty memory system may even lead to potentially disastrous consequences.

This Thesis looks at the ways in which delayed intentions, that is memories for actions that have to be performed in the future, can be forgotten and misremembered. In particular, its focus is on two main factors affecting the fulfilment of a delayed intention, namely stress and misinformation. Part One of this Thesis, entitled *Stress and Prospective Memory*, focuses on unsuccessful operations of "proper" prospective memory tasks, namely failing to remember to do things in the future like taking a medication or resuming an interrupted work task. The role of stress is examined in two studies and it appears to be crucial in affecting the fulfilment of this type of future intentions both in our daily life and in the work context. Part Two of the Thesis, entitled *Misinformation and Prospective Memory*, rather than just considering failures to accomplish tasks in the future, broadens the discussion to examine those circumstances when we fail to stick with our future intentions and plans because we inadvertently continue to rely on inaccurate information. One example of our continued reliance on misinformation is when we hear that vaccines cause autism, then learn that is not true, and nevertheless decide not to immunize our children in the future. Specifically, four studies exemplify the problems associated with encountering misinformation as well as possibilities for remediating the continued influence of misinformation in our memory, reasoning and decision-making. The Thesis ends with some recommendations on how to come to terms with our memory fallibility.

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List of publications

Some results reported in this Thesis have been presented in conferences and have been published in peer-reviewed outlets as well as disseminated for lay people audience:

Conference presentations:

- Pluviano, S., Gamboz, N., & Brandimonte, M. A. (2016, May). On the effect of stress on cognitive failures in everyday life: A look into prospective memory errors. Poster presented at the 2nd International Meeting of the Psychonomic Society, Granada, Spain.

Articles in peer-reviewed journals:

- Pluviano, S., Della Sala, S., & Watt, C. (2018). Correcting vaccines misinformation: The effects of source expertise and trustworthiness. Manuscript under review.
- Pluviano, S., Watt, C., Ragazzini, G., & Della Sala, S. (2018). Parents' beliefs in misinformation about vaccines are strengthened by pro-vaccine campaigns. Manuscript under review.
- Pluviano, S., Watt, C., & Della Sala, S. (2017). Misinformation lingers in memory: Failure of three pro-vaccination strategies. *PLoS ONE, 12*(7), e0181640. doi:10.1371/journal.pone.0181640
- Pluviano, S., Gamboz, N., & Brandimonte, M. A. (2016, May). On the effect of stress on cognitive failures in everyday life: A look into prospective memory errors. *European Academic Research, 3*(9), 9601–9625.

Dissemination articles:

- Pluviano, S., & Della Sala, S. (2017). La credibilità delle fonti di comunicazione e il loro potenziale persuasivo. *Query*, *32*, 47–51.
- Pluviano, S. (2017). Perché le campagne pro-vaccinazione non funzionano. Available at: http://www.queryonline.it/2017/08/18/perche-le-campagne-pro-vaccinazione-non-funzionano-ne-parliamo-con-sara-pluviano/
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- Pluviano, S., & Della Sala, S. (2015). Valicare le barriere inamovibili del pensiero: Gli stratagemmi della demistificazione. *Query, 22*, 44–49.

Contents

Introduction and Outline of the Thesis

A hallmark of human behaviour is the capacity to settle in advance the actions to be carried out in the future and to act accordingly once the time of action comes or when the circumstances permit it (McDaniel, Howard, & Butler, 2008; Ferrero, 2017). For instance, a pianist may form the intention of playing *Clair de Lune*, one of Claude Debussy's best-known composition, at a recital next year; he may keep this intention in mind for as long as necessary and, because of it, he may begin to play the piece once the time of the recital comes.

However, we are all familiar with scenarios where, despite our best intentions, we forgot to buy something, call someone, take a medication, or send a letter. These and countless other cases exemplify the distance between intending and doing. As Gollwitzer (1999) humorously noted, this vast distance is perfectly reflected in the common New Year's ritual of forming heroic resolutions (e.g., quitting smoking, avoiding unhealthy foods) that soon resolves into the realization that implementing those intentions is much more difficult compared to forming them. The question naturally arising is why it is so difficult to act upon one's intentions, even when one may be highly motivated to so (Cohen & Hicks, 2017).

The concept of intention is considered to be central in human goal striving and attainment (e.g., Bandura, 1991; Gollwitzer & Moskowitz, 1996; Wicklund & Gollwitzer, 1982). However, the correlations between intentions and behaviour appear to be modest; as Gollwitzer and Sheeran (2006) concluded in their meta-analytic review, the strength of intentions accounts for only 20% to 35% of the variance in future behaviour. Intriguingly, the weak association between intentions and behaviour seems to be largely due to people having good intentions but failing to act on them (Gollwitzer, 1999; Orbell & Sheeran, 1998).

Researchers acknowledge the great variety of challenges that individuals face when attempting to pursue a goal; for instance, one may be absorbed by other competing goals, wrapped up in one's own thoughts, or simply unmotivated (Cohen & Hicks, 2017; Kliegel, McDaniel, & Einstein, 2008). But often we fail to carry out intended actions because we simply forget. Human memory is in fact essentially prone

to various kinds of distortions and illusions (Mazzoni & Memon, 2003; Mazzoni & Scoboria, 2007; Scoboria, Boucher, & Mazzoni, 2015). The extant empirical literature has acknowledged that our memory is inherently fallible – an acceptance that was influenced considerably by the research of Elizabeth Loftus on the accuracies of eyewitness testimony (e.g., Loftus, 1993, 2003, 2005, 2008; Loftus & Pickrell, 1995). Our memory does not provide a veridical representation of events as experienced (Bartlett, 1932; Cubelli & Della Sala, 2009; Schacter, 1996). It simply does not work as a camera or a VCR and implies more subtle processes than record, rewind, and playback (De Vito & Della Sala, 2011). Human memory is, in fact, entirely *reconstructive*, meaning that what gets encoded into memory is shaped by what people have already stored in memory, their own expectations, needs, beliefs and emotional state (Schacter, Norman, & Kouts, 1998; Tulving, 1983). Moreover, what gets reconstructed later on is determined by that same multitude of factors that contributed to its encoding. Thus, a memory trace is always in an unstable state as it gets rewritten and remodeled every time it is retrieved (Howe & Knott, 2015; Schacter & Addis, 2007; Tulving, 2002).

Whilst the idea that our memory is far from being perfect might sound like a truism, it is nevertheless important to accept that memory errors are a necessary part of daily living. In his classic book on human error, Reason (1990, p. 17) claimed that "the more predictable varieties of human fallibility are rooted in the essential and adaptive properties of human cognition". In a similar vein, Schacter (1999, p. 183) argued that "memory's sins should not be viewed as flaws in system design or unfortunate errors made by Mother Nature during the course of evolution". In his view, memory foibles are the result of an adapted system that retains the kind of information that is most likely to be needed in the environment in which the system operates. More recently, Gigerenzer (2008, 2015) adapted Herbert Simon's (1955, 1956) notion of "bounded rationality" to stress the cognitive limitations of human mind and highlight the large repertoire of "fast-and-frugal" heuristics that people use to make decisions, often based on very little information and in little time. At any given moment in time, there is indeed a huge amount of information in one's immediate surroundings that one might attend to. Therefore, to function properly, one needs to create incomplete

records of the events and to forget information that is no longer current, such as old phone numbers or where we parked the car yesterday (Laney, 2013).

Yet, as described earlier, this may also backfire resulting in testable patterns of errors. Some of these errors can be merely annoying and correctable, like when one forgets to attach a file after having written an email message or to buy bread when passing the grocery store, while others can have huge impacts on people's lives, such as when a surgeon forgets an instrument inside a patient's body before closing an incision or a pilot forgets to roll down the wheels before landing a jet. What is common in all these examples is that one's intentions are temporarily put on hold – stored in memory – to be reactivated or retrieved at an appropriate point in the *future*; they are fundamentally failures of our memory for future actions or *prospective memory errors* (Brandimonte, 2006). Besides, as Reason (1990, p. 107) stated, "failures of prospective memory…are among the most common forms of human fallibility".

The present Thesis focuses on the factors that may affect the fulfilment of a delayed intention and thus contribute to prospective memory failures. In particular, it aims at investigating the role of stress on prospective memory errors in a strict sense, namely forgetting to carry out intended actions at the appointed time and place, and failures in performing future intentions in a broader sense, that is misremembering future intentions because of the lingering effect of misinformation on our memory, attitudes, and behaviors.

The Thesis is divided into two parts. To set the stage, Part One starts with a thumbnail sketch of what is generally intended by prospective memory, the main characteristics and phases of a prospective memory task, the methodologies for investigating prospective memory, and the relevance of prospective memory in real-world settings. Chapter 2 and Chapter 3 examine the role of stress on unsuccessful prospective remembering, here described *stricto sensu* as forgetting to carry out intended actions at the appointed time and place. Part Two of this Thesis aims to develop the analysis of prospective memory failures into a broader conceptual framework. It has been stated that "the theoretical development of this area [prospective memory] will depend on the integration of theories of memory with theories of action" (Baddeley & Wilkins, 1984). Hence, to progress in our understanding of this topic we need to examine questions and theories that extend

beyond those normally considered by prospective memory researchers. For this reason, here I considered under the umbrella of prospective memory not only remembering to accomplish some task in the future, but also remembering to stick with one's future intentions and plans. To illustrate, prospective memory failures may include intending to prepare dinner in a few minutes time but then, when the doorbell suddenly rings and a neighbour starts discussing the latest gossip, forgetting all about dinner. However, prospective memory glitches may also refer to intending to dine at the "China Garden" restaurant but then deciding to go elsewhere because we heard a news report about a family who died after eating at that restaurant. And we intend to dine elsewhere despite we also heard about the medical examiner who reported that food poisoning was ruled out as a possible cause of death for the family (Seifert, 2002). Part Two therefore expands upon Part One by addressing how future intentions transform into actions *despite* or *by virtue* of new information becoming available and substituting previous information and the intentions formulated on its basis. Chapter 5 to 8 encompass a total of 6 Experiments, investigating how the lingering phenomenon of misinformation may continue to influence our memory, reasoning, decision making, beliefs, attitudes, and behaviours even after sophisticated correction attempts, interfering with our future intentions and plans. These experiments focused on vaccine misinformation and the strategies intended to correct it, a topic that concerns precisely those mechanisms which underlie false remembering (in this case, remembering myths instead of facts about vaccines), and, because of that, failures of acting on intentions (in this case, failures to carry out the planned activity of following medical advice and getting the recommended shots). In doing so, Part Two tries to connect the dots between intentions, its antecedents (i.e., beliefs and attitudes) and outcomes (i.e., behaviours), and memory. As will be further explained through the Chapters, treating prospective memory alongside beliefs and attitudes makes a whole literature on beliefs/opinions formation and change available and potentially relevant to provide insights into the reasons why one's future intentions may be forgotten. A General Discussion concludes the dissertation.

Part One

Stress and Prospective Memory

Chapter 1

Introduction

1.1 What is prospective memory?

Since the publication of the first book entirely devoted to prospective memory (Brandimonte, Einstein, & McDaniel, 1996), a large and growing body of literature has considered prospective remembering as a distinctive aspect of memory that is central to developing our understanding of how intentions are translated into actions and under which circumstances they fail (Kliegel et al., 2008).

Prospective memory (PM) involves the mechanisms and characteristics of memory for actions that have to be performed in the future (Brandimonte, 2006). It is usually defined either as remembering to carry out a task at a particular moment in the future or as the timely execution of a previously formed intention (Brandimonte et al., 1996). Einstein and McDaniel (1990) distinguished between two general classes of PM tasks. One class, termed *time-based*, requires the individual to perform an action at a specific time (e.g., attend a meeting tomorrow at 2 p.m.) or after some amount of time has passed (e.g., take food out of the oven in 10 minutes). Here, time serves as a trigger to retrieve the memory to attend the meeting or to empty the oven. The other class, termed *event-based*, requires the individual to perform an action in response to a specific cue in the future (e.g., remember to buy bread on the way home from work). Here, the trigger to retrieve a PM intention is the occurrence of a specific event in the environment.

Both time- and event-based PM have been intensively investigated in laboratory and naturalistic settings (Kliegel et al., 2008). In particular, a great deal of attention has focused on the causes of the memory trace reactivation. According to the preparatory attentional and memory processes (PAM) theory (Smith, 2003), individuals periodically recollect their plans, which can subsequently lead them to monitor the environment for cues that signal that the PM intention should be

performed. Consider the concrete example of remembering to buy bread on the way home from work. According to this view, we self-initiate retrieval of this plan throughout the day and when we are driving home from work then we will begin to monitor the environment for signs of the grocery store. It derives that PM retrieval cannot occur in the absence of monitoring and PM failures are due either to lapses in devoting attentional resources to monitoring or to a retrospective memory loss of the content of the intention (e.g. forgetting that it is bread that needs to be purchased) (Scullin, Mullet, Einstein, & McDaniel, 2015). Instead, the multiprocess theory (McDaniel and Einstein, 2000) contends that both monitoring and spontaneous retrieval are used in prospective remembering. According to this view, in the absence of monitoring, the occurrence of a target event (e.g., the grocery store) that has been associated with an intention can spontaneously trigger retrieval of an episodic memory (e.g., the intention to stop at the grocery store and buy bread) (Scullin et al., 2015).

Anyhow, Einstein and McDaniel's (1990) distinction between time- and event-based PM does not fully capture all the important dimensions along which PM tasks may vary. For instance, distinctions have been made between habitual and episodic PM tasks (Harris, 1983), simple and complex PM tasks (Einstein, Holland, McDaniel, & Guynn, 1992), and single- and dual-activity PM tasks (Harris, 1983), just to mention a few. Memory researchers agree indeed that there are many different forms of future intentions and that each type of intention has its own characteristics and processing requirements (Brandimonte, 2006). However, there are also some common features to all PM tasks (Brandimonte et al., 1996; Ellis & Kvavilashvili, 2000).

First, prospective memory properly takes place when there is a consciously formed intention or plan to perform an action at some later time when circumstances permit it (Dismukes & Nowinski, 2007). This is a subtle but critically important aspect as it permits to distinguish prospective memory from other kinds of behaviors. Consider, for example, the case of classical conditioning: by virtue of pairings of a biological potent, unconditioned stimulus (e.g., food) to a neutral, conditioned stimulus (e.g., a bell), the organism has a readiness to act in a certain way (e.g., salivation) when the conditioned stimulus is encountered in the future. However, classical conditioning should not be studied under the umbrella of prospective memory research (McDaniel & Einstein, 2007).

The second feature of PM tasks is that the execution of the intended action is not immediate, rather there is a retention interval between forming and executing the intention, typically filled with activities not directly related to that delayed intention. This period may last minutes, hours, or days (Brandimonte, 2006).

A third consideration is that in a typical PM task the individual must recollect the intended action at the appropriate instance without an explicit prompt stimulating retrieval. A critical difference between prospective and retrospective memory rests indeed on the presence and absence of explicit prompting for remembering. For PM, no agent explicitly prompts the individual to remember the deferred intention when execution becomes appropriate; thus, one must "remember to remember" (Dismukes, 2012). According to Ste-Marie and Jacoby (1993), PM involves indeed what is called *spontaneous remembering*, that is an automatic process that occurs when memories arise in consciousness involuntarily and without direct prompts to interrogate memory. To illustrate, when passing the grocery store, nothing alerts us to pay attention to this cue, and no one instructs us that this cue is relevant to a previously formed intention (e.g., buy bread when on the way home from work). As Graf and Uttl (2001, p. 442) underlined, "what is unique about PM tasks is that they require identifying or recognizing cues as telltale signs of previously formed plans and intentions when (the cues) occur as a part of ongoing thoughts, actions, or situations".

Any PM task, in fact, is embedded in an ongoing activity. To illustrate, in a typical laboratory PM task, individuals are required to memorize a list of words – which represents the ongoing task – while they have to remember to press a particular key on the computer keyboard when a particular item appears – which represents the prospective, background task. As part of ongoing thoughts, actions, or situations, PM is not an isolable act of pure cognition; yet, it involves the cognitive processes of attention, planning, task management as much as it involves memory (Dismukes, 2012). For this reason, some researchers have suggested that "the loss of the term PM would leave us better off, not impoverished" (Brandimonte et al., 1996, p. 144) and questioned that PM is a distinct form of episodic memory. However, others insist on the unique requirements of PM (Graf & Uttl, 2001) and on the existence of special storage properties associated with PM (Brandimonte et al., 1996). For example, Goschke and Kuhl's (1993) findings of faster recognition latencies for PM relative to

retrospective memory suggests that the former may be stored in a more highly activated state, which is adaptive given the special cueing problem inherent in PM tasks.

1.2 Phases of a PM task

The realization of a delayed intention and its associated action consists of some general phases (Brandimonte et al., 1996), as illustrated in Figure 1.1:

A. formation and encoding of intention and action;
B. retention interval;
C. performance interval;
D. initiation and execution of intended action;
E. evaluation of outcome.

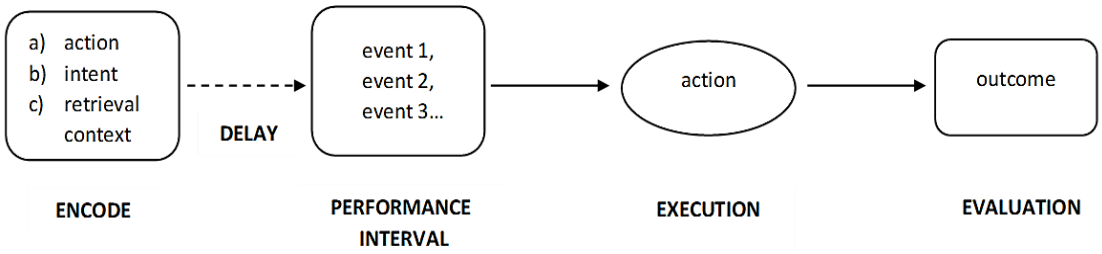


Figure 1.1. *Overview of the different phases involved in the realization of a delayed intention (adapted from Brandimonte et al., 1996)*

Phase A refers to the retention of an intention (*what* a person wants to do), an intent (*that* he/she has decided to do something), and a retrieval context that concerns the criteria for recall (*when* he/she should retrieve the intent and the action and initiate them). For instance, the different elements of an intention to buy groceries after work may be encoded as follows: "I will" (*that*-element) "buy groceries" (*what*-element) "after work" (*when*-element).

Phase B refers to the delay between encoding and the start of a potential performance interval, while *phase C* concerns the performance interval or period when the intention should be retrieved. For example, an intention to telephone a friend this evening may have been encoded 2 days ago. Therefore, it would have a retention

interval of approximately 2 days and a performance interval of approximately 3 hours (7:00 p.m. – 10:00 p.m.).

Finally, *phases D* and *E* are concerned with the initiation and execution of the intended action, and evaluation of the resultant outcome, respectively.

According to Einstein and McDaniel (1990), each prospective memory task comprises two components. The first retrospective component corresponds to *phase A* and consists of the *what*- (action), *that*- (intent), and *when*- (retrieval context) elements that together form the content of a postponed intention. Instead, the second prospective memory component corresponds to the elements described in phases B through E and refers to the retrieval of the action "at the appropriate time or in response to the appropriate event" (p. 725).

1.3 PM in real-world settings

Our everyday life is filled and sometimes overflowing with PM demands. Remembering to attend meetings in our work activities, to have dinner with a friend to maintain our social relations, or to take medication to handle our health-related needs are unequivocal examples showing how good prospective memory is essential for normal functioning (McDaniel & Einstein, 2007). As a consequence, PM failures can cause problems in effectiveness and efficiency or be even devastating. For instance, non-adherence to prescribed medication schedules due to a prospective memory failure can be particularly problematic for patients with asymptomatic conditions like hypertension (Insel & Cole, 2005), leading to serious health problems.

Direct and pervasive consequences of PM errors are also evident in the workplace, especially for people working in complex and stressful work contexts, such as the healthcare or aviation (Bourne & Yaroush, 2003; Grundgeiger, Sanderson, & Dismukes, 2014; Rothschild et al., 2005). For instance, in the intensive care unit, nurses must remember to deliver medications, to redress wounds, or to properly chart changes in vital signs and failures to perform any of these actions may result in poor health outcomes for the patient. Similarly, aircraft pilots must remember to perform several actions before take-off and landing and failures to perform any of these actions may result in injury or death (Scullin et al., 2015). Indeed, Dismukes (2006) revealed that almost one-fifth of the major airline accidents can be attributed to PM failures.

Similarly, analysing self-reported errors by airline pilots, Nowinski, Holbrook, and Dismukes (2003) observed that 74 of the 75 errors involving memory failures were prospective in nature. Thus, PM is not only ubiquitous in our lives, but it is also essential to maintaining health and safety (Dismukes, 2012).

1.4 Methodologies for studying PM

Several methods exist for studying PM, each of which has its own methodological strengths and weaknesses. In an important laboratory paradigm devised by Einstein and McDaniel (1990), participants are instructed that, while performing a primary, ongoing task, such as rating the pleasantness of a series of words, if a certain target cue appears, they should perform a separate action, such as pressing the keyboard space bar, which represents the PM component of the task. In this case, PM performance is simply measured as the percentage of trials on which the individual remembers to perform the separate action.

Whilst this represents a well-controlled experimental setting, it may not capture the extent to which PM demands occur in real-world contexts. For this reason, researchers have usually preferred incident reports, field studies, and simulations. For example, Nowinski and colleagues (2003) analysed airline accident reports as well as pilot reports of errors in order to document PM errors and to assess the conditions that may contribute to them. Instead, Grundgeiger and colleagues analysed videos from a full-scale patient simulator for factors enhancing or inhibiting anaesthesiologists' PM or recordings of a light-weight eye tracking worn by nurses during their shift to observe various PM tasks occurring in the intensive care unit (Grundgeiger, Liu, Sanderson, Jenkins, & Leane, 2008; Grundgeiger, Sanderson, MacDougall, & Venkatesh, 2009). Other widely used methods for investigating prospective memory are questionnaires including specific questions tapping information about recall of future intentions (e.g., "How often do you forget to keep appointments?") or naturalistic studies during which participants may be asked, for example, to return postcards from home, telephone the experimenter, or record information relevant to their PM intention in a diary.

As suggested by McDaniel and Einstein (2007), there should be a healthy interplay between the laboratory and nonlaboratory approaches, because only combing

different methods researchers can provide converging evidence, which can be used to more convincingly support theoretical and empirical positions.

Chapter 2

Study 1: On the effect of stress on prospective memory errors in everyday life[1]

2.1 Introduction

In spite of its relevance and implications for real-world functioning, thus far empirical literature on prospective memory has been somewhat inconsistent (Woods et al., 2014). For instance, it seems surprising that the effectiveness of prospective memory functioning has only recently attracted research with respect to experiencing stress, a fairly pervasive condition in daily life that may affect how we perform, how we feel, and many of our bodily functions (Bourne & Yaroush, 2003).

Simply defined, stress refers to a disturbance of bodily homeostasis caused by a mismatch between situational demands and the individual's perceived resources to cope with such demands (Lazarus & Folkman, 1984). Adverse effects of prolonged stress on physical (e.g., heart disease, cancer, stroke, etc.; Cohen, Janicki-Deverts, & Miller, 2007) and mental health (e.g., depression, post-traumatic stress disorder, pathologic aging, etc.; Hammen, 2005; Kendler, Karwoski, & Prescott 1999; Marin et al., 2011) are well-documented and a great deal of research suggests that stress can also tax cognitive functions, including memory (Rönnlund, Sundström, Sörman, & Nilsson, 2013; Staal, 2004). In particular, stress seems to force the individual to focus on the here-and-now, with consequent potential degradation of retrospective and prospective memory performance (Bourne & Yaroush, 2003). Indeed, stress is a strong modulator of memory functioning but it is also well-know that memory is not a unitary

[1] Pluviano, S., Gamboz, N., & Brandimonte, M. A. (2016, May). On the effect of stress on cognitive failures in everyday life: A look into prospective memory errors. *European Academic Research, 3*(9), 9601–9625.

process and, therefore, stress can exert different effects depending on the memory type under study (Luethi, Meier, & Sandi, 2008).

Across the board, previous works have found that everyday stress was the most perceived cause of everyday memory problems as individuals reported a greater number of memory failures on stressor days than on non-stressor days (Neupert, Almeida, Mroczek, & Spiro, 2006; Neupert, Mroczek, & Spiro, 2008; Vestergren & Nilsson, 2011). Specifically, Rönnlund et al. (2013) revealed that high-stressed individuals reported a higher frequency of retrospective and prospective memory failures. Similarly, Gupta and Pande (2015) revealed that daily stress was a significant predictor of mindfulness, attentional errors, prospective and retrospective memory errors. Instead, Luethi et al. (2008) found that exposure to stress was associated with a pronounced working memory deficit and this seems particularly interesting because of the unclear relationship between the latter and prospective memory (Nater et al., 2006).

Also a substantial body of neurophysiological evidence seems to substantiate the detrimental effect of stress on prospective memory. Indeed, it clearly appears that prospective memory performance is closely related to prefrontal cortex (PFC) functioning (Arnsten, 2009) and that stress-induced increased sympathetic nervous-system (SNS) activity is associated with increased catecholamine release, which, in turn, decreases firing of PFC neurons (Ramos & Arnsten, 2007). Thus, one would reasonably expect that stress has the potential to strongly affect prospective memory performance. However, recent studies in which stress was experimentally induced in laboratory settings (e.g., Schnitzspahn, Plessow, Kirschbaum, & Kliegel, 2014; Walser, Fischer, Goschke, Kirschbaum, & Plessow, 2013) showed that prospective memory performance was not impaired under stress. Nater et al. (2006) even found that stress might enhance time- (but not event-) based prospective memory.

Conceivably, the inconsistency in the available evidence is due, among other things, to the different classes of stressors each time at stake as well as to the diverse cognitive performances examined and their objective or subjective evaluation. It should also be noted that the threshold level at which stress begins to have an impact on cognitive performance is likely to vary with several individual factors that are often overlooked in the literature (Rönnlund et al., 2013).

For instance, consider how the simple use of compensatory strategies to meet cognitive challenges under stress and support everyday habitual performance and competence can enhance memory performance. In addition, there are specific personality factors that seem to play an important role in determining resistance to stress. In this regard, resilience has increasingly become a focus of research in the behavioural and medical sciences, conceived as a universal coping ability to bounce back or recover from stress, to adapt to stressful circumstances, and to function in spite of stress or adversity by virtue of a positive engagement with the world (Caprara, Steca, & De Leo, 2003; Carver, 1998). Indeed, its buffering effect in relation to the adverse impact of stress on psychological functioning is well-established (e.g., Beasley, Thompson, & Davidson, 2003) but there is not substantial empirical evidence supporting its protective effect as referred to cognitive functioning. Additionally, there seem also to exist particular individual mood factors, such as depression or anxiety, that are associated not only with stress but also with memory performance (Eysenck, Derakshan, Santos, & Calvo, 2007; Rönnlund et al., 2013), even though their relevance for prospective memory is still to establish.

Therefore, the general purpose of the present study was to examine the relationship between daily stress and prospective memory in everyday life, as well as to explore the potential moderating effect of individual factors (i.e., compensatory memory strategies, resilience and mental health) on the above relationship.

2.2 Method

Participants

The sample comprised 52 (56.5%) men and 40 women (43.5%) and included 4 subjects (4.3%) aged under 26 years, 16 (17.4%) aged between 26 and 35 years, 36 (39.1%) aged between 36 and 45 years, 21 (22.8%) aged between 46 and 55 years, and 15 (16.3%) aged over 55 years. The great majority of the participants (n = 48, 52.5%) had a degree or a post degree (n = 21, 22.8%), while 23 (25%) subjects had a high school degree.

Measures

After collecting a brief demographic profile (sex, age, educational level), participants were administered several self-report questionnaires and an objective test of prospective memory. These instruments are described below (see Appendix A).

Psychological stress was evaluated using the Perceived Stress Scale (PSS-10; Cohen & Williamson, 1988) (Cronbach's α = .86; M = 19.82, SD = 7.05), which measures the degree to which situations in one's life are appraised as stressful. Item were designed to tap how unpredictable, uncontrollable, and overloaded individuals find their lives. A sample item is: "In the last month, how often have you been upset because of something that happened unexpectedly?". Responses were based on a five-point Likert scale (from 0 = never to 4 = very often). PSS scores are obtained by reversing the scores on the four positively stated items (items 4, 5, 7, and 8) and then summing across all scale items. It is possible to obtain a range of scores ranging from 0 to 40. Higher scores indicate a higher level of stress perceived by each individual.

Self-reported everyday cognitive failures were assessed via the Cognitive Failure Questionnaire (CFQ; Broadbent, Cooper, FitzGerald, & Parkes, 1982; Di Fabio, Giannini, & Martelli, 2004) (Cronbach's α = .95; M = 45.63, SD = 18.07), which examines the level of slips of action, inattentiveness, and forgetfulness in daily life. The scale comprises 25 items on a five-point Likert format (from 0 = never to 4 = very often). A sample item is: "Do you read something and find you haven't been thinking about it and must read it again?". All questions are worded in the same direction. CFQ scores are obtained summing across all items and it is possible to obtain a range of scores ranging from 1 to 100. Higher scores indicate more self-reported cognitive failures.

Self-reported prospective and retrospective memory failures were evaluated using the Prospective and Retrospective Memory Questionnaire (PRMQ; Smith, Della Sala, Logie, & Maylor, 2000), which is a 16-item questionnaire assessing the frequency of memory failures on two main subscales: the Prospective Memory subscale (PRMQ ProM; sample item: "Do you fail to mention or give something to a visitor that you were asked to pass on?") (Cronbach's α = .88; M = 19.4, SD = 6.44) and the Retrospective Memory subscale (PRMQ RetM; sample item: "Do you forget something that you were told a few minutes before?") (Cronbach's α = .91; M = 19.59,

SD = 6.7). Respondents rate the frequency of their ProM and RetM failures on a five-point Likert scale (from 1 = never to 5 = very often), resulting in minimum and maximum scores on either scale of 8 and 40, respectively. Higher scores indicate more self-reported memory failures.

A *paper-and-pencil measure of prospective memory* was obtained adapting the Continuous Lab Measure of Event Cued ProM (Lab EC ProM/C; Uttl & Kibreab, 2011), which provides a more objective measure of prospective memory performance that is nearly reliable as standardized tests of episodic retrospective memory (Uttl, Hodgson, & White 2014). Participants were instructed to circle all occurrences of a prospective memory cue while filling the various questionnaires. The prospective memory cue appeared four times in an increasingly intrusive visual form and location (e.g., increased font size, vertical lift, and horizontal spacing). The first prospective memory cue circled was used as an index of prospective memory ability; participants who circle the 1st occurrence of the prospective memory cue receive 4 points, 3 points if the first circled cue is the 2nd cue, 2 points if it is the 3rd cue, 1 point if it is the 4th cue, and lastly 0 points if participants do not circle any cues. In the present study the cue word was "*punto*" (= point) and it appeared in the following visual form and spatial location: 1) in lower case, normal font, non-prominent location, embedded in the last question of the PSS; 2) in lower case, normal font, more prominent location, as part of question #3 in the MCQ; 3) in lower case, bold, more prominent location, appearing as part of question #11 of the Ego-Resiliency scale (this question was added for this purpose but was not included in the scoring of the scale); 4) in capitals, bold, more prominent location, appearing as part of the instruction of the GHQ-12.

Memory strategies were evaluated via the Memory Compensation Questionnaire (MCQ; Dixon & Bächman, 1992), which assesses the extent to which individuals compensate for memory losses and deficits. In order to reduce participants' burden for the present investigation, three out of seven original scales of the MCQ have been selected, featuring 23 items. The External scale (Cronbach's $\alpha = .84$; M = 2.04, SD = .78) comprises 8 items concerning the use of external memory aids (e.g., notes, calendars, and bookmarks) for enhancement of everyday memory performance. A sample item is: "Do you post notes on a board or other prominent place to help you remember things for the future (e.g., meetings or dates?)". The Internal scale

(Cronbach's α = .90; M = 1.91, SD = .81) includes 10 items focusing on the use of mnemonic strategies (e.g., imagery and rehearsal) for promoting effective memory performance. A sample item is: "Do you repeat telephone number to yourself in order to remember them well?". Finally, the Reliance scale (Cronbach's α = .81; M = 2.02, SD = .85) consists of 5 items concerning the extent to which the respondent recruits or uses other people as memory aids. A sample item is: "When you want to remember an important appointment do you ask somebody else (e.g., spouse or friend) to remind you?". Responses are based on a five-point Likert scale (from 0 = never to 4 = always), with higher scores representing more frequent use of the indicated compensatory behaviour.

Resilience was assessed via the Ego-Resiliency scale (Block & Kremen, 1996; Caprara et al., 2003) (Cronbach's α = .92; M = 4.6, SD = 1.07) whose items tap the ability to recover from stress and return to individual's ego-control after the temporary stressing influence is no longer acutely present. A sample items is: "I get over anger with someone reasonably quickly". The scale comprises 14 items on a four-point Likert scale (from 1 = never to 7 = always). Higher scores mean higher individual resilience.

Mental health was evaluated using the shortest version of the General Health Questionnaire (GHQ-12, Piccinelli, Bisoffi, Bon, Cunico, & Tansella, 1993; Goldberg & Williams, 1998) (Cronbach's α = .89; M = 12.32, SD = 7.22), which is a well-known measure for the screening of non-psychiatric mental problems. Items tap factors such as somatic symptoms, anxiety, insomnia, social dysfunction, and depression. Participants report whether they have experienced a particular symptom of mental distress over the past few weeks according to a four-point Likert scale, ranging from 0 (= better than usual) to 3 (= much less than usual) for the six positively worded items and from 0 (= no) to 3 (= much more than usual) for the other six negatively worded items. Hence, the questionnaire gives a total score ranging from 0 to 36. The higher the score, the more symptoms an individual is experiencing.

2.3 Procedure

First, following the procedure by Gupta and Pande (2015), independent sample t-tests and correlations between study variables were conducted to account for the results.

Then, multiple hierarchical regression was used to identify possible predictors of prospective memory. Next, variables were standardized and, subsequently, prospective memory and a single moderator at a time were entered into the second step of the regression equation (after control variables inserted at the first step), while the interaction term was added at the third step. When the interaction term was statistically significant, that is provided additional significant variance, Jeremy Dawson's Excel worksheet (2014) was used to graphically represent the interaction.

2.4 Results

Independent sample t-tests

Table 2.1 shows the median value of perceived stress scores. The perceived stress scores were divided into two groups (*low-perceived stress group* and *high-perceived stress group*) by using median split technique. The median was found to be 20.

Table 2.1. *Median of perceived stress scores*

Variable	Median
Perceived Stress	20

Table 2.2 presents the independent sample t-tests between low- and high-perceived stress groups. When the two groups were compared, several significant differences emerged.

When it comes to cognitive failures, individuals experiencing high perceived stress reported more cognitive errors. Indeed, there was a significant difference in the scores for the low- (M = 40.13, SD = 16.6) and high-perceived stress (M = 53.21, SD = 17.55) groups; t(90) = -3.59, $p < .01$.

Likewise, as regards self-reported prospective memory, individuals experiencing high perceived stress reported more prospective memory errors. In fact, there was a significant difference in the scores for the low- (M = 17.11, SD = 5.3) and high-perceived stress (M = 22.66, SD = 6.57) groups; t(90) = -4.48, $p < .01$. Similarly, high-stressed participants also reported more retrospective memory errors. Again, there was a significant difference in the scores for the low- (M = 17.3, SD = 5.15) and

high-perceived stress (M = 22.82, SD = 7.36) groups; t(90) = -3.99, $p < .01$. In fact, we further remember that, according to the scoring pattern of the Prospective and Retrospective Memory Questionnaire (PRMQ), the lower the score, the better the memory for both subscales.

Afterward, referring to the paper and pencil prospective memory test, the performance of individuals experiencing low perceived stress was slightly better than the one of high-stressed participants. Indeed, there was a significant difference in the scores for the low- (M = 2.89, SD = .98) and high-perceived stress (M = 2.24, SD = 1.17) groups; t(90) = 2.89, $p < .01$.

Subsequently, t-tests for memory compensation strategies suggested that low-stressed individuals drew upon them more than high-stressed ones. Indeed, in relation to external memory strategies, there was a significant difference in the scores for the low- (M = 2.3, SD = .74) and high-perceived stress (M = 1.68, SD = .7) groups; t(90) = 3.98, $p < .01$. Similarly, regarding internal memory strategies, there was a significant difference in the scores for the low- (M = 2.22, SD = .72) and high-perceived stress (M = 1.74, SD = .72) groups; t(90) = 4.9, $p < .001$. Again, as concerns reliance memory strategies, there was a significant difference in the scores for the low- (M = 2.35, SD = .73) and high-perceived stress (M = 1.55, SD = .79) groups; t(90) = 4.98, $p < .001$. Next, in respect to resilience, low-stressed participants were slightly more resilient than high-stressed ones. In fact, there was a significant difference in the scores for the low- (M = 4.94, SD = .88) and high-perceived stress (M = 4.11, SD = 1.13) groups; t(90) = 3.99, $p < .001$.

Finally, low-stressed individuals' mental health was remarkably better than high-stressed ones. Indeed, there was a significant difference in the scores for the low- (M = 10.3, SD = 6.63) and high-perceived stress (M = 15.18, SD = 7.13) groups; t(90) = -3.37, $p < .01$.

Table 2.2. *Means, standard deviations and t-values for the low- and high-perceived stress group on study variables*

Dependent variables	Mean		SD		t	Sign.
	M1 Low-perceived stress group	M2 High-perceived stress group	SD1	SD2		
Cognitive failures	40.3	53.21	16.6	17.55	-3.59**	.001
Prospective memory	17.11	22.66	5.3	6.57	-4.48***	.000
Retrospective memory	17.3	22.82	5.15	7.36	-3.99***	.000
Prospective memory test	2.89	2.24	.98	1.17	2.89**	.005
External memory strategies	2.3	1.68	.74	.7	3.98***	.000
Internal memory strategies	2.22	1.47	.72	.72	4.9***	.000
Reliance memory strategies	2.35	1.55	.73	.79	4.98***	.000
Resilience	4.94	4.11	.88	1.13	3.99***	.000
Mental health	10.3	15.18	6.63	7.13	-3.37**	.001

Note: *** $p < .001$, ** $p < .01$

Correlations

Table 2.3 depicts Pearson correlations between study variables. Age positively correlated with cognitive failures (r = .22, $p < .05$), prospective (r = .25, $p < .05$) and retrospective memory (r = .25, $p < .05$), and negatively with the prospective memory test (r = -.26, $p < .05$), external (r = -.25, $p < .05$) and internal memory strategies (r = -.27, $p < .01$).

Perceived stress positively correlated with cognitive failures (r = .35, $p < .01$), mental health (r = .33, $p < .01$), prospective (r = .43, $p < .01$) and retrospective memory (r = .41, $p < .01$), while it negatively correlated with the prospective memory test (r = -.29, $p < .01$), resilience (r = -.39, p <.01), external (r = -.24, $p < .01$), internal (r = -.34, $p < .01$) and reliance memory strategies (r = -.20, $p < .01$).

Cognitive failures positively correlated with mental health (r = 58, $p < .01$), prospective (r = .78, $p < .01$) and retrospective memory (r = .77, $p < .01$), and negatively with the prospective memory test (r = -.39, $p < .01$), resilience (r = -.37, $p < .01$), external (r = -.24, $p < .01$), internal (r = -.34, $p < .01$) and reliance memory strategies (r = -.20, $p < .01$).

Prospective memory positively correlated with retrospective memory (r = .94, $p < .01$) and mental health (r = .54, $p < .01$), and negatively with the prospective memory test (r = -.46, $p < .01$), external (r = -.32, $p < .01$) and internal memory strategies (r = -.39, $p < .01$), and resilience (r = -.39, $p < .01$).

Retrospective memory positively correlated with mental health (r = .54, $p < .01$), and negatively with the prospective memory test (r = -.48, $p < .01$), external (r = -.32, $p < .01$) and internal memory strategies (r = -.40, $p < .01$), and resilience (r = -.38, $p < .01$).

The scores on the prospective memory test positively correlated with resilience (r = .33, $p < .01$), external (r = .37, $p < .01$) and reliance memory strategies (r = .25, $p < .05$), while they negatively correlated with internal memory strategies (r = -.45, $p < .01$) and mental health (r = -.39, $p < .01$).

In respect to memory compensation strategies, external memory strategies positively correlated with resilience (r = .48, $p < .01$), internal (r = .72, $p < .01$) and external memory strategies (r = .67, $p < .01$). Instead, internal memory strategies positively correlated with reliance memory strategies (r = .58, $p < .01$) and resilience (r = .56, $p < .01$). Moreover, reliance memory strategies positively correlated with resilience (r = .60, $p < .01$) and negatively with mental health (r = -.26, $p < .05$).

Finally, resilience negatively correlated with mental health (r = -.45, $p < .01$).

Table 2.3 *Pearson correlations between study variables*

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Gender (1 = m, 2 = f)	-												
2. Age	.03	-											
3. Education	.03	-.11	-										
4. Perceived stress	.02	.18	-.07	-									
5. Cognitive failures	.11	.22*	-.04	.35**	(.95)								
6. Prospective memory[a]	.16	.25*	.01	.43**	.78**	(.88)							
7. Retrospective memory[a]	.15	.25*	.02	.41**	.77**	.94**	(.91)						
8. Prospective memory test[b]	-.09	-.26*	.03	-.29**	-.39**	-.46**	-.48**	-					
9. External memory strategies	-.1	-.25*	-.04	-.39**	-.24*	-.32**	-.32**	.37**	(.84)				
10. Internal memory strategies	-.04	-.27**	.04	-.46**	-.34**	-.39**	-.40**	-.45**	.72**	(.90)			
11. Reliance memory strategies	-.05	-.11	.07	-.46**	-.20*	-.17	-.16	.25*	.67**	.58**	(.81)		
12. Resilience	-.04	-.17	-.1	-.39**	-.37**	-.39**	-.38**	.33**	.48**	.56**	.60**	(.92)	
13. Mental health[c]	.06	.12	.01	.33**	.58**	.54**	.54**	-.39**	-.16	-.18	-.26*	-.45**	(.89)

Note. Internal consistencies (Cronbach alphas) between brackets on the diagonal; [a] In both cases, lower scores indicate better memory; [b] Higher scores indicate better memory; [c] Lower scores mean better mental health, while higher scores mean worse mental health; ** $p < .01$, * $p < .05$

Hierarchical regression and moderation

A hierarchical regression analysis was conducted where the criterion variable was prospective memory as subjectively measured via the Prospective and Retrospective Memory Questionnaire (PRMQ). As depicted in Table 2.4, control variables (i.e., gender, age, and education) were inserted at step 1, perceived stress at step 2, while compensatory memory strategies (i.e., internal, external, and reliance), resilience and mental health were inserted at step 3.

As regards control variables, only age showed a positive association ($\beta = .25$, $p < .05$) at step 1, but its beta coefficient lost statistical significance after the insertion of perceived stress ($\beta = .54$, $p < .001$) at step 2. At step 3, after the insertion of the other predictors, the beta coefficient of perceived stress decreased. A significant positive association emerged for both reliance memory strategies ($\beta = .35$, $p < .01$) and mental health ($\beta = .34$, $p < .01$) at step 3, while resilience, internal and external memory strategies did not show any significant association. Total R2 was equal to 49% ($p < .01$). Age explained 9% ($p < .05$) of prospective memory, while 15% of variance ($p < .001$) was attributable to perceived stress and, ultimately, 25% ($p < .001$) to both mental health and reliance memory strategies.

The decrease in age beta coefficient between step 1 and 2 could be an indicator of a potential moderation effect by perceived stress towards the relationship between age and prospective memory. Similarly, the decrease in perceived stress beta coefficient between steps 2 and 3 could be an indicator of a potential moderation effect by mental health and reliance memory strategies towards the relationship between perceived stress and prospective memory. In an exploratory way, other hierarchical regressions were conducted to check for these interactions.

Table 2.4. *Hierarchical regression analysis for prospective memory as criterion variable*

	Prospective memory		
	$\beta_{Step\ 1}$	$\beta_{Step\ 2}$	$\beta_{Step\ 3}$
Gender	.15	.15	.11
Age	.25*	.18	.07
Education	.03	.05	-.01
Perceived stress		.54***	.23*

External memory strategies			-.18
Internal memory strategies			-.21
Reliance memory strategies			.37**
Resilience			-.12
Mental health			.43***
R^2	.09*	.24***	.49***
ΔR^2	.09*	.15***	.25***

Note. *** $p < .001$, ** $p < .01$, * $p < .05$

Table 2.5 shows the only significant interaction detected, namely the one between perceived stress and reliance memory strategies on prospective memory ($\beta = .21$, $p < .05$). Perceived stress indicated a significant association ($\beta = .42$, $p < .001$) but reliance memory strategies did not ($\beta = .03$, $p = .77$), while the interaction term was significant ($\beta = .21$, $p < .01$). The interaction term explained an additional R2 equal to .04 ($p < .05$; overall R2 = .28). In order to analyse this relationship properly, a graphic representation was made (see Figure 2.1). Perusal of this interaction suggested that individuals using more reliance strategies reported less prospective memory errors only in the condition of low stress. Indeed, individuals experiencing a higher level of stress reported more prospective memory errors when using more reliance memory strategies.

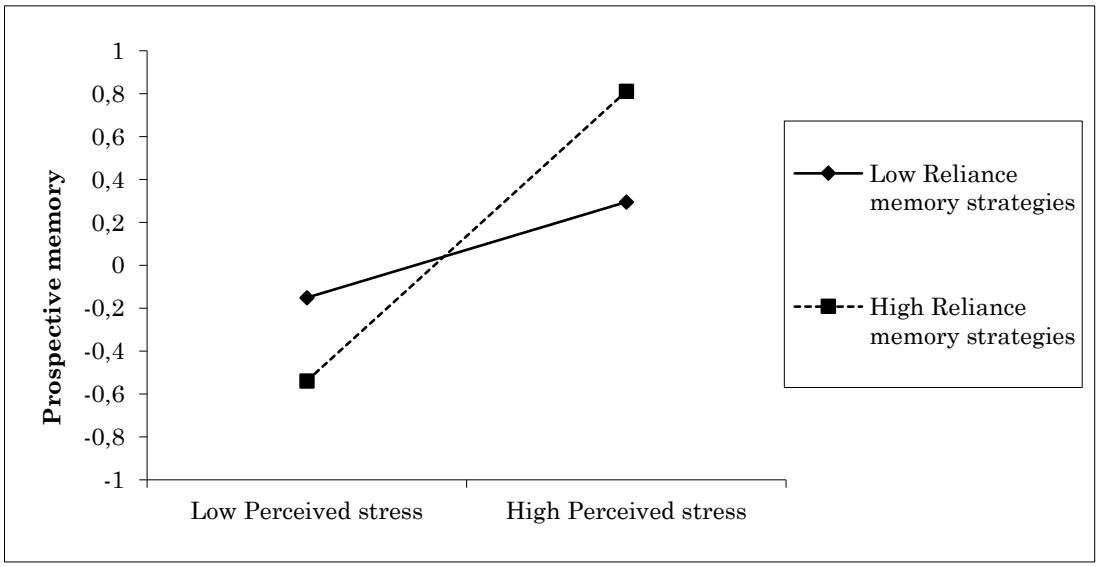
Table 2.5. *Hierarchical regression results for the effect of perceived stress and reliance memory strategies on prospective memory*

Variable	Model 1 β	Model 2 β	Model 3 β
Step 1: control variables			
Gender	.15	.15	.17
Age	.25*	.18	.16
Education	.03	.05	.05
Step 2: main effects			
Perceived stress		.42***	.45***
Reliance memory strategies		.05	.03
Step 3: interaction effect			

Perceived stress x Reliance memory strategies			.21**
R^2	.09*	.24***	.28**
ΔR^2	.09*	.15***	.04**

Note. *** $p < .001$, ** $p < .01$, * $p < .05$

Figure 2.1. *Significant interaction effect between perceived stress and reliance memory strategies on prospective memory*



2.5 Discussion

Although for a long time has received scarce attention by memory researchers, prospective memory is essential for a wide array of everyday activities and its breakdown may be as disruptive as the impairment in retrospective memory (Graf & Uttl, 2001). Drawing on a fairly inconclusive debate about its decline under stress conditions, the main objective of the current study was to examine the adverse effects of perceived stress on prospective memory errors.

The present results showed that high-stressed individuals reported a substantial higher frequency of both general cognitive failures and prospective memory errors compared to low-stressed ones. Therefore, the detrimental impact of stress also applies to proper prospective memory functioning. Confirmatory evidence of this negative effect was also provided by the association between perceived stress and both the objective and subjective measure of prospective memory. Indeed, to achieve a

comprehensive assessment of prospective memory, this study evaluated both prospective memory as reported subjectively by the participants and objectively via a self-made test, observing a high concordance between the two measures.

Besides these cognitive performance discrepancies between high- and low-stressed individuals, pronounced differences were also found regarding the use of compensatory memory strategies, as it clearly appears that they were more frequent among less stressed individuals, and mental health, because participants who reported higher level of stress also complained about greater negative symptoms. Also resilience negatively related to perceived stress, suggesting that higher levels of resilience matched with lower levels of stress.

By means of a hierarchical regression analysis, it was observed that, when age was controlled, perceived stress accounted for the 15% of variance in prospective memory (as subjectively evaluated). Moreover, mental health (e.g., negative symptoms as anxiety and depression) and reliance memory strategies, combined, explained the 25%. In addition, consistently with the literature suggesting that memory complaints are common among the elderly or increase with age (e.g., Jonker, Geerlings, & Schmaud, 2000; Reid & MacLullich, 2006; Vestergren & Nilsson, 2011), also age related to prospective memory failures, accounting for the 9% of variance. Instead, neither resilience, nor external memory strategies, nor internal memory strategies were associated with prospective memory.

An interaction effect between perceived stress and reliance memory strategies on prospective memory was also detected, indicating that, in the case of moderate stress, leaning on reliance memory strategies might help in reducing prospective memory errors. However, the same did not seem true in high-stress situations, in which other more useful resources might come into play. Clearly, further research on the buffering effects of individual factors is overdue, in particular referring to those situations where persistent stressors linger.

Some limitations of the present study should be pointed out. Firstly, the sample size was relatively small, even though a post-hoc power analysis (G*Power 3; Faul, Erdfelder, Lang, & Buchner, 2007) indicated a 96% chance of detecting a large effect size and a 65% chance of detecting a medium effect size between the two groups, the low- and the high-perceived stress group, as significant at the 5% level. Secondly, the

nature of the study was cross-sectional, meaning that no reliable conclusions can be drawn regarding the causal directions of the effects. Furthermore, I used self-report measures for all the study variables except prospective memory, which might have increased the risk of misinterpret relationships because of the impact of common method variance. However, some authors argue that common method variance tends to attenuate rather than to inflate interactions (Spector, 2006).

In conclusion, the present study provided a further look into the relationship between everyday stress and memory problems, shedding light on the adverse effect of stress on prospective memory functioning. From a practical standpoint, the results obtained could be useful for therapeutic interventions among individuals who report feeling stressed to overcome potential memory failures. Future population-based studies on this issue could benefit from longitudinal designs to take into account causal chains effects and, as the current study may be considered only a first contribution for a more exhaustive examination of the moderation effects of individual factors, future research should also address in more depth the buffering role of other variables (e.g., personality traits) that may weaken the disruptive effect of stress on memory.

The next chapter continues to discuss the relationship between stress and prospective memory focusing upon the human contribution to accidents in complex, high-stress environments like the healthcare system.

Chapter 3

Study 2: On the effect of stress on prospective memory errors in the healthcare context

3.1 Introduction

Imagine a nurse who begins her long work shift by examining every patient's chart. Some patients are scheduled for surgery, while others are about to undergo urgent medical examinations or are waiting for critical test results. All patients need to be checked at different times throughout the day, while the nurse must also perform a number of tasks that are not limited to direct contact with the patient, such as charting, documentation, care coordination, and searching for equipment or supplies. Despite her best efforts, the nurse may find it difficult to provide the best quality of care in such fast-paced environment, which is so plagued by frequent interruptions. Thus, it is likely that she may forget to carry out some pending tasks, which may result in potential adverse events.

This example underlines how the Florence Nightingale's famous dictum "first, do no harm" (Leape, 1994) is not so simple to follow for healthcare providers. Indeed, the extremely demanding context in which they usually work does not accommodate human beings' physical and cognitive limits, contributing to job stress and increasing the risk of medication errors and accidental injuries (DeLucia, Ott, & Palmieri, 2009). In particular, nurses' job is inundated with prospective memory demands, which require to recall a previously formed intention at a specific time (time-based PM) or in response to a specific cue in the future (event-based PM; McDaniel & Einstein, 2000). Unsurprisingly, a significant number of iatrogenic injuries to patients is due to nurses' slips and lapses, namely PM failures to carry out intended plans of action (Dieckmann, Reddersen, Wehner, & Rall, 2006; Fink, Pak, Bass, Johnston, & Battisto, 2010; Leape et al., 1995). Indeed, medication errors due to PM failures may play a role in patients' deaths (Institute of Medicine, 1999). Although PM failures may have such damaging

consequences, there are still few studies that have explicitly analysed nurses' role in making, preventing, and detecting this type of errors.

Very little is also known about the association between medication errors, PM failures and feeling of distress (West et al., 2006). A great deal of research suggests that long-term stress can negatively impact memory functioning in everyday life (e.g., Pluviano, Gamboz, & Brandimonte, 2016; Rönnlund, Sundström, Sörman, & Nilsson, 2013; Staal, 2004). As concerns the medical area, some studies revealed that work-related stress and burnout may dramatically contribute to general cognitive failures and PM errors in healthcare delivery, leading to reduced quality of care and patient safety (Barret & Yates, 2002; Battisto et al., 2009; Eskildsen, Andersen, Pedersen, Vandborg, & Andersen, 2015). This can be very alarming as work stress and burnout are quite commonly experienced among healthcare workers. According to a survey investigating nurses' opinions about their work environments, 53% of them agreed with the following statement: "*My job is often so stressful that I felt burnt out*" (Boyle & Miller, 2009). Along the same line, Mayo and Duncan (2004) reported that the most frequent causes of errors according to nurses were fatigue and exhaustion. Moreover, previous studies addressing the relationship between burnout and information processing showed that burnout is associated with difficulties in voluntary control over attention and impaired memory (Peterson et al., 2008; Rydmark et al., 2006; Sandström, Rhodin, Lundberg, Olsson, & Nyberg, 2005; Van Der Linden, Keijsers, Eling, & Van Schaijk, 2005). This is not surprising as individuals with burnout symptoms often complain about difficulties in "keeping in their mind" daily tasks (Maslach, Schaufeli, & Leiter, 2001), which is an essential ability for successful prospective remembering.

Furthermore, nurses often lack the correct knowledge of what constitutes a medication error; indeed, they often fail to recognise errors when confronted with real examples of medication scenarios (Mayo & Duncan, 2004). As the primary step for preventing medical errors is the correct recognition of these very errors, it is necessary to clarify what truly constitutes a medication error and what specific actions and best practices could prevent it from happening.

Based on the above arguments, the present study aims at further examining *a)* the relationship between general cognitive failures, PM errors, work-related stress, and

burnout among healthcare workers, and *b)* the individual perception of medications errors.

3.2 Method

Participants

Thirty-one healthcare workers (24 females and 7 males) from the gynaecologic and obstetrician ward of the San Paolo Hospital in Naples volunteered in participating in this study. Mean sample age was 47.16 years (SD = 8.29), while job tenure was 18.13 years (SD = 8.53). All participants had completed at least some college-level education, with 21 (67.7%) having earned a college degree and 10 (32.3%) an advanced degree. Among those workers, 19 were nurses (61.3%), 6 (19.4%) obstetricians, and 6 (19.4%) healthcare assistants.

Measures

Data were gathered via a battery of self-report questionnaires (see Appendix B) assessing work stress, burnout, everyday cognitive failures, prospective memory, and perception of medication errors.

Work stress was assessed by means of the Need for Recovery Scale (Van Veldhoven & Meijman, 1994), a measure derived from the Questionnaire on Experience and Evaluation of Work (QEEW; Van Veldhoven & Meijman, 1994). The 11 items included in this scale investigate the severity and duration of work stress by assessing symptoms related to overload, lack of energy for new efforts, reduced performance, and social withdrawal. This scale proved to predict accidents at work (Swaen, van Amelsvoort, Bültmann, & Kant, 2003). Items are on a 4-point Likert scale, ranging from 1 (= never) to 4 (= always). Higher scores reflect a higher need for recovery.

Burnout was measured by means of the Oldenburg Burnout Inventory (OLBI; Demerouti, Bakker, Vardakou, & Kantas, 2001), which assesses two core dimensions of burnout, i.e., exhaustion and disengagement from work. It consists of two subscales containing 8 items each, wherein four are positively worded and four negatively

worded. The exhaustion subscale (items 2, 4, 5, 8, 10, 12, 14, and 16) refers to general feelings of intensive physical, affective, and cognitive strain, therefore being a long-term consequence of prolonged exposure to certain job demands. Instead, the disengagement subscale (items 1, 3, 6, 7, 9, 11, 13, and 15) refers to distancing from one's work and experiencing negative attitudes toward the work object, work content, or work in general. Each item in the OLBI is on a 4-point Likert scale ranging from 1 (= strongly agree) to 4 (= strongly disagree). Items 2, 4, 8, and 12 from the exhaustion subscale and items 3, 6, 9, 11 from the disengagement subscale were reversed so that for all of the items higher scores indicated a higher level of burnout.

Everyday cognitive failures were evaluated using the Cognitive Failures Questionnaire (CFQ; Broadbent, Cooper, Fitzgerald, & Parks, 1982; Di Fabio, Giannini, & Martelli, 2004). This questionnaire examines the level of slips of action, inattentiveness, and forgetfulness in daily life. It comprises 25 items in a 5-point Likert format, from 0 (= never) to 5 (= very often). Higher scores indicate more self-reported cognitive failures.

Prospective memory was evaluated using both subjective and objective measures. Three subjective measures were used. First, 8 items from the Prospective and Retrospective Memory Questionnaire (PRMQ ProM; Smith, Della Sala, Logie, & Maylor, 2000) were used to evaluate self-reported PM failures. Respondents rated the frequency of their PM errors on a 5-point Likert scale from 1 (= never) to 5 (= very often). Minimum and maximum possible scores were 8 and 40, respectively. Higher scores indicated more prospective memory errors. Second, participants were presented with one item investigating participants' perceived relevance of PM for daily practice on a five-point Likert scale, ranging from 1 (= not important at all) to 5 (= absolutely essential). Third, a self-developed scale partially based on an existing taxonomy of PM tasks from the aviation setting (Dismukes & Nowinski, 2007) was presented in order to account for the peculiarities of the healthcare context as a prospective memory-demanding work situation. This scale encompasses five items on a five-point Likert scale, ranging from 1 (= never) to 5 (= very often). Respondents were asked to estimate how often they encountered five prototypical work situations prone to PM errors during the preceding month. These work situations were related to: (a) *episodic tasks* (item no. 1), which require to remember to perform at a later time a task that is not

habitually performed; (b) *interruptions* (item no. 2), by which individual's attention is diverted by the intrusion of another task and then he/she must remember to resume where he/she left off; (c) *habitual tasks* (item no. 3), which involve multiple steps whose execution becomes largely automatic; (d) *habit capture* (item no. 4), by which habitual actions substitute atypical actions; and, lastly, (e) *interleaving tasks* (item no. 5), which force the individual to juggle several task concurrently. The objective test of PM was administered to have a comprehensive account of participants' prospective memory failures. It consisted in the Continuous Lab Measure of Event Cued ProM (Lab EC ProM/C; Uttl & Kibreab, 2011). Participants were instructed to circle any and all occurrences of a prospective memory cue while filling the questionnaire. The PM cue consisted of a word ("serie" = *series*), appearing four times in an increasingly intrusive visual format and location. More precisely, the cue-word appeared in the following visual format and spatial location: 1) in lower case, normal font, non-prominent location, as part of question no. 9 in the Need for Recovery Scale. This question (i.e., "Quando torno a casa da lavoro, mi assalgono pensieri ricorrenti su una serie di cose che avrei potuto fare meglio a lavoro" – "When I get home from work, I have a series of reoccurring thoughts about what I could do better at work") was added to the original scale for this purpose but it was not included in the scoring for calculating the level of stress; 2) in lower case, normal font, more prominent location, as part of the instructions in the OLBI (i.e., "Di seguito trova una serie di affermazioni rispetto alle quali può essere d'accordo o meno" – "Below you can find a series of statements which you may agree or not agree with"); 3) in lower case, bold, more prominent location, appearing as part of question #20 of the CFQ. This question (i.e., "La sua **serie** televisiva preferita verrà tramessa domani sera. Le capita mai di chiedere a qualcun altro (ad esempio il suo coniuge o un amico) di ricordarglielo?" – Your favourite TV **series** will be broadcast tomorrow night. Do you ever ask someone else (such as your spouse or a friend) to remind you?") was included in the CFQ for this purpose but it was not included in the scoring for calculating the frequency of everyday cognitive failures; 4) in capitals, bold, more prominent location, as part of those items modelled after Dismukes & Nowinski's (2007) taxonomy of PM tasks in the aviation setting (i.e., "C'è una **SERIE** di crescenti cambiamenti nelle sue mansioni lavorative" – "A **SERIES** of changes is occurring in your work"). This item was not included in

the following analyses. The scoring procedure of the objective test of prospective memory was as follows: 4 points were given when the first circled cue-word was the first cue-word presented; 3 points were given when the first circled cue-word was the second cue-word presented; 2 points were given when the first circled cue-world was the third cue-word presented; 1 point was given when the first circled cue-world was the last cue-word presented; 0 points were given when participants did not circle any cue-word.

Perception of medication errors was evaluated by means of a modified version of the Gladstone Questionnaire (Gladstone, 1995), encompassing diverse subscales. The first 10 items require to rank possible causes of medication errors on a five-point Likert scale ranging from 1 (= never) to 5 (= very often). The following 5 items are formulated as scenarios where respondents have to indicate, with a "yes/no" response, whether the described fictitious event represents a medication error and whether it should be reported to the physician. The last 5 items, requiring a "yes/no" response, elicit participants' perspective about dealing with medication errors and reporting them to superiors or other members of the medical staff.

Table 3.1 provides a summary of the measures and of the relevant variables included in the following analyses.

Table 3.1. *Summary of the measures and of the relevant variables included in the analyses*

Issue	Measure	Variable	Scale
Work stress	Need for Recovery Scale	Need for Recovery	4-point Likert scale (1 = never; 4 = always)
Burnout	Oldenburg Burnout Inventory	Exhaustion	4-point Likert scale (1 = strongly agree; 4 = strongly disagree)
		Disengagement	4-point Likert scale (1 = strongly agree; 4 = strongly disagree)

Cognitive failures	Cognitive Failures Questionnaire	Cognitive failures	5-point Likert scale (1 = never; 5 = very often)
Prospective memory	Prospective and Retrospective Memory Questionnaire	Self-reported PM failures	5-point Likert scale (1 = never; 5 = very often)
	Single item on perceived relevance of PM for daily practice	Perceived relevance of PM	5-point Likert scale (1 = not important at all; 5 = absolutely essential)
	Self-developed scale assessing frequency of encountering five prototypical work situations prone to PM errors	Frequency of encountering situations prone to PM errors at work	5 points Likert scale (1 = never; 5 = very often)
	Continuous Lab Measure of Event Cued ProM	Objective PM errors	0 (when participants did not circle any cue-word) to 4 points (when participants' first circled cue-word was the first cue-word presented)
Perception of medication errors	Modified version of the Gladstone Questionnaire	Causes of medication errors	5 points Likert scale (1=never; 5 = very often)
		Recognition and reporting of fictitious medication errors	"yes/no" response
		Dealing with medication errors at work and propensity to report them	"yes/no" response

3.3 Procedure

After providing some demographic details (i.e., sex, age, educational level, and tenure), participants were administered the various self-reported questionnaires. As they worked through the questionnaires, they were instructed to circle any and all occurrences of a prospective memory cue word ("serie" = *series*). Questionnaires, accompanied by a cover letter outlying the aims of the study, were distributed in sealable envelops to further guarantee privacy and were collected immediately after the completion. At the end, participants were carefully debriefed and thanked.

3.4 Results

Relationship between PM errors and work-related stress, burnout, and general cognitive failures

Correlational analyses were used to assess the relationship between PM failures, general cognitive failures, work-related stress, and burnout. In particular, the variables of interests were Gender, Age, Education, Tenure, Need for Recovery, Exhaustion, Disengagement, Cognitive failures, Self-reported PM failures, and Objective PM errors. Descriptive statistics (mean, standard deviation, Cronbach's α) and correlations among these variables are presented in Table 3.2. Results showed that age positively correlated with tenure (r = .69, $p < .01$). Then, need for recovery positively correlated with exhaustion (r = .6, $p < .01$), disengagement (r = .4, $p < .05$), cognitive failures (r = .87, $p < .01$), and self-reported PM errors (r = .66, $p < .01$), while it negatively correlated with the scores from the objective PM task (r = -.5, $p < .001$). Exhaustion was positively associated with disengagement (r = .45, $p < .05$) and cognitive failures (r = .58, $p < .01$), while disengagement was positively associated with self-reported PM errors (r = .52, $p < .01$). Then, cognitive failures positively correlated with self-reported PM errors (r = .71, $p < .01$) and the objective PM task (r = -.53, $p < .01$). Finally, self-reported PM errors negatively correlated with the scores from the objective PM task (r = -.41, $p < .05$).

Table 3.2. *Means, standard deviations, Cronbach's α (on the diagonal), and zero-order correlations for the research variables*

	M (SD)	1	2	3	4	5	6	7	8	9	10
1. Gender [a]	-	-									
2. Age	47.16 (8.29)	.03	-								
3. Education [b]	-	.04	-.3	-							
4. Tenure	18.13 (8.53)	.04	.69**	-.03	-						
5. Need for recovery	25.48 (8.35)	-.18	.2	-.18	.05	.94					
6. Exhaustion	20 (3.53)	.07	.03	-.04	.05	.6**	.70				
7. Disengagement	20.32 (3.5)	-.19	-.15	.16	-.11	.4*	.45*	.62			
8. Cognitive failures	45.59 (21.39)	-.07	.28	-.18	.03	.87**	.58**	.34	.95		
9. Self-reported PM errors	18.35 (6.37)	-.34	.18	.1	.19	.66**	.29	.52**	.71**	.87	
10. Objective PM task	2.06 (1.55)	-.03	-.3	.2	-.18	-.5**	-.2	-.22	-.53**	-.41*	-

Note. [a] 0 = male, 1 = female; [b] 1 = lower, 2 = higher; ** $p < .01$, * $p < .05$

Individual perception of medications errors

Concerning nurses' perceptions of the relevance of PM errors for daily practice (see Table 3.3), results showed that 93.5 percent of respondents rated PM as "absolutely essential", "very important" or "of average importance", while 6.4 percent estimated PM as having "little importance" or being "not important at all".

Table 3.3. *Importance attributed to PM for daily practice*

Importance attributed to PM	No. (n = 31)	(%)
absolutely essential	17	54.8
very important	8	25.8
of average importance	4	12.9
of little importance	1	3.2
not important at all	1	3.2

Note: "Importance attributed to PM for daily practice" measures responses on a five-point Likert scale from 1 (= not important at all) to 5 (= absolutely essential) to the question "In your opinion, how much is important prospective memory for patient safety?".

Descriptive statistics concerning the frequency of encountering situations prone to PM errors at work (see Table 3.4) showed that participants rated interleaving and interrupted tasks as the situation most prone to lead to PM errors.

Table 3.4. *Mean ratings of frequency of self-reported PM errors*

Type of task	Item	M (SD)
Interleaving task	You made some mistake while accomplishing simultaneous or interleaving tasks.	2.58 (1.5)
Interrupted task	While accomplishing a work task, you were abruptly interrupted by a colleague or an event and you cannot remember whether you eventually accomplished the task or not.	2.55 (1.39)

Atypical actions substituted for habitual actions	While accomplishing a highly habitual task, circumstances required you to deviate from a well-established procedural sequence and you cannot remember whether you unintentionally reverted to the normal procedure or not.	2.35 (1.4)
Episodic task	You had to postpone at a later time some work task that is not usually performed. However, you cannot remember whether you eventually accomplished the task or not.	2.22 (1.1)
Habitual task	You made some mistake during the execution of a highly habitual task, which consists of steps performed always in the same sequence.	2.16 (.97)

Note: Participants rated the frequency of each PM error on a five-point Likert scale, ranging from 1 (= never) to 5 (= very often).

With respect to the perceived causes of medication errors (see Table 3.5), participants identified fatigue and exhaustion, wrong prescriptions of the physician, and failures to correctly identify the patient as the most frequent causes of medication errors.

Table 3.5. *Mean ratings of possible causes of medication errors*

Item	M (SD)
Medication errors occur when nurses are tired and exhausted.	3.84 (.97)
Medication errors occur when the physician prescribes the wrong dose.	3.35 (1.47)
Medication errors occur when the nurse fails to check the patient's name-band with the Medication Administration Record (MAR).	3.35 (1.4)
Medication errors occur when nurses are distracted by other patients, co-workers, or events on the unit.	3.32 (1.07)
Medication errors occur when the nurse miscalculates the dose.	3.29 (1.37)
Medication errors occur when the nurse sets up or adjusts an infusion device incorrectly.	3.13 (1.41)
Medication errors occur when the medication label/packaging are of poor quality or are damaged.	3.1 (1.51)
Medication errors occur when there is confusion between two drugs with similar names.	3.1 (1.32)

Medication errors occur when the physician's writing on the doctor's order form is difficult to read or illegible.	3.03 (1.3)
Medication errors occur when nurses are confused by different types and functions of infusions devices.	2.87 (1.52)

Note: Participants rated the frequency of each possible cause of medication errors on a five-point Likert scale, ranging from 1 (= never) to 5 (= very often).

Concerning the recognition and reporting of medication errors on the basis of five different medication scenarios describing fictitious incidents (see Table 3.6), descriptive statistics revealed that there was a considerable disagreement between respondents as to whether each described incident constituted a medication error (e.g., 48.4% yes vs. 51.6% no in the second scenario), as well as to whether each described incident should be reported to the physician (e.g., 54.8% "yes" vs. 45.2% "no" in the first scenario).

Table 3.6. *Perception of medication errors and their reporting to supervisors in fictitious scenarios*

Item	Response	No. (n = 31)	(%)
Scenario 1. A patient misses his midday dose of oral ampicillin because he was in x-ray for 3 hours.			
Medication error	Yes	13	41.9%
	No	18	58.1%
Notify physician	Yes	17	54.8%
	No	14	45.2%
Scenario 2. Four patients on a busy surgical unit receive their 6 PM dose of IV antibiotics 4 hours late.			
Medication error	Yes	15	48.4%
	No	16	51.6%
Notify physician	Yes	12	38.7%
	No	19	61.3%
Scenario 3. A patient receiving TPN feeding via an infusion pump is given 200 ml/hr instead of the correct rate of 125 ml/hr for the first 3 hours of the 24-h infusion. The pump was reset to the correct rate after the change of shift at 7 A when the oncoming nurse realized the pump was set at the incorrect rate.			
Medication error	Yes	25	80.6%
	No	6	19.4%
Notify physician	Yes	23	74.2%
	No	8	25.8%

Scenario 4. A patient admitted with status asthmaticus on 08/13 at 2 AM is prescribed albuterol (ventolin) nebulizers every 4 h. The nurse omits the 6 AM dose on 08/13 as the patient is asleep.			
Medication error	Yes	13	41.9%
	No	18	58.1%
Notify physician	Yes	14	45.2%
	No	17	54.8%
Scenario 5. A physician orders oxycodone hydrochloride and acetaminophen (Percocet) 1-2 tabs for post-operation pain every 4 h. At 4 pm the patient complains of pain, requests 1 pill and is medicated. At 6.30 pm the patient requests a second pain pill. The nurse administers the pill.			
Medication error	Yes	16	51.6%
	No	15	48.4%
Notify physician	Yes	19	61.3%
	No	12	38.7%

Concerning how participants deal with medication errors at work (see Table 3.7), descriptive statistics showed most participants indicated that they usually know what constitutes a medication error (71%) and when an incident report should be completed (58.1%). Only half of the sample (54.8%) indicated that medication errors are reported regardless of the fear of possible reactions of the nurse manager or co-workers. Finally, most participants stated that they never failed to report a medication error because they thought it was not serious (58.1%) or because they were afraid of repercussions (71%).

Table 3.7. *Perceptions about medication errors reporting*

Item	Response	No. (n = 31)	(%)
I am usually sure what constitutes a medication error.	Yes	22	71
	No	9	29
I am usually sure when a medication error should be reported using an incident report.	Yes	18	58.1
	No	13	41.9
Some medication errors are not reported because nurses are afraid of the reaction they will receive from the nurse manager or co-workers.	Yes	14	45.2
	No	17	54.8
Have you ever failed to report a medication error because you did not think the error was serious enough to warrant reporting?	Yes	13	41.9

	No	18	58.1
Have you ever failed to report a medication error because you were afraid that you might be subject to disciplinary action or even lose your job?	Yes	9	29
	No	22	71

3.5 Discussion

Healthcare delivery is colloquially termed a "24/7" operation as it takes place 24 hours a day and 7 days a week, imposing a continuing challenge to healthcare workers. Indeed, they are confronted with complex tasks that require sustained attention and are particularly vulnerable to the effects of fatigue and stress (Warltier, Howard, Rosekind, Katz, & Berry, 2002). In particular, nurses daily monitor the quality of care delivered in hospitals and, as they spend the most time with patients as compared to any healthcare providers, the burden of medication errors falls more heavily on them than on any other member of the healthcare team (Osborne, Blais, & Hayes, 1999).

A number of reviews (e.g., DeLucia et al., 2009) identified slips and memory lapses, as well as stress and fatigue, as the most frequent causes contributing to medication errors. Yet, there is a paucity of empirical research examining memory errors caused by work stress and burnout as co-factors which may lead to forget clinical tasks and potential adverse events. Given the centrality of this issue for patients' safety, this study attempted to evaluate how stress and burnout can contribute to PM errors in the healthcare context, along with examining individual perception of medication errors.

Our findings highlighted the detrimental impact of work stress and burnout on cognitive processes, as these negative experiences appeared to positively correlate with both general cognitive failures and self-reported PM errors. Confirmatory evidence of this negative effect was also provided by the significant correlation between perceived stress and burnout, on the one hand, and the objective evaluation of prospective memory, on the other.

Our investigation of healthcare workers' perception of medication errors also provided some useful insights. Firstly, healthcare workers claimed that PM is particularly relevant for their daily practice. They reported that PM errors, posing a

significant threat to patient safety, more frequently derive from interruptions or multitasking. Moreover, consistently with Mayo and Duncan (2004), our results provided confirmatory evidence that healthcare workers were not sure about what constitutes a medication error. Indeed, even though most participants declared to be "usually sure what constitutes an error" (71% yes, 29% no), they did not correctly recognise medication errors when confronted with fictitious medication scenarios. Then, when we asked whether existed barriers to reporting errors to other people, many participants revealed that fear of disciplinary actions is still widespread and errors are consequently often hidden. Therefore, a great deal of difficulty persists in dealing with human error when it occurs, and a non-blaming, non-punitive, and non-fearful learning culture, in which one can openly admit errors, in order to learn from them and to avoid them in the future, is still needed (Vrbnjak, Denieffe, O'Gorman, & Pajnkihar, 2016).

Some limitations of this study need to be acknowledged. First, our data came from the use of self-report measures, raising the issue of common method bias and the risk of misinterpret relationships between variables (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Second, this study involved a small sample of workers from a gynaecological unit in one hospital system, which may limit the broader generalizability to other wards and hospitals. Moreover, a post-hoc power analysis (G*Power 3; Faul et al., 2007) showed that the statistical power for this study was .40 for detecting a moderate effect, whereas the power increased to .87 for the detection of a large effect. Thus, there was more than adequate power at the large effect size level, but less than adequate statistical power at the moderate effect size level (Button et al., 2013). Third, the nature of the study was correlational, meaning that no reliable conclusions can be drawn regarding the causal directions of the relationships between variables. However, I believe that the knowledge gained from this study can contribute to improving practitioners' understanding of the cognitively demanding nursing work environment, and it may draw attention to the need for redesigning the nursing work system in order to minimize the reliance on memory (e.g., through the use of tools, such as checklists or protocols) and reduce errors caused by stress. This study can also inform educational programs designed to promote the recognition of medication errors among healthcare workers, insisting on a whole-system approach that considers errors as system failures rather than just the fault of the individual.

Part Two

Misinformation and Prospective Memory

Chapter 4

Introduction

4.1 Planning out future actions about health

Part One of this Thesis portrayed prospective memory as the cognitive function we use for formulating plans and promises, for retaining them, and for recollecting them subsequently when circumstances permit (Brandimonte, 2006; Graf, 2012). What we have learned from Studies 1 and 2 is that this function is essential for many everyday tasks, from picking up groceries after work to attending an important meeting at the right time and place, as well as for maintaining our efficiency at work.

Deficient prospective memory may also significantly impact our health. Medical adherence is, in fact, deeply intertwined with how people set and maintain future health goals and plans. As Gollwitzer and Oettingen (2007) highlighted:

> "a first prerequisite for medical adherence is that people walk away from a health care provider (or from medical instructions obtained elsewhere) with a strong intention (goal) to act on the advice or instruction given. Second, and equally important, people need to effectively translate their goals into action, not only after the advice has been given but also weeks and months thereafter" (p. 23).

Poor prospective remembering has long been recognised as a substantial obstacle in the treatment of several conditions including HIV/AIDS, rheumatoid arthritis, and diabetes (Eysenck, 2009), as well as in health-promotion and disease-prevention enterprises requiring immediate costs and only long-term rewards, such as starting to exercise regularly or picking up a healthy diet (Gollwitzer, 1999; Gollwitzer & Oettingen, 1998). Preventive health behaviours like vaccination could be added to these examples. Indeed, getting vaccinated involves multiple steps truly resembling a prospective memory act: first, the individual needs to form and encode the intention

of getting the vaccine at hand; then, there is a retention interval that lasts weeks or even months between intention formation and intention execution; finally, after this delay, the individual may successfully retrieve the intention from retrospective memory. There may be particular problems during these diverse steps because of the complexity of the intention, its relationship to other stored intentions, or the presence of other competing intentions. For example, individuals may ask themselves whether the intention to vaccinate is compatible with what they believe, whether it is based on information coming from a perceived credible source, or whether relevant others believe that vaccines are safe and effective, therefore endorsing this intention (Lewandowsky, Ecker, Seifert, Schwarz, & Cook, 2012; Schwarz & Newman, 2017).

However, according to Gollwitzer (1993, 1996, 1999), there is a strategy that may help people to keep their health intentions in mind, which is referred to as "implementation intentions". An implementation intention is a planning technique that delineates what people need to do, and when, to fulfil their intentions. It is usually formulated as an if-then plan that might take the form of "If I receive a notice about a flu-shot clinic, then I will immediately schedule an appointment" (Brewer, Chapman, Rothman, Leask, & Kempe, 2017). A wealth of research indicates that implementation intentions are effective at enhancing the likelihood of goal achievement (for a review, see: Gollwitzer & Sheeran, 2006). In the context of vaccination, a randomized control trial that prompted people to specify a date and a time for their next influenza vaccination increased vaccination coverage (Milkman, Beshears, Choi, Laibson, & Madrian, 2011). However, implementation intentions are designed to help people to *act* rather than to *change* their intentions. As Sheeran, Webb and Gollwitzer (2005) suggested, implementation intentions could be particularly effective for individuals who hold favourable beliefs, attitudes, and intentions toward the target behaviour. This implies that vaccines-hesitant people may be less easily persuaded by this kind of "self-reminder". As detailed in the following Chapters, the reasons for their resistance to vaccination may be related to the complex issues of misinformation and mistrust.

4.2 The continued influence effect of misinformation in memory

Our everyday lives revolve around the acquisition of information. Sadly, we are not always presented with accurate and valid information; we often encounter ideas and

concepts that are instead inaccurate and invalid; we are misinformed (Rapp & Braasch, 2014). Misinformation by definition does not accurately reflect the true state of the world (Cook, Ecker, & Lewandowsky, 2015); rather, it refers to "any information that turns out to be incorrect, irrespective of why and how that information was acquired in the first place" (Cook & Lewandowsky, 2011, p. 1).

Much research indicates that misinformation can survive in the face of updated records; people can continue to rely on misinformation even if they remember and understand a subsequent retraction (e.g., Wilkes & Leatherbarrow, 1988; Seifert, 2002; Cook & Lewandowsky, 2011). The lingering phenomenon by which misinformation continues to influence memory, reasoning, and decision making even after sophisticated correction attempts is known as "continued influence effect" (Johnson & Seifert, 1994). Reliance on misinformation may spread and have severe social effects because, if people believe in something that is factually incorrect, misinformation may form the basis for decisions that run counter to a society's best interest (Lewandowsky et al.,2012), as in the case I chose to analyse: vaccine misinformation. Therefore, there is the need to learn more about how people come to hold misperceptions and to determine the most effective way to counter mistaken beliefs (Nyhan & Reifler, 2012).

This chapter analyses the intricate phenomenon of misinformation: where it originates and is spread, how it affects our cognition, and how to counteract its negative effects.

4.3 Mapping the origins and sources of misinformation

Misinformation can come in many guises. The analysis of the origin and dissemination of misinformation has yielded a new field known as "agnotology", that is the study of ignorance and its cultural production arising from intentional attempts to spread confusion and deceit, usually to sell a product or win favour (Proctor, 2008).

Some evidence indicates that corporations with vested interests have been involved in deliberate campaigns to disseminate misinformation. For instance, companies like the American Petroleum Institute or the Western Fuels Association have promoted doubt and ignorance about the anthropogenic influences on global warming (Hoggan & Littlemore, 2009). For years, big tobacco firms have conspired to deny, distort, and minimize the harmful effects of cigarette smoking (Glantz,

Barnes, Bero, Hanauer, & Slade, 1995). Similarly, the Coca-Cola Company has poured vast amounts of money into studies aimed at countering claims that drinking soda does not cause obesity (Malhotra, Noakes, & Phinney, 2015). When it comes to vaccines, a popular argument by vaccine deniers is that those who defend vaccine are "in the pocket of Big Pharma" (Kata, 2012) or other companies interested in promoting pharmaceutical products for devious purposes or profit, ignoring, for example, that the direct cost to the public health infrastructure of containing one case of measles is far greater than the estimated cost of uncomplicated individual illness (Dayan, Ortega-Sánchez, LeBaron, & Quinlisk, 2005).

Rumours and fiction can constitute further significant sources of misinformation. For example, Michael Crichton's novel "State of Fear", whose central thesis is that scientists are bending facts to fit their unsubstantiated global-warming theories, has become a bestseller and the fiction author has been invited as a climate "expert" to testify before a US Senate committee. Another case of particular concern involves the controversial documentary "Vaxxed: From Cover-Up to Catastrophe", which has alleged a cover-up of a purported link between the MMR vaccine and autism. The movie, directed by Andrew Wakefield – the former doctor who perpetuated the hoax that originated the current vaccine scare – was scheduled to premiere at the "2016 Tribeca Film Festival" but was eventually withdrawn after receiving harsh criticisms from members of the scientific community worldwide.

The media play a large role in disseminating misinformation. Sometimes this deception occurs accidentally and without malice; because of the need for timely news coverage of unfolding events, TV news, radio reports, and the press tend to update and correct earlier information (e.g., announcing partial results of an opinion poll or the death toll after a natural disaster). Another potential source of misinformation relies on journalists' tendency to present "balanced" coverage by giving equal weight to all sides of an issue. Even though this is not formally wrong, it could imply presenting an issue as being more balanced between opposing viewpoints than the evidence actually supports. In this way, experts could be given equal voice with non-experts and important information that would establish one side's claims as baseless could be omitted. For instance, evidence shows that balanced presentations of the autism-vaccine controversy can deceive the public and influence judgments of vaccines risk

(Dixon & Clarke, 2013). Another example is the false controversy related to global warming, which is remote from the actual state of science and slides into overt denial of scientific facts (Lewandowsky, Mann, Brown, & Friedman, 2016). For this reason, giving equal voice to the majority of scientists that attribute climate change to the effects of the greenhouse-gas emission caused by humans and to the small number of sceptics who still dispute this conclusion can induce laypeople to think there is a serious disagreement within the scientific community, when in fact there is an overwhelming scientific consensus favouring anthropogenic global warming (Verheggen et al., 2014).

With regard to new media, digital misinformation has been labelled by the World Economic Forum (WEF) as one of the main threats to our society (Zollo et al., 2015). The Internet has become a sort of "modern Pandora's box" (Kata, 2010), where the amount of misinformation grows proportionally with the availability of valid information or even faster because of the lack of fact-checking. The nature of the new generation of the Internet (Web 2.0) has obliterated authority and "flattened truth" (Keen, 2007), allowing any and all opinions to spread widely and in record time (Kata, 2010, 2012; Wineburg, 2016). To the extent that it is not uncommon for the naïve user to fall into the trap of "echo-chambers", where the same misleading content appear on many linked websites and blogs of similar persuasion, giving the false impression of corroborative evidence from multiple independent sources (Del Vicario et al., 2016). An added complexity related to digital misinformation is that users tend to select and share content related to a specific narrative that reinforces their own opinions and beliefs, a phenomenon known as "selective exposure" (Prior, 2002). In particular, those considered on the fringe – members of marginalized groups – tend to aggregate into like-minded and isolated clusters or "cyber-ghettos" (Johnson, Bichard, & Zhang, 2009), which foster segregation, polarization, and the spread of conspiracy theories (Bessi et al., 2015; Grimes, 2016). This is demonstrated by the anti-vaccination movement on the Internet, where self-proclaimed experts are able to spread their deceiving messages and weaken evidence-based opinions from qualified experts, taking advantage of the postmodern characteristic of relativism by which there are no objective facts but rather multiple meanings and way of "knowing" (Kata, 2012). This is particularly worrisome because recent studies demonstrated that people are

increasingly turning to the Internet to find health information and have a hard time gauging source credibility appropriately and accurately, being distrustful of official sources like healthcare professionals, health departments or government sources and reporting more confidence in alternative and unreliable sources such as anti-vaccination organizations (Salmon, Moulton, Omer, DeHart, Stokley, & Halsey, 2005; Salmon et al., 2009). As discussed later in Study 5, some studies corroborate indeed that source trustworthiness – the perception that the source is willing to provide information that the source itself believes to be accurate – is crucial in affecting belief change and gaining behavioural compliance, regardless of the level of source expertise – the extent to which the source is capable of providing accurate information (Guillory & Geraci, 2013). Even worse, the lower one's prior knowledge about the health topic at hand and involvement with it, the more influential the source credibility becomes (Jung, Walsh-Childers, & Kim, 2016). In the area of vaccine safety, given that laypeople lack relevant knowledge and trust in science and institutions, the implication is that inferences about the trustworthiness of the source of information, rather than about its real expertise, could steer one's vaccination intention, regardless of the ability of the source to provide reliable information.

4.4 Reasons for resistance to misinformation

To better understand how people form and hold misperceptions even over matters where the evidence is so unequivocal (e.g., climate change, vaccines, and the birthplace of the American president Barack Obama; Lewandowsky et al., 2012), it is particularly useful to draw from social psychology research on motivated reasoning. Festinger's pioneering theory of cognitive dissonance (1957) postulated that inconsistency between facts, opinions, beliefs, or attitudes in an individual's cognitive system produces tension that must be reduced or eliminated. The discrepancy between these elements is labelled "cognitive dissonance".

Festinger (1957) described four basic situations that facilitate dissonance: *a)* decision making, by which dissonance is a result of making a decision between two or more alternatives; *b)* forced compliance, by which dissonance occurs when individuals comply to public pressure without a concomitant change in their private opinion; *c)* social support, by which dissonance is caused by the disagreement with other persons;

and, finally, *d)* voluntary or involuntary exposure to dissonant information, by which dissonance arises from information that is inconsistent with the cognitions already held (Martin & Briggs, 1986).

This last situation may be particularly tricky when trying to correct misinformation. The main problem is that people are not blank slates, rather they already have beliefs and a set of facts lodged in their mind, which usually have an uneasy relationship with external facts. Nevertheless, these pre-existing beliefs dictate how people gather information and what they choose to accept, to the extent that, under certain circumstances, people may display a "confirmation bias". This means that they uncritically choose to believe only what they want to believe, usually what fits their pre-existing beliefs and deeply held views, trying to avoid opposite claims and uncongenial information that challenge these beliefs (Klayman, 1995; Nickerson, 1998). Inconsistent cognitions may indeed produce cognitive dissonance, namely that feeling of discomfort described earlier that is threatening for one's self and usually activates a natural self-defence mechanism. Moreover, when something is inconsistent with prior beliefs and knowledge, people have trouble processing it (Winkielman, Huber, Kavanagh, & Schwarz, 2012). Instead, when the new information matches existing beliefs, processing is easier and people tend to nod along (Schwarz, Newman, & Leach, 2016). Confirmation bias is particularly strong among politically sophisticated individuals and among those with stronger underlying beliefs or attitudes on the issue in question (Nyhan & Reifler, 2012). Nevertheless, it can be spontaneously activated in the minds of most individuals, to the extent that "we may not even notice information that challenges our existing beliefs – at best we can be easily persuaded to ignore or misinterpret the information" (Whitworth, 2011, p. 203).

There are several ways to reduce cognitive dissonance fuelled by information challenging beliefs that people hold strongly, including counter-arguing the message (attempting to directly rebut the claim in question), bolstering one's original attitude (bringing to mind reasons why the initial belief was correct), derogating the source of the message (dismissing the validity of the source of the claim), social validation of one's original attitude (bringing to mind others who hold the same view), and reacting with negative affect (becoming upset or angry). Worst of all, even in the face of clear contradictory scientific evidence, people may continue to hold their beliefs by

distrusting the efficacy of scientific methods and concluding that the topic in question is not amenable to scientific investigation, a particular resistance strategy called "scientific-impotence excuse" (Munro, 2010).

Much experimental evidence corroborates the idea that for those who are strongly fixed in their views, being confronted with counterarguments can cause their views to be strengthened. In fact, one of the most potent backfire effects of corrective information strategies occurs with topics that tie in with people's "worldviews" (Cook & Lewandowsky, 2011). For instance, using in-depth "challenge" interviews that presented participants with substantive challenges to their political opinions, Prasad et al. (2009) showed that Republicans who believed Saddam Hussein was linked to the 9/11 terrorist attacks – a false belief that was the result of a campaign of false information and innuendo from the Bush administration – did not change their mind even after being presented with a direct quote from George Bush denying any connection between the two. These voters displayed a behaviour called "inferred justification": they believed 9/11 was the main reason for the war against Iraq and actively resisted information suggesting otherwise, even though the correction was made by a source they seemingly trusted. Along the same line, Nyhan and Reifler (2010) conducted an experiment in which participants were given mock news articles, each of which contained a false claim followed by a clear and direct correction, for example that Bush's tax cuts increased government revenues (revenues actually fell). Later corrections in the stories slightly decreased misperceptions among liberals but increased them dramatically among conservatives.

Apart from deep-rooted beliefs and ideologies, the acceptance and persistence of misinformation are favoured by tacit norms of everyday conversational conduct. According to Grice's conversational logic perspective (1989), information relayed in conversation comes with a "guarantee of relevance" and listeners proceed on the assumption that speakers try to be truthful, relevant, and clear (Lewandowsky et al., 2012). Therefore, invalid information, as any other information, can be taken at face value just because people have a response bias towards uncritically accepting something as true, believing the speaker is acting in "good faith" (Pennycook, Cheyne, Barr, Koehler, & Fugelsang, 2015). This could also be the reason why correction attempts frequently fail: if the correction is truthful, why would a well-intentioned

source have presented misinformation in the first place? And if the earlier information (representing actually misinformation) is believed to be accurate, how can its correction be simultaneously accepted as accurate? (Seifert, 2002). People feel extremely uneasy when two sources of information cue conflicting responses and conflict monitoring failures represent an important source of bias in reasoning and decision making (Pennycook, Fugelsang, & Koehler, 2012; Pennycook et al., 2015). Moreover, when we initially encounter information, a mental model of the unfolding events as we know them is built. When new information becomes available and relevant, this model needs to be updated. If the required changes are small, they can be integrated into this model incrementally, while if they are more pervasive, a "global" update becomes necessary and the old mental model needs to be discarded to create a new one (Bailey & Zachs, 2015; Swire & Ecker, 2018). The problem here arises because people, feeling uncomfortable with gaps in their knowledge of an event, tend to prefer an incorrect but complete model over a corrected but incomplete one, clinging to the original misinformation and ignoring the correction. To illustrate, part of the reason why so many people continued to believe in the alleged link between vaccines and autism, despite extensive corrections, was that autism was on the rise, increasing in notoriety and frequency each year, and seemingly so just as the measles vaccine was stepped up, consolidating into the public's mind the false causal link that the measles vaccine caused autism (Jacobson, Targonski, & Poland, 2007). The conflict created by having a readily available plausible answer to a question ("What causes autism? Measles vaccine!"), but at the same time knowing that it was wrong because of the numerous retractions, was easily resolved by sticking to the original misconception and ignoring the overwhelming evidence indicating the opposite (Lewandowsky et al., 2012).

4.5 Corrective efforts

Debunking misinformation is no easy job. Corrective efforts can even trigger backfire effects, so that people not only fail to change their minds when confronted with facts, but they may come to hold their wrong beliefs more tenaciously than ever (Cook & Lewandowsky, 2011; Lewandowsky et al., 2012). Vaccines misinformation is no exception (Nyhan, Reifler, Richey, & Freed, 2014; Nyhan & Reifler, 2015); several

attempts have been made to counteract vaccination misconceptions and the diverse strategies usually employed to this end will be presented in the following chapter.

More generally, researchers have come to understand that corrections should not be solely informational, rather they should replace the original misinformation with a better alternative, or at least, explain why the misinformation came to be (Seifert, 2002). This is why, as explained before, people build mental models of the world and want them to be complete. When we retract something, this leaves a gap in people's understanding. But people do not like gaps and they will go back to that misinformation, put it back in their model and use it in their reasoning. To avoid this, the best thing to do is to give people an alternative piece of information that they can put in their model. Two useful guides, the Debunking Handbook (Cook & Lewandowsky, 2011) and the Uncertainty Handbook (Corner, Lewandowsky, Phillips, & Roberts, 2015), provide other useful recommendations to debunk misinformation, including not overloading people with information, emphasizing the core facts and not the myths, using a graphic as a pie chart to visually enhance the message, choosing a messenger who is trustworthy to communicate the consensus, and finding the closest match between the values of the audience and those of the messenger.

Yet, there is no single formula, recipe, or procedure that completely removes misinformation from memory and works in every situation. To foreshadow briefly, the following studies will corroborate the idea that the continued influence effect of misinformation is a powerful influence on later reasoning (Seifert, 2002). That is not to say there is no reason for optimism. While correcting misinformation is absolutely important and finding the best way to do so is much needed, we should worry that misinformation should not be acquired in the first place. In the political unrest following Brexit and the 2016 presidential election in the US, where the political landscape was rife with misinformation, it is not difficult to understand that there is no such thing as free-floating information; all information we encounter comes from somewhere and may be distorted by political motives, personal opinions or biases (Swire & Ecker, 2018; Wineburg, 2016). As the possibility for misinformation multiplies, the only candle in the dark relies upon laypeople's baloney detection ability (Sagan, 1995), adopting a critical mindset before they put their trust in what they are being told.

Chapter 5

Study 3: Misinformation lingers in memory: Failure of three pro-vaccination strategies[2]

5.1 Introduction

Vaccines are the safest and most effective tools for preventing infectious diseases and their success in achieving relevant public health outcomes, such as the reduction or eradication of many life-threatening conditions, is well-established. However, many people appear hesitant about vaccines, doubting their benefits, worrying over their safety or questioning the need for them. Addressing *vaccine hesitancy*, defined as a "delay in acceptance or refusal of vaccines despite availability of vaccination services" (WHO, 2014, p. 575), is not a simple task for the following reasons. First, vaccine hesitancy is rooted in a set of cognitive mechanisms that conspire to render misinformation particularly "sticky" and pro-vaccination beliefs counter-intuitive (Miton & Mercier, 2015), involving a multitude of emotional, social, cultural, and political factors (Larson, Jarrett, Eckersberger, Smith, & Paterson, 2014). Second, public information campaigns designed to dispel erroneous vaccination beliefs often overlook these factors and have limited or even unintended opposite effects (Nyhan & Reifler, 2015; Nyhan, Reifler, Richey, & Freed, 2014). Furthermore, even when attempts to correct invalid information do not "backfire" by entrenching the original misinformation (Johnson & Seifert, 1994), they can frequently fail because people cannot successfully update their memories and still fall back on information they know is not correct in order to make inferences and explain events.

A vivid example of persistent reliance on mistaken beliefs despite extensive corrections involves the alleged risks of childhood vaccines, especially the purported link between certain vaccines and autism, fear of which escalated following the widely discredited Wakefield et al.'s study (Offit & Coffin, 2003). Despite an abundance of

[2] Pluviano, S., Watt, C., & Della Sala, S. (2017). Misinformation lingers in memory: Failure of three pro-vaccination strategies. *PLoS ONE, 12*(7), e0181640. doi:10.1371/journal.pone.0181640

scientific evidence that shows no causal effect between any vaccine and autism (Heron & Golding, 2004; Honda, Shimizu, & Rutter, 2005) sizable segments of the public still champion Wakefield's view. To understand what causes such persistent reliance on patently incorrect information, it is useful to consider some relevant memory processes in more detail.

Classical laboratory research on memory for inferences (Johnson & Seifert, 1994; Wilkes & Leatherbarrow, 1988) demonstrates that the continued reliance on discredited information is very difficult to correct. Even when people clearly remember and understand a subsequent correction when asked about it immediately (suggesting that they have encoded it and can retrieve and potentially comply with it), they can still be influenced by the effect of the retracted misinformation. That is, people are susceptible to misinformation even though they had acknowledged that the information at hand is factually incorrect. As Rapp and Braasch stated (2014; p. 3), "the problem is not just that people rely on inaccurate information but that they rely on it *when they seemingly should know better*". This seemingly irrational reliance on outright misinformation has been demonstrated with beliefs related to well-known material (e.g., biblical narratives; Erickson & Mattson, 1981; Hannon & Daneman, 2001), blatant hoaxes (e.g., paranormal claims; Manza, Hilperts, Hindley, Marco, Santana, & Hawk, 2010) or personally experienced events (e.g., distorted eyewitness testimonies; Loftus, 2003). It also occurs despite measures intended to make the presentation of information clearer and despite explicit warnings about the misleading nature of the information at hand (Ecker, Lewandowsky, & Tang, 2010; Trembath, Paynter, Keen, & Ecker, 2016). Therefore, simply retracting a piece of information does not stop its influence because outdated pieces of information linger in memory. In the case of vaccines, providing evidence about the safety of immunisation may not be enough as people may have heard or read somewhere that, for example, vaccines are not necessary, that they cause autism or contain dangerous chemicals. This false information persists in their minds.

An added complication is that the use of inaccurate information does not necessarily emerge immediately after its presentation but may occur after a delay between the initial presentation and later test points (Appel & Richter, 2007; Zhu et al., 2012). Classical laboratory research on the lasting effect of misinformation in

memory confirms that immediate tests following the presentation of inaccurate information are less likely to detect people's susceptibility to misinformation compared to longer time intervals (Belli, Windschitl, McCarthy, & Winfrey, 1992; Loftus, Miller, & Burns, 1978).

Given these difficulties, there is a need to investigate debiasing practices used to disseminate correct information concerning vaccines, which, at the very least, should do no harm and ideally should help people better understand why and when they can trust scientific advice.

A number of strategies have been used to communicate the scientific consensus about vaccination and promote correction of misinformation. Perhaps the simplest strategy is exposing myths while concurrently debunking them, which is based on the idea of reiterating myths and then discrediting them with a number of facts. However, repeating myths might contribute to increasing their acceptance due to their perceived familiarity (Dechêne, Stahl, Hansen, & Wänke, 2010; Hasher, Goldstein, & Toppino, 1977; Peter & Koch, 2016). According to content-focused models of judgement, the strong arguments presented by the facts should decrease the acceptance of myths (Schwarz, Sanna, Skurnik, & Yoon, 2007). Moreover, some have argued that simply reviewing misinformation may even facilitate memory updating (Pashler, Kang, & Mozer, 2013). The scant available experimental evidence appears to only marginally support this approach. Consistent with it, in a natural classroom environment, Kowalski and Taylor (2009) found that "refutational lectures" (in which popular misconceptions about psychology where directly addressed and contrasted with evidence opposing them and supporting the correct information) resulted in students having better access at the end of the course to the correct information. In the context of immunisation, there has been an inconclusive debate about whether health messages using a fact versus myth format are effective in reinforcing accurate information and refuting false information. Some studies found that repeating myths led to a marked increase in accepting those myths as true. For example, in an unpublished study, participants who read a "myths vs. facts" flyer regarding the flu vaccine subsequently misremembered myths as facts after only 30 minutes and expressed less favourable attitudes toward flu vaccination and lower intentions to get vaccinated, relative to control participants who did not read the flyer (Schwarz et al., 2007). Similarly, in a

study by Skurnik et al. (2005) participants who read either true or false health-related statements could not distinguish fact from fiction after a 3-day delay. Even worse, the more they were warned that a statement was false, the more they accepted it as true. Despite these backfire effects, many pro-vaccination initiatives continue to confront erroneous beliefs with established evidence. A recent study by Cameron et al. (2013) employing different facts versus myths message formats justifies the use of myths to overcome health misinformation, as participants who were exposed to facts, myths, and evidence to counteract those myths gained more knowledge regarding a specific health topic and had a better recall accuracy than those who were merely presented with factual information.

An alternative corrective technique is to represent information in visual form, using well-designed graphs which can attract and hold people's attention, help the observer to process information more effectively, and facilitate recollection (van der Linden, Leiserowitz, Feinberg, & Maibach, 2014). Being easier to process than complex verbal description, graphical representation of data can also provide more clarity and less opportunity for misinterpretation than text, simplifying complex ideas and highlighting what is important. According to Gigerenzer (2014), a specific tool that could allow people with no medical or statistical competence to make competent decisions is a "fact box", which consists of a table for transparent risk communication, summarizing the scientific evidence for a drug, treatment, or screening method in an easily understandable manner. Fact boxes usually show benefits and harms for people with and without treatment in plain frequencies, avoiding misleading statistics or statements of risk that may be misunderstood by laypeople. As transparent as a fact box, even though visually more appealing, is an "icon box", which consists of a visual tool showing two groups of individuals: those who underwent a treatment and those who did not. Each individual is represented by an icon indicating benefits and harms. Although there has been relatively little research on the use of fact boxes as tools for informing the general public about pros and cons of a treatment, some studies show promising results. For instance, Schwartz et al. (2007, 2009) demonstrated how the use of simple fact boxes about drugs may help people to make better informed choices by improving their knowledge of drug benefits and side effects.

A third alternative to counter anti-vaccination attitudes is to harness the power that fear exerts on people, by highlighting grave risks from diseases (i.e., emotionally-charged messages that show the possible serious consequences of a disease likely to happen in non-vaccinated individuals). According to Nyhan et al. (2014), this puts individuals into the "domain of losses", making them aware of the dangers associated with the decision not to vaccinate their own children. An early meta-analysis by Witte and Allen (2000) revealed that fear appeals can actually increase the perception of the severity of the health threat inducing behaviour changes, at least as long as the individuals believe that they are able to protect themselves and avert the threat. Results from a comprehensive meta-analysis by Tannenbaum et al. (2015) showed that fear appeals are particularly effective at positively influencing attitudes, intentions, and behaviour under specific circumstances. Powerful persuasive messages like fear appeals seem also more successful when they recommend one-time behaviours (as is often the case for vaccination) compared with behaviours that should be repeated over an extended period of time (Robertson, 1978; Rothman, Martino, Bedell, Detweiler, & Salovey, 1999). However, the outcome of Nyhan et al.'s (2014) recent study did not corroborate the effectiveness of this approach. The images of sick children that they used to make risks more salient paradoxically increased beliefs in the false vaccine/autism link, a phenomenon they labelled danger-priming effect. Similarly, a study by Guillaumier et al. (2014) on the effectiveness of diverse anti-smoking messages showed that highly emotive warnings, which stressed the negative health effects of smoking via resonant texts and vivid pictures, did not motivate smokers to quit their behaviour. To achieve this aim, the use of a plain cigarette packaging proved to be more effective (Wakefield, Hayes, Durkin, & Borland, 2013).

Notwithstanding the centrality of the vaccine issue, there is little systematic research on correcting vaccine misinformation and we found no strong evidence recommending any specific intervention to address vaccines hesitancy (Betsch, Böhm, Chapman, 2015; Jarrett, Wilson, O'Leary, Eckersberger, & Larson, 2015; Larson et al., 2014). Therefore, the present study aims at adding to our knowledge by directly contrasting the effectiveness of three promising strategies employed to reduce vaccine misperceptions in a controlled experimental setting. More specifically, we sought to test the three information strategies discussed above, namely the myth vs. fact message

frame, the presentation of fact/icon boxes, and the use of fear appeals. Two research questions were raised: 1) to what extent can these different approaches influence people's vaccination beliefs and behaviour?; 2) does any of these approaches have a comparative advantage in terms of its ability to counter anti-vaccination attitudes, given the persistent effect of misinformation in influencing memory, reasoning and decision making, as well as the possibility of backfire effects? Finding answers to these questions can help to determine the best way to provide corrective information, undermining widespread vaccination myths, advancing our understanding of how people process information regarding controversial health issues, and ultimately improving public health.

5.2 Method

Participants

Participants were students from diverse departments of the University of Edinburgh, the Suor Orsola Benincasa University of Naples, and the Second University of Naples, resulting in an initial sample of 134 individuals. Participants were recruited via adverts, e-mail invitations, and snowball sampling. All participants gave their written informed consent and participated on a voluntary basis. The first wave of the study was completed by 134 respondents. We then re-contacted all participants from Wave 1. A total of 120 participants completed the second wave of the study (drop-out rate: 10%). Respondents who dropped out from the study and those who completed both waves did not differ on any relevant aspect. Our sample for all subsequent analyses consisted of the 120 participants who completed both waves of the study. Among those, 47 (39.2%) were men and 73 (60.8%) women. Mean age was 25.35 years (*SD* 3.52, range 19-34). Most participants had a Bachelor's (n. 46, 38.3%) or a Masters' degree (n. 63, 52.5%), while 11 respondents (9.2%) were PhD students. The study received ethical approval from the Psychology Research Ethics Committee of the University of Edinburgh. Data collection was conducted from March to June, 2016.

Materials

Questionnaires. All participants in the study completed two questionnaires (see Appendix C). The first questionnaire was a preliminary survey aimed at assessing participants' baseline beliefs and attitudes towards vaccines, which has been used in previous studies (Freed, Clark, Butchart, Singer, & Davis, 2010; Nyhan et al., 2014). It consisted of 8 items which covered common attitudes from both the pro- (e.g., "Getting vaccines is a good way to protect my future child(ren) from disease") and the anti-vaccination side (e.g., "Some vaccines cause autism in healthy children"). Participants were asked to indicate their degree of agreement with each statement on a 5-point Likert scale, ranging from 1 (= strongly disagree) to 5 (= strongly agree). The second questionnaire was a post-manipulation survey that assessed whether and how participants' beliefs and attitudes toward vaccines changed compared to the baseline measure. The three-item post-manipulation survey has also been used in previous studies (Nyhan et al., 2014). The first item evaluated general misperceptions about vaccines causing autism ("Some vaccines cause autism in healthy children") with a 5-point Likert scale, ranging from 1 (= strongly disagree) to 5 (= strongly agree). Item two investigated beliefs about vaccines side effects ("Children vaccinated against measles, mumps, and rubella will suffer serious side effects") with a 6-point Likert scale, ranging from 1 (= very unlikely) to 6 (= very likely). The third item asked participants to evaluate how likely they would be to give MMR vaccine to their child on a 6-point Likert scale, ranging from 1 (= very unlikely) to 6 (= very likely). This post-manipulation survey was administered twice, immediately after the correction interventions ('Time 1') and after a 7-day delay to evaluate the longevity and robustness of the observed effects ('Time 2').

Correction interventions. Participants could be exposed to one of 4 experimental conditions. Examples of messages for each condition are presented in Figures 5.1, 5.2, and 5.3. In the first condition (*Myths vs. Facts Correction*), participants received a booklet confronting 10 "myths" with a number of "facts". Each page of the leaflet contrasted a popular erroneous belief about vaccination (e.g., low perception of vaccine efficacy, safety concerns about immune overload, fear of the alleged presence of toxic poisons and chemicals in vaccines, etc.) with established evidence intended at decreasing the acceptance of that myth. Myth/fact #10

specifically addressed the common misconception about the link between MMR vaccine and autism (Figure 5.1). The text for this intervention, which was taken nearly verbatim from the WHO's (World Health Organization) website, was displayed in a columnar format, with the "myth" and "fact" headings on each column to avoid any ambiguity. The length of each myth and fact was matched to reduce the risk of individuals devoting more attention to one text rather than the other.

In the second condition (*Visual Correction*), participants viewed a series of tables comparing the potential problems caused by measles, mumps, and rubella with the potential side effects caused by the MMR vaccine (Figure 5.2). Each table showed the chance of various outcomes for people who do and do not get vaccinated. In order to test the effectiveness of graphic material as a communication device, the MMR Decision Aid presented in the NCIRS' (National Centre for Immunization Research & Surveillance) website was adapted for this intervention.

In the third condition (*Fear Correction*) participants were presented with pictures of unvaccinated children with measles, mumps, and rubella, along with the description of the symptoms of each disease and a brief warning about the importance of vaccinating one's own child (Figure 5.3). Materials for this intervention were drawn from the IDPH's (Illinois Department of Public Health) website. The brief warning in the instructions, formulated in personalised language (i.e., "The following images show some of the consequences *you* may face choosing to not vaccinate *your* child"), emphasized the similarities between the victims of these diseases and participants' actual or future children to increase perceptions of susceptibility.

Finally, in the control condition (*Control*) participants read two unrelated fact sheets containing tips to help prevent medical errors (Agency for Healthcare Research and Quality, December 2014) and get safer healthcare (Agency for Healthcare Research and Quality, October 2014). All the intervention materials are available in Appendix D.

Figure 5.1. *Example of message for the Myths vs. Facts Correction*

MYTH	FACT
A 1998 study showed that the MMR vaccine causes autism, because some signs of autism appear around the same age that children receive the MMR vaccine against measles, mumps, and rubella.	There is no evidence of a link between the MMR vaccine and autism. The 1998 study which first suggested this link was later found to be seriously flawed and the paper was retracted.

Figure 5.2. *Example of message for the Visual Correction*

This message compared the potential problems caused by measles with the potential problems caused by the MMR vaccine. Common and usually mild symptoms that can be treated at home are represented in green, moderate complications that need medical attention but may not include hospitalisation are portrayed in yellow, and serious complications that need urgent medical attention and could include hospitalisation are marked in red.

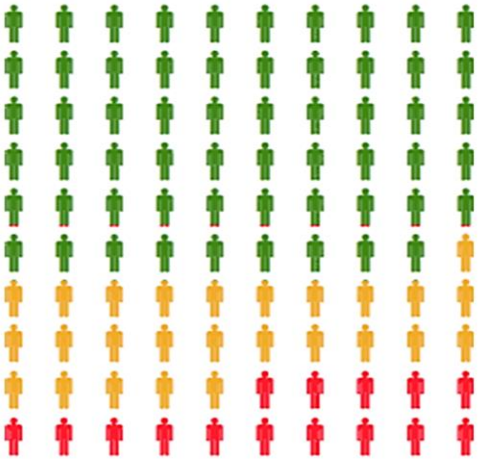
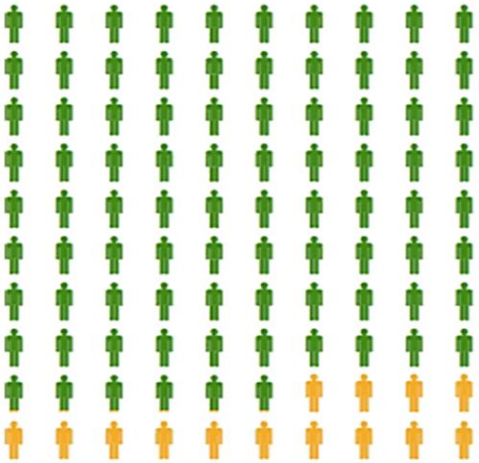
POTENTIAL RISKS IN A GROUP OF 100 CHILDREN UNDER 5 YEARS OF AGE WHO GET MEASLES	POTENTIAL RISKS IN A GROUP OF 100 CHILDREN WHO HAVE THE MMR VACCINE
	
Most children will have the common and usually mild **(in green)** symptoms of measles e.g. fever, cough, runny nose, red, painful eyes, rash. Some may have more than one of these symptoms at the same time.	Most will have common and usually mild **(in green)** symptoms of the MMR vaccine e.g. pain or swelling at the injection site, joint pain and stiffness. Some may have more than one of these symptoms at the same time.
26 in 100 may have moderate **(in yellow)** symptoms: • **12** may have diarrhoea; • **14** may get an ear infection.	**14** in 100 may have moderate **(in yellow)** symptoms: • **4** may have high fever; • **4** may be irritable; • **1** may have swelling of salivary glands; • **5** may have a non-infectious faint red rash.

Figure 5.3. *Example of message for the Fear Correction*

This message was accompanied by a picture of a child with swelling at the side of the face under the ears.

MUMPS

The mumps virus causes fever, headaches and swollen salivary glands under the jaw.

Children who get mumps may develop meningitis (inflammation of the covering of the brain and spinal cord) and encephalitis (inflammation of the brain).

Mumps can also result in permanent hearing loss.

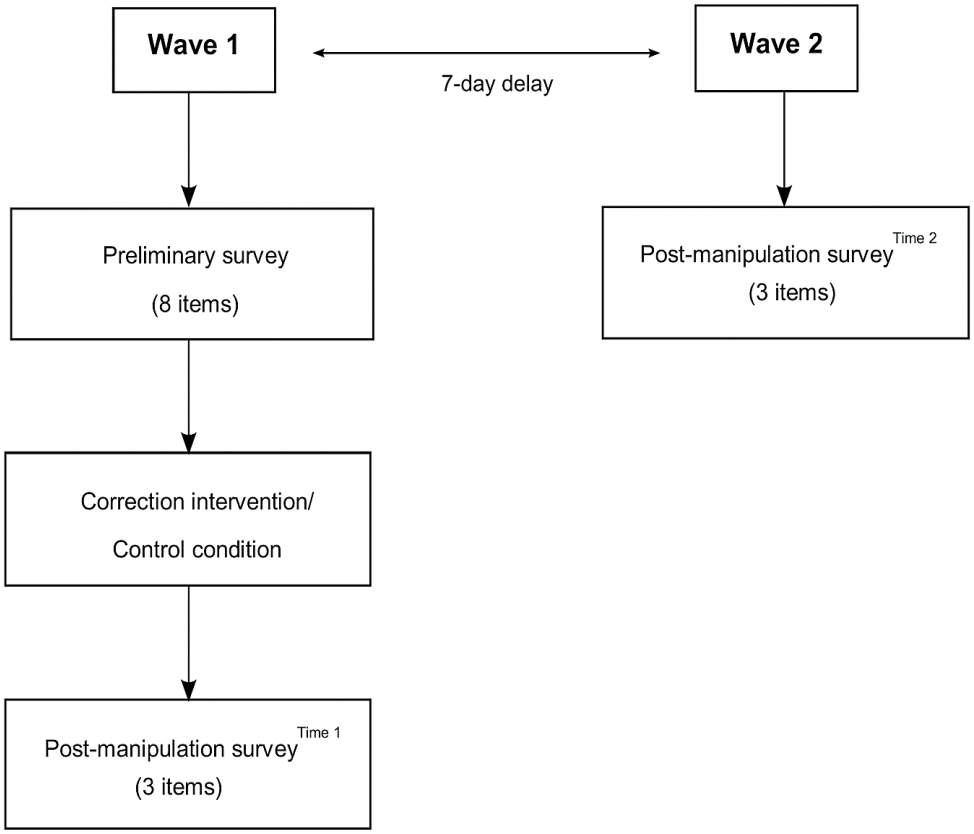
5.3 Procedure

Participants were informed at the outset that the experiment consisted of two parts or sessions, both seeking to gather their opinions about vaccines (Figure 5.4). After providing some demographic details (i.e., sex, age, educational level), all participants completed the preliminary survey aimed at assessing their baseline beliefs and attitudes towards vaccines. Next, participants were randomly assigned to 1 of the 4 conditions, namely the Myths vs. Facts Correction, the Visual Correction, the Fear Correction, or the Control Condition. Participants were unaware of the other experimental conditions and researchers were blind to condition allocation until printed materials were delivered to the study participants. After the experimental intervention, all participants completed the post-manipulation survey (*Time 1*), evaluating their beliefs in the link between vaccines and autism, in vaccines side effects, and vaccination intention. After a 7-day delay, all participants were re-contacted to participate in the second wave of the study during which the same questions of the post-manipulation survey were asked again (*Time 2*). At the end of the second session, participants were carefully debriefed. The researcher made the actual purpose of the study clear, revealing the experimental condition to which each participant was assigned and asking whether he/she had any questions about the study. Lastly, participants were thanked and compensated.

Three key outcomes were evaluated: individual beliefs in vaccines causing autism (*Vaccines Cause Autism*) and side effects (*Vaccines Side Effects*), and intention to vaccinate (*Vaccine Hesitancy*). As these outcomes were collected twice for all the participants, our study design consisted of one between-subject variable (*Correction*

Intervention) with four levels (*Myths vs. Facts Correction*, *Visual Correction*, *Fear Correction*, and *Control*), and three within-subject variables (*Vaccines Cause Autism*, *Vaccines Side Effects*, and *Vaccine Hesitancy*), each with two levels (*Time 1* and *Time 2*).

Figure 5.4. *Overview of the different phases of the study*



5.4 Results

Data were stored and analysed using SPSS (version 20).

For ease of interpretation, the item evaluating one's vaccination intent was reverse-coded so that higher values indicated higher vaccine hesitancy. Therefore, all 3 key outcomes were in the same direction as higher means indicated stronger vaccine misconceptions.

To determine whether correction interventions had a time-varying effect or resulted in null effect on vaccination attitudes, different mixed-design ANOVAs were

performed on the whole sample, with independent measure on correction interventions (treated as a between-subjects variable) and repeated dependent measures on the three items/outcomes of the post-manipulation survey, i.e., *Vaccines Cause Autism*, *Vaccines Side Effects*, and *Vaccine Hesitancy* (treated as within-subjects variables). When significant interactions between correction interventions and time were found, separate estimates of simple main effects were carried out. Finally, to test whether the difference between outcomes measurements at Time 1 and Time 2 was statistically significant, we created 'change scores' for each of the 3 key outcomes (*Vaccines Cause Autism*, *Vaccines Side Effects*, and *Vaccine Hesitancy*), which were computed as the difference between mean outcomes scores at Time 2 and Time 1.

For multiple comparisons between groups, Tukey's HSD correction method was applied. Significance was accepted at $p < .05$ for all statistical analyses.

Table 5.1 indicates means and standard deviations for the outcomes at Time 1 and Time 2 in the whole sample. Following Table 1, the three sub-sections address our three key outcome measures.

Table 5.1. *Descriptive statistics (means and standard deviations) for the outcomes at Time 1 and Time 2*

	Time 1		Time 2	
	M	*SD*	*M*	*SD*
Vaccines Cause Autism	1.8	.9	2.12	.93
Vaccines Side Effects	2.1	1	2.72	1.3
Vaccine Hesitancy	1.66	.83	2.02	.92

Beliefs in vaccines/autism link

Concerning beliefs in the vaccines/autism link, there was a statistically significant interaction between correction interventions and time [$F(3, 116) = 23.263$, $p < .001$, partial $\eta^2 = .376$]. The data in the conditions by time interaction are detailed in Figure 5.5A. Simple main effect for condition revealed that there was a statistically significant difference in these beliefs between interventions at Time 1 [$F(3, 116) = 6.183$, $p = .001$, partial $\eta^2 = .138$]. Indeed, beliefs in the vaccines/autism link were significantly greater in the fear correction intervention compared to the myths vs. facts (M = .83,

SE = .22, p = .001) and visual condition (M = .8, SE = .22, p = .002). A statistically significant difference in these beliefs between interventions was also detected at Time 2 [F(3, 116) = 8.194, p < .001, partial η^2 = .175]. This time, beliefs in the vaccines/autism link were statistically significantly higher in the myths vs. facts condition compared to the visual (M = .97, SE = .22, p < .001) and control condition (M = .8, SE = .22, p = .002), and in the fear condition compared to visual condition (M = .67, SE = .22, p = .016). Simple main effect for time confirmed that there was a statistically significant effect of time on beliefs in the vaccines/autism link for the myths vs. facts [F(1, 29) = 31.508, p < .001, partial η^2 = .521] and the visual condition [F(1, 29) = 4.462, p = .043, partial η^2 = .133]. Pairwise comparisons indicated that these beliefs were statistically significantly higher at Time 2 compared to Time 1 for both the myths vs. facts (M = 1.13, SE = .2, p < .001) and visual condition (M = .13, SE = .06, p = .043).

As shown in Figure 5.6A, there was a significant difference between conditions in *Vaccine Cause Autism Change Score* [F(3,116) = 23.263, p < .001]. This effect was driven by the myths vs. facts condition, which led to larger changes in scores and therefore strongest beliefs in vaccines causing autism compared to the other two correction interventions, that is the visual (M = 1, SE = .16, p < .001) and the fear condition (M = 1.13, SE = .16, p < .001), and the control condition (M = 1.13, SE = .16, p < .001).

Beliefs in vaccines side effects

Concerning beliefs in vaccines side effects, there was a statistically significant interaction between interventions and time [F(3, 116) = 18.914, p < .001, partial η^2 = .328]. The data in the conditions by time interaction are detailed in Figure 5.5B. Simple main effect for condition revealed that there was a statistically significant difference in these beliefs between interventions at Time 1 [F(3, 116) = 3.651, p = .015, partial η^2 = .086]. Beliefs in vaccines side effects were statistically significantly higher in the fear correction intervention compared to the myth vs. facts (M = .67, SE = .24, p = .035), visual (M = .63, SE = .24, p = .05), and control condition (M = .67, SE = .24, p = .035). A statistically significant difference in beliefs concerning vaccines side effects between interventions was also detected at Time 2 [F(3, 116) = 32.919, p < .001, partial

η^2 = .46]. Again, beliefs in vaccines side effects were statistically significantly greater in the fear correction intervention compared to the myth vs. facts (M = 1.57, SE = .25, p < .001), visual (M = 2.07, SE = .25, p < .001), and control condition (M = 2.17, SE = .25, p < .001). Simple main effect for time revealed that there was a statistically significant effect of time on beliefs in vaccines side effects for the myths vs. facts [F(1, 29) = 9.207, p = .005, partial η^2 = .241] and fear intervention [F(1, 29) = 96.000, p < .001, partial η^2 = .768]. Pairwise comparisons indicated that these beliefs were statistically significantly higher at Time 2 compared to Time 1 for both the myths vs. facts (M = .7, SE = .23, p = .005) and fear condition (M = 1.6, SE = .16, p < .001).

There was also a significant difference between conditions in *Vaccines Side Effects Change Score* [F(3,116) = 18.914, p < .001] (Figure 5.6B). This time, this effect was driven by the fear condition, which led to larger changes in scores and therefore strongest beliefs in vaccines causing side effects than the other two correction interventions, that is the myths vs. facts (M = .9, SE = .22, p = .001) and the visual condition (M = 1.43, SE = .22, p < .001), and the control condition (M = 1.5, SE = .22, p < .001).

Vaccine hesitancy

Concerning vaccine hesitancy, there was a statistically significant interaction between interventions and time [F(3, 116) = 2.828, p = .042, partial η^2 = .068]. The data in the conditions by time interaction are detailed in Figure 5.5C. Simple main effects for condition revealed that there was a statistically significant difference in vaccination intentions between interventions at Time 1[F(3, 116) = 3.613, p = .015, partial η^2 = .085]. Vaccine hesitancy was statistically significantly higher in the myths vs. facts condition compared to the fear condition (M = .67, SE = .21, p = .01). A statistically significant difference in vaccination hesitancy between interventions was also detected at Time 2 [F(3, 116) = 6.413, p < .001, partial η^2 = .142]. Vaccine hesitancy was statistically significantly higher in the myths vs. facts condition compared to the fear (M = .6, SE = .22, p = .04) and control condition (M = .97, SE = .22, p < .001). Simple main effects for time showed that there was a statistically significant effect of time on vaccination intentions for the fear condition [F(1, 29) = 20.605, p < .001, partial η^2 =

.415]. Pairwise comparisons indicated that vaccine hesitancy increased over time (M = .6, SD = .13, $p < .001$).

There was a significant difference between conditions in *Vaccine Hesitancy Change Score* [F(3,116) = 2.828, $p = .042$], (Figure 5.6C) as the fear correction led to larger changes in scores and higher vaccine hesitancy than the control condition (M = .6, SE = .23, $p = .045$).

Figure 5.5. *Mean scores of the 3 key outcomes evaluated: Vaccines Cause Autism (A), Vaccines Side Effects (B), and Vaccine Hesitancy (C) by condition and time (after a week).* Outcomes means at Time 1 are represented by blue bars, while outcome means at Time 2 by green bars. Error Bars: 95% CI.

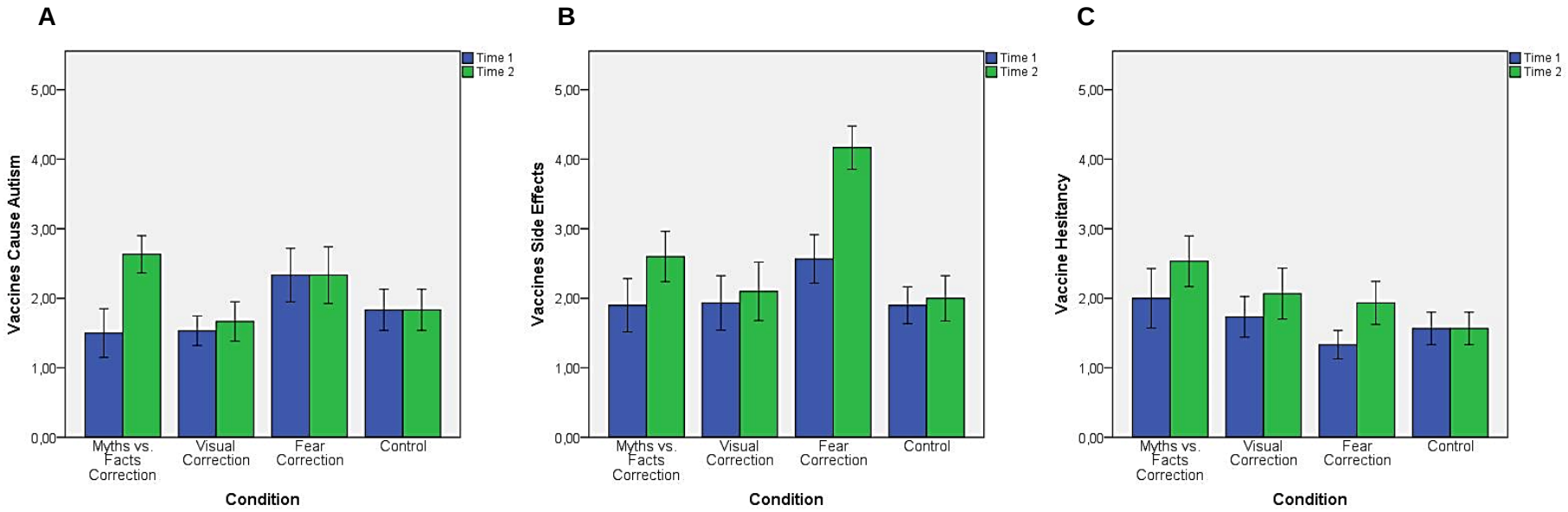
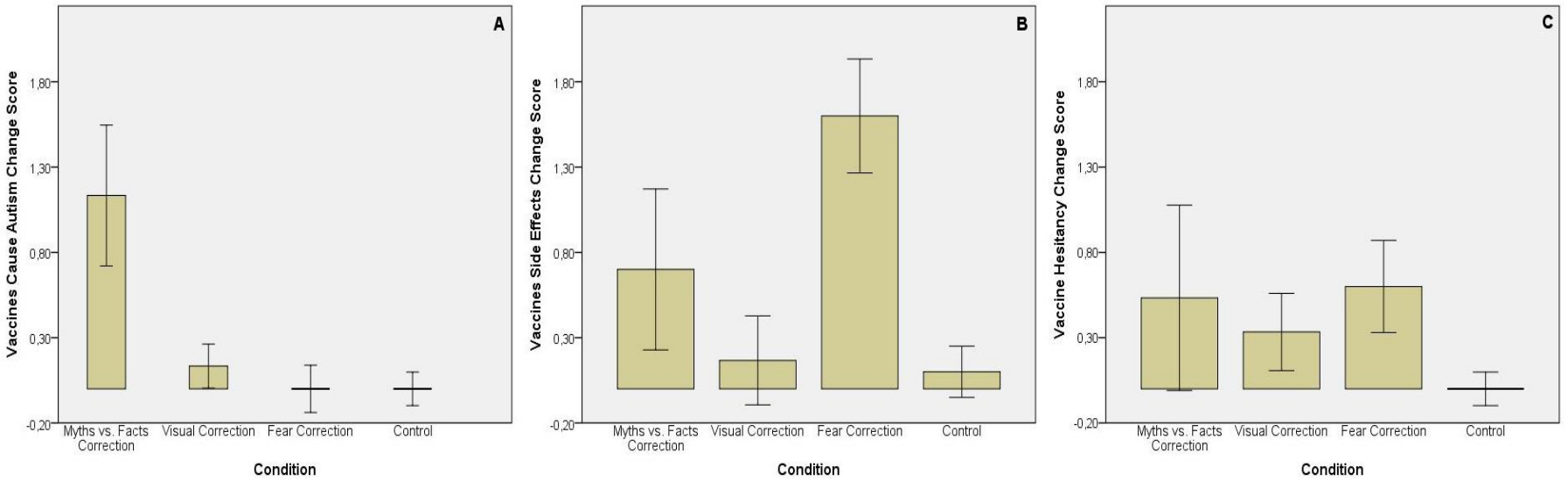


Figure 5.6. *Change scores for the 3 key outcomes evaluated: Vaccine Cause Autism Change Score (A), Vaccines Side Effects Change Score (B), and Vaccine Hesitancy Change Score (C) across conditions.* Error Bars: 95% CI.



5.5 Discussion

The serious psychological and social implications of the persistence of incorrect information have been under investigation for decades, although interest has intensified in recent years, arguably because of the increasing presence of misinformation regarding relevant and sensitive topics, such as health care. The present study addressed the pertinent case of misinformation about vaccines. The correction of vaccine misinformation has become an urgent priority to assure the continued success of immunization programs. In this respect, some authors advocated the need to carefully test pro-vaccination messaging before making it public, especially given the risk of backfire effects, whereby messages created with a pro-social intent can result in the targeted attitude or behaviour at issue actually becoming worse (Nyhan & Reifler, 2015; Nyhan et al., 2014). However, there has been little systematic comparison of different forms of correction of vaccine misinformation.

In this study, we provided a direct test of corrections on factual beliefs about vaccines, investigating the different impact of three common strategies used to promote vaccination. These were the use of the myth vs. fact message frame, the presentation of fact/icon boxes, and a format involving fear-inducing material. We outlined two core questions to evaluate the continued influence effect of misinformation. The first question concerned the extent to which these different techniques supported people's updating process of information, being effective in discounting or at least reducing vaccine misperceptions. The second question was constrained by the answer to the previous one and reconnected to the issue of memory: in other words, to what extent the various effects described in this study faded, were amplified, or backfired over time? As our primary concern was in the phenomenon by which misinformation in memory can affect later inferences and behaviours, we incorporated a delay in our design to evaluate the effectiveness of the aforementioned strategic messages over time, with a particular interest in explaining possible backfire effects.

Our study provided further support to the growing literature showing how corrective information may have unexpected and even counter-productive results. Specifically, we found that the myths vs. facts format, at odds with its aims, induced stronger beliefs in the vaccine/autism link and in vaccines side effects over time,

lending credit to the literature showing that countering false information in ways that repeat it may further contribute to its dissemination (Schwarz et al., 2007). Also the exposure to fear appeals through images of sick children led to more increased misperceptions about vaccines causing autism. Moreover, this corrective strategy induced the strongest beliefs in vaccines side effects, highlighting the negative consequences of using loss-framed messages and fear appeals to promote preventive health behaviours (Erceg-Hurn & Steed, 2011; Guillaumier, 2014). Our findings also suggest that no corrective strategy was useful in enhancing vaccination intention. Compared to the other techniques, the usage of fact/icon boxes resulted in less damage but did not bring any effective result.

Our pattern of results thus confirms that there should be more testing of public health campaign messages. This is especially true because corrective strategies may appear effective immediately yet backfire even after a short delay, when the message they tried to convey gradually fades from memory, allowing common misconceptions to be more easily remembered and identified as true (Schwarz et al., 2007). This is the case for one of the most frequently used corrective strategy employing the myths versus facts format, which often backfires because the simple repetition of the myth, though well-intended and necessary in order to contrast it with the available evidence, paradoxically amplifies the familiarity of that false claim making it seem even more believable and widely-shared (Schwarz et al. 2016). This happens, at least partly, because people tend to mistake repetition for truth, a phenomenon known as the "illusory truth" effect (Dechêne et al., 2010; Hasher et al., 1977). Familiarity appears as a key determinant of this effect; indeed, when something seems familiar is easier to process and one is more inclined to believe it (Peter & Koch, 2016), regardless of whether the statement is factually true or false (Hasher et al., 1977; Gigerenzer, 2014) or was initially rated as credible or questionable (Arkes, Hackett, & Boehm, 1989).

Multiple explanations have been proposed for the continued influence of misinformation. A strong argument is that, once a belief is formed, people generate explanations that fit and further reinforce this belief and tend to vigorously reject counter-arguments that make them uncomfortable, regardless of their validity (Nyhan & Reifler, 2010). People's worldview, or personal ideology, can indeed override unwelcome facts and determine the effectiveness of retractions, which can even

backfire when they are attitude-incongruent and strengthen the initial held beliefs (i.e., "attitude bolstering"; Prasad et al., 2009). This effect can be better understood within a cognitive consistency perspective (Festinger, 1957), according to which rejecting a belief would generate numerous inconsistencies that threaten one's self-concept. To reduce the emerging fear they may feel, people (especially those with high personal or partisan stakes on the issue in question) can engage in different defensive mechanisms, which are likely to appear in combination and may include selective exposure (engaging in a biased search process, seeking out information from outlets that supports ones' preconceptions), source derogation (dismissing the validity of the source of the unwelcome corrective information), social validation (bringing to mind others who held the same view), and even reactance (coming to support one's original opinion even more strongly, which is a classic backfire effect).

Another explanation for the lingering effect of misinformation assumes that people build mental models of unfolding events. If a central piece of the model is invalidated, people are left with a gap in their knowledge of the event, whose representation simply does not make any sense unless one decides to maintain the false and invalidated information. Thus, feeling uncomfortable with gaps in their understanding, people prefer a more readily available and complete model, albeit inaccurate, over a correct but incomplete one, sticking to the original idea and ignoring the retraction (Lewandowsky et al., 2012).

Presumably, a golden strategy capable of overcoming all the intricacies of setting people straight, regardless of their basic beliefs and/or temporal shifts, does not exist. Public information campaigns may instead benefit from tailoring different, simultaneous, and frequent interventions to increase the likelihood of corrective messages' dissemination and acceptance (Jarrett et al., 2015). Ideally, corrective strategies should be directed at the precise factors that may influence vaccination decision-making and impede vaccine uptake, which include, over and beyond strong attitudes against vaccines, social norms pushing individuals to conform to the majority's behaviour, standards for vaccine uptake in a specific population, and structural barriers to vaccination such as potential financial costs of vaccines and their ease of access. Successful interventions should therefore be targeted to differently "driven" vaccine-hesitant individuals. For instance, when people do not vaccinate

because they lack confidence in vaccines, corrective strategies should dispel vaccination myths, or when people do not vaccinate because perceived risks outweigh benefits, interventions should emphasize the social benefit deriving from vaccination and add incentives (Betsch et al., 2015). However, the inter-relationship of multi-level factors which contribute to vaccine hesitancy seems somewhat difficult to disentangle in order to make such targeted approach successful; indeed, the independent and relative impact of each determinant of vaccination choice is complex and context-specific, varying across time, place, and vaccines (Larson et al., 2014). What is clear, though, is the urgent need for appropriately designed, well-executed, and rigorously evaluated interventions to address parental vaccine refusal and hesitancy (Sadaf, Richards, Glanz, Salmon, & Omer, 2013).

Some aspects of our experimental procedures may limit the generalization of the findings. Firstly, we used a convenience sample with limited variability in age and educational level. Future research should rely on more representative and specific samples (e.g., parents, health practitioners), as well as investigate possible moderating variables (e.g., age, education, socioeconomic status) to account for a broader range of individual differences in how people comprehend scientific information. Also, our participants were domiciled in Italy or Scotland, which raises the question of possible effects of between-country heterogeneity in vaccine attitudes, which might introduce uncontrolled variance into our data. To the best of our knowledge, comparative data on vaccine attitudes and uptake in the UK and Italy are still lacking. However, some studies report a general shift towards a more positive perception of vaccines in both countries (Impicciatore, Bosetti, Schiavio, Pandolfini, & Bonati, 2000; Smith, Yarwood, & Salisbury, 2007). Because our participants were randomly allocated to conditions, there is no reason to expect our results to be systematically biased by between-country heterogeneity. Because of the small sample size of our study, we are not able to ascertain whether these differences actually exist and are reflected in our findings. Nevertheless, we do not believe that the modest sample size (N = 120) in the present study may have limited the significance of the statistical comparisons conducted because a post-hoc power analysis (G*Power 3; Faul et al., 2007) revealed that there was an almost perfect 99% chance of correctly rejecting the null hypothesis of no significant effect of the interaction with a total sample size of 120 participants.

Secondly, self-reported vaccine uptake should be supplemented with objective data from primary records to produce a more reliable measure of uptake. Moreover, as beliefs can change and evolve dynamically over time, prospective longitudinal data are also needed to assess the robustness of changes in individual beliefs.

Notwithstanding these limitations, our findings offer a useful example of how factual information is misremembered over time. More importantly, our work can help public health authorities and practitioners to understand why it is necessary to adopt an appropriate strategy to influence people's beliefs and behaviours toward vaccination, which can result in better health outcomes for the individuals themselves and for society as a whole.

Given the relevance of this topic, in the next chapter I try to replicate the findings with a sample of real parents, rather than in a simulation with university students.

Chapter 6

Study 4: Parents' beliefs in misinformation about vaccines are strengthened by pro-vaccine campaigns

6.1 Introduction

Although vaccines are recognized by health authorities and the medical community as an important tool for reducing the incidence of life-threatening diseases, their acceptance among the general population is quite variable (Barrows, Coddington, Richards, & Aaltonen, 2015; Shrivastava, Shrivastava, & Ramasamy, 2016). According to recent World Health Organisation (WHO, 2018b) estimates, 1.5 million children die every year because of diseases that could have been prevented by vaccines. Like other European countries, Italy has recorded a dangerous decrease in childhood vaccination coverage rates, resulting in a widespread measles epidemic in 2017 (Ministry of Health, National Institute of Public Health, 2017; WHO, 2018a). In an attempt to prevent other outbreaks of potentially fatal diseases across the country, in July 2017 the Italian parliament made vaccinations compulsory for all children up to 16 years of age (Mantovani & Santoni, 2018). Whether mandatory vaccination is the best way to improve vaccine uptake rates remains debated (Editorial, 2018). However, ironically many parents no longer perceive a threat from a number of vaccine-preventable diseases, hold misconceptions about the safety of vaccines, and often decide against immunization because they are not confident in medical, public health, and government advice on vaccines (Myers & Pineda, 2009; Lewandowsky et al., 2017; Salmon et al., 2005; Smailbegovic, Laing, & Bedford, 2003).

Research on how people respond to corrections of misinformation has painted a rather pessimistic picture where the most salient misconceptions appear to be widely held, easily spread, and difficult to correct (Cook et al., 2015; Cook & Lewandowsky, 2011; Myers & Pineda, 2009; Nyhan & Reifler, 2012). This is true also for vaccines misinformation. It has been shown in an online study (Nyhan et al., 2014) and in Pluviano et al.'s (2017) previous laboratory experiment with university students that

campaigns intended to correct misinformation about vaccines are likely to have little or no effect or even backfire by entrenching anti-vaccination beliefs.

These difficulties in belief updating account for some of the uncertainty of immunization providers about how best to communicate with parents. One of the most commonly employed strategies used to debunk myths relies on the use of the "myths vs. facts" format, which is based on the idea of reiterating myths and then discrediting them with a number of facts (Yeh & Jewell, 2015). To illustrate, the myth is usually presented in form of a highlighted statement (e.g., "There is a link between the MMR shot and autism"), followed by a longer passage that contrasts it with scientific data about the actual situation (e.g., "Scientists have carefully studied the MMR shot. None has found a link between autism and the MMR shot"). In many cases, myths and facts are identified by clear labels or are directly followed by short claims such as "False!" and "True!", respectively (Peter & Koch, 2016).

A key problem with this technique is that repeating myths might contribute to increasing their acceptance due to their perceived familiarity. Several studies suggest, in fact, that people are more swayed when they hear an opinion more than once, confounding its familiarity with its validity (Dechêne et al., 2010; Weaver et al., 2007). The familiarity boost associated with this type of correction can be so counterproductive that it may cause a "familiarity backfire effect", such that the correction inadvertently increases individuals' beliefs in the very myth it is aiming to debunk (Cook & Lewandowsky, 2011; Lewandowsky et al., 2012; Swire et al., 2017). A number of studies have reported that myths are often misremembered as facts over time, corroborating the idea that campaigns using the myths vs. facts format may do more harm than good toward positive health behaviour (Nyhan et al., 2014; Pluviano et al., 2017; Peter & Koch, 2016; Swire et al., 2017).

However, another theoretical framework that focuses on the salience of the misinformation during the correction suggests that repeating misinformation in the course of a retraction could facilitate memory updating. According to the co-activation hypothesis advanced by Kendeou, Walsh, Smith, & O'Brien (2014), refutation texts that directly state a belief incorrectly held by the reader and then refute that belief elicit the activation of both the erroneous and new information – the necessary first step in the knowledge revision process (Kendeou & O'Brien, 2015). Consistent with this

view, Pashler et al. (2013) found that reviewing erroneous information actually improves storage of new information. Similarly, according to Stadtler, Scharrer, Brummernhenrich, & Bromme (2013), as well as Putnam, Wahlheim, & Jacoby (2014), the detection of conflicting information, which is arguably more likely to occur if the correction explicitly refers to both the invalidated information and the new correct information, is beneficial for memory updating. Indeed, a study by Ecker et al. (2017) found that an explicit reminder or repetition of misinformation in the course of its retraction effectively reduces people's reliance on misinformation because it makes both the falsity of the misinformation and the conflict between the outdated and updated event representations salient. Finally, in the specific context of health misinformation, a study by Cameron et al. (2013) revealed that people exposed to facts, myths, and evidence to counteract those myths may gain more knowledge regarding a specific health topic and have a better recall accuracy than those merely presented with factual information.

Therefore, we face a conundrum: while some accounts indicate that the best strategy to counter vaccine misinformation is to emphasize the facts instead of drawing further attention to false information to avoid a familiarity backfire effect, other accounts suggest that if a myth is not repeated when corrected, the associated lack of salience, conflict detection, and myth/correction co-activation may be equally or even more detrimental to belief updating than the boost of the myth's familiarity (Swire et al., 2017).

Systematic reviews on the strategies for reducing vaccine hesitancy concluded that there is no convincing evidence to support one intervention over the other (Dubè Gagnon, & MacDonald, 2015; Sadaf et al., 2013). Acknowledging the need to identify the best ways to convince hesitant parents in an age of internet-fed misinformation, the current study aims to determine whether the myths vs. facts format can be considered an effective tool to counter vaccines misinformation. Since parental choice to decline childhood vaccinations is widely recognised as an important factor in suboptimal uptake (Brown et al., 2010; Tickner, Leman, & Woodcock, 2006) the method employed in the current study improves upon that of Pluviano et al. (2017) because the current study tests parents, rather than university students.

6.2 Method

Participants

A total of 60 Italian parents attending pediatricians' surgeries and nurseries in three Italian Regions were recruited for participation in the current study. Participants were divided into two groups, and randomly assigned half to the control condition (*Control*; 5 males and 25 females, average age M = 38.06, SD = 4.55 years) and half to the experimental condition (*Myths vs. Facts Correction*; 2 males and 28 females; average age M = 32.2, SD = 5.52 years). 41 participants had a high school education, while 19 had an academic degree. Both participants and researchers were blind to condition allocation. The study received ethical approval from the University of Edinburgh's ethic panel. Written informed consent was obtained from each participant.

Materials

Questionnaires. All participants in the study completed two questionnaires, which have been used in previous studies (Nyhan et al., 2014; Pluviano et al., 2017; see Appendix C). The first one was a preliminary survey aimed at assessing participants' baseline beliefs and attitudes towards vaccines. It consisted of 8 items covering common stances from both the pro- (e.g., "Getting vaccines is a good way to protect my future child(ren) from disease") and the anti-vaccination side (e.g., "Some vaccines cause autism in healthy children"). Participants were asked to indicate their degree of agreement to each statement on a 5-point Likert scale, ranging from 1 (= strongly disagree) to 5 (= strongly agree). The second questionnaire was a post-manipulation survey that assessed whether and how participants' beliefs and attitudes toward vaccines changed compared to the baseline measure. It consisted of three items. The first item ("Some vaccines cause autism in healthy children") evaluated general misconceptions about vaccines causing autism on a 5-point Likert scale, ranging from 1 (= strongly disagree) to 5 (= strongly agree). The second item ("Children vaccinated against measles, mumps, and rubella will suffer serious side effects") investigated beliefs about vaccine side effects on a 6-point Likert scale, ranging from 1 (= very unlikely) to 6 (= very likely). Lastly, the third item asked participants to evaluate how likely they would be to give the MMR vaccine to their child on a 6-point Likert scale,

ranging from 1 (= very unlikely) to 6 (= very likely). This post-manipulation survey was given twice, immediately after the intervention and after a 7-day delay to evaluate the longevity and robustness of the observed effects.

Conditions. Control condition (*Control*) participants read some tips to help prevent medical errors and get safer healthcare, drawn from the AHRQ's (Agency for Healthcare Research and Quality) website. Experimental condition (*Myths vs. Facts Correction*) participants received a booklet confronting 10 "myths" with a number of "facts". Each page of the leaflet contrasted a popular erroneous belief about vaccination with established evidence intended at decreasing the acceptance of that myth. The text for this intervention, which was taken nearly verbatim from the WHO's (World Health Organization) website, was displayed in a columnar format, with the "myth" and "fact" headings on each column to avoid any ambiguity. The length of each myth and fact was matched to reduce the risk of individuals attending more to one text than the other.

6.3 Procedure

Participants were informed at the outset that the experiment consisted of two parts or sessions, both seeking to gather their opinions about vaccines. After providing some demographic details (i.e., gender, age, educational level), all participants completed the preliminary survey aimed at assessing their baseline beliefs and attitudes towards vaccines. Next, they were randomly assigned to the Control condition or the Myths vs. Facts Correction condition. All participants then completed the post-manipulation survey (*Time 1*), evaluating their beliefs in the link between vaccines and autism, in vaccines side effects, and vaccination intention. After a 7-day delay, all participants were re-contacted to participate in the second wave of the study during which the same post-manipulation questions were asked (*Time 2*). At the end of the second session, participants were carefully debriefed.

Three key outcomes were evaluated: individual beliefs in vaccines causing autism (*Vaccines Cause Autism*) and side effects (*Vaccines Side Effects*), and intention to vaccinate (*Vaccines Hesitancy*). As these outcomes were collected twice for all the participants, our study design consisted of one between-subject variable (*Conditions*) with two levels (*Myths vs. Facts Correction* and *Control*), and three within-subject

variables (*Vaccines Cause Autism*, *Vaccines Side Effects*, and *Vaccines Hesitancy*), each with two levels (*Time 1* and *Time 2*).

6.4 Results

Data were stored and analysed using SPSS (version 20). For ease of interpretation, the item evaluating vaccination intent was reverse-coded so that higher values indicated higher vaccine hesitancy. Therefore, all 3 key outcomes were in the same direction as higher means indicated stronger vaccine misconceptions.

To determine whether correction interventions had a time-varying effect or resulted in null effect on vaccination attitudes, different mixed-design ANOVAs were performed on the whole sample, with independent measure on conditions (treated as a between-subjects variable) and repeated dependent measures on the three items/outcomes of the post-manipulation survey, i.e., *Vaccines Cause Autism*, *Vaccines Side Effects*, and *Vaccines Hesitancy* (treated as within-subjects variables). When significant interactions between conditions and time were found, separate estimates of simple main effects were carried out.

Finally, to test whether the difference between outcomes measurements at Time 1 and Time 2 was statistically significant, we created "change scores" for each of the 3 key outcomes (*Vaccines Cause Autism*, *Vaccines Side Effects*, and *Vaccines Hesitancy*), which were computed as the difference between mean outcomes scores at Time 2 vs Time 1. Significance was accepted at $p < .05$ for all statistical analyses. Table 6.1 indicates means and standard deviations for the outcomes at Time 1 and Time 2 in the two subgroups. Following Table 6.1, the three sub-sections address our three key outcome measures.

Table 6.1. *Descriptive statistics (means and standard deviations) for the outcomes at Time 1 and Time 2 in the two subgroups.*

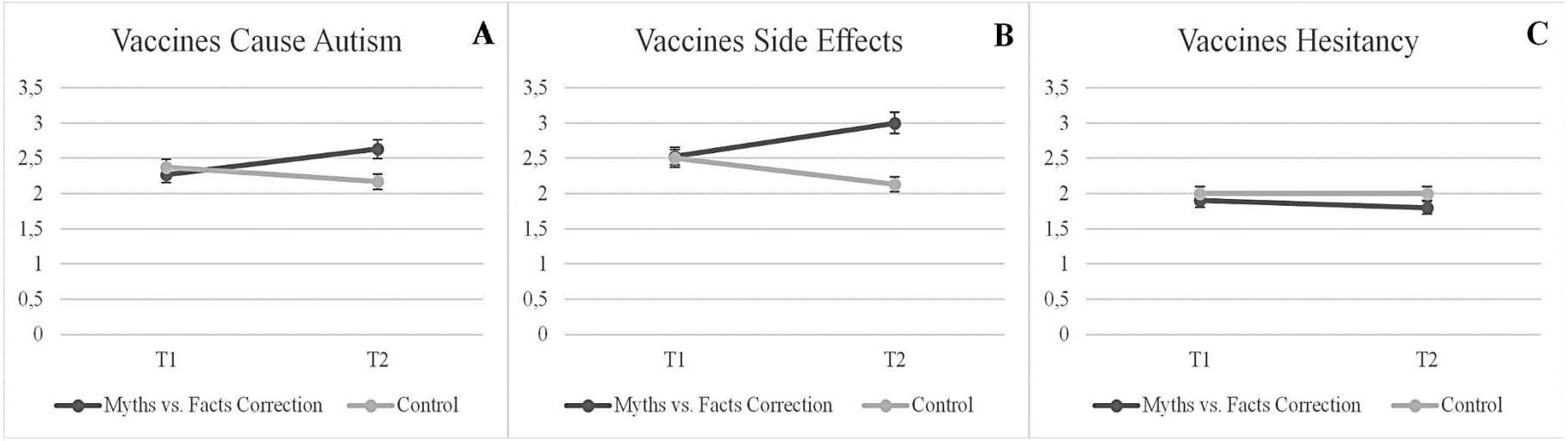
	Control				Myths vs. Facts Correction			
	Time 1		Time 2		Time 1		Time 2	
Outcomes	M	SD	M	SD	M	SD	M	SD
Vaccines Cause Autism	2.37	.89	2.17	.83	2.27	.74	2.63	.76
Vaccines Side Effects	2.5	.82	2.13	.73	2.53	.73	3	.87
Vaccines Hesitancy	2	1.2	2	1.29	1.9	1.02	1.83	.87

Beliefs in vaccines/autism link. Concerning beliefs in the vaccines/autism link, there was a statistically significant interaction between correction interventions and time [$F(1, 58) = 14.133$, $p < .001$, partial $\eta^2 = .196$]. The data in the conditions by time interaction are detailed in Figure 6.1A. Simple main effect for condition revealed that there was a statistically significant difference in these beliefs between interventions at Time 2 [$F(1, 58) = 5.102$, $p = .028$, partial $\eta^2 = .081$]. Indeed, beliefs in the vaccines/autism link were significantly greater in the myths vs. facts condition (M = 2.63, SD = .76) compared to the control (M = 2.17, SD = .84) condition. Simple main effect for time confirmed that there was a statistically significant effect of time on beliefs in the vaccines/autism link for both the myths vs. facts [$F(1, 29) = 9.021$, $p = .005$, partial $\eta^2 = .237$] and control condition [$F(1, 29) = 5.118$, $p = .031$, partial $\eta^2 = .150$]. Pairwise comparisons indicated that these beliefs were statistically significantly higher at Time 2 compared to Time 1 for the myths vs. facts condition (M = .367, SE = .122, $p = .005$) and, conversely, lower at Time 2 compared to Time 1 for the control condition (M = -.200, SE = .088, $p = .031$). Furthermore, there was a significant difference between the two conditions in *Vaccines Cause Autism Change Score* [$F(1, 58) = 14.133$, $p < .001$], with the myths vs. facts condition leading to larger changes in scores and therefore strongest beliefs in vaccines causing autism (M = .37, SD = .67), compared to the control condition (M = -.2, SD = .5).

Beliefs in vaccines side effects. Concerning beliefs in vaccines side effects, there was a statistically significant interaction between conditions and time [$F(1, 58) = 19.852$, $p < .001$, partial $\eta^2 = .255$]. The data in the conditions by time interaction are detailed in Figure 6.1B. Simple main effect for condition revealed that there was a statistically significant difference in these beliefs between interventions at Time 2 [$F(1, 58) = 17.441$, $p < .001$, partial $\eta^2 = .231$]. Indeed, beliefs in vaccines side effects were significantly greater in the myths vs. facts condition (M = 3, SD = .87) compared to the control condition (M = 2.13, SD = .73). Simple main effect for time revealed that there was a statistically significant effect of time on beliefs in the vaccines side effects for both the myths vs. facts [$F(1, 29) = 9.733$, $p = .004$, partial $\eta^2 = .251$] and control [$F(1, 29) = 10.666$, $p = .003$, partial $\eta^2 = .269$] condition. Pairwise comparisons indicated that these beliefs were statistically significantly higher at Time 2 compared to Time 1 for the myths vs. facts condition (M = .467, SE = .15, $p = .004$) and, conversely, lower at Time 2 compared to Time 1 for the control condition (M = -.367, SE = .112, $p = .003$). Furthermore, there was a significant difference between the two conditions in *Vaccines Side Effects Change Score* [$F(1, 58) = 19.852$, $p < .001$], with the myths vs. facts condition leading to larger changes in scores and therefore strongest beliefs in vaccines side effects (M = .47, SD = .82), compared to the control condition (M = -.37, SD = .61).

Vaccines hesitancy. Concerning vaccine hesitancy, there was no statistically significant interaction between interventions and time [$F(1, 58) = .326$, $p = .570$, partial $\eta^2 = .006$]. Simple main effects for condition revealed that there was no statistically significant difference in vaccination intentions between the two groups [$F(1, 58) = .226$, $p = .636$, partial $\eta^2 = .004$]. Also, simple main effects for time showed that there was no statistically significant effect of time on vaccination intentions regardless of group [$F(1, 58) = .326$, $p = .570$, partial $\eta^2 = .006$].

Figure 6.1. *Mean scores of the 3 key outcomes evaluated: Vaccines Cause Autism (A), Vaccines Side Effects (B), and Vaccines Hesitancy (C) by condition and time*



6.5 Discussion

Numerous strategies have been attempted in an effort to increase vaccination rates (Jarrett et al., 2015). However, debate still continues about the best ways to convince hesitant parents to vaccinate their children, mainly because extant studies often have a limited scope, differ in approach, and contradict one other (Kupferschmidt, 2017). This is very much the case for one of the most commonly employed strategies to counter vaccine misinformation, which employs the myths vs. facts format. While a number of studies warn about correcting misinformation in this way because it is often ineffective and even counterproductive (Nyhan et al., 2014; Peter & Koch, 2016; Pluviano et al. 2017; Skurnik et al., 2005), other studies revealed a stronger belief updating with explicit repetitions of misinformation while correcting (Ecker et al., 2017; Kendeou et al., 2014; Pashler et al., 2013; Putnam et al., 2014; Stadtler et al., 2013).

The present study aimed to assess the potential effectiveness of the myths vs. facts strategy to address vaccine hesitancy, focusing on its impact on belief changes and vaccination intention in parents. Results provided support for the existence of backfire effects associated with the use of this information strategy, with participants in the Myths vs. Facts condition having stronger vaccine misconceptions over time, both in terms of beliefs in the vaccines/autism link and in vaccines side effects, compared with participants in the Control condition. As for vaccination intention, the analyses did not reveal any significant differences between the Myths vs. Facts and Control group. However, this is not particularly surprising considering Italy's recent introduction of compulsory vaccination which coincided with the period when we were gathering data and which means that Italian parents no longer have a choice over whether or not to vaccinate against MMR.

The myths vs. facts technique, which is one of the most common strategies adopted to counteract vaccine misinformation, was found to be ineffective on its own. Clearly, countering vaccines misinformation with education, providing people with more or better information, is necessary but not sufficient to address the issue (Kata, 2012). Vaccination hesitancy is, in fact, intertwined with a range of subtle cognitive mechanisms and biases such as motivated reasoning (i.e., clinging to pre-existing beliefs despite contrary evidence to avoid cognitive dissonance; Festinger, 1957).

Furthermore, measures countering misinformation should also be informed by the larger political, technological, and societal context. For instance, factors likely to influence parents' decision-making may include the salience of social norms, vaccination uptake in the population, and the presence of structural barriers in terms of access to vaccination and potential financial costs (Betsch et al., 2015). Also, to counteract the loss of societal fear, it is critical to communicate the risks associated with the diseases in an accessible way (Myers & Pineda, 2009). Ultimately, getting immunizations is fundamentally a matter of trust. The parent's trust in his/her doctor and, more generally, in science and institutions also plays a part in shaping individual vaccination decisions (Kupferschmidt, 2017). Misinformation research suggests that expertise may not be a very relevant factor here; rather, when people encounter a piece of information, they ask themselves whether and to what extent it fits in with what other people – and particularly trusted others – already believe, which obviously may open up to biases if what other people believe is based on misinformation (Festinger, 1957; Guillory & Geraci, 2013).

A post-hoc power analysis (G*Power 3; Faul et al., 2007) revealed there was a 97% chance of correctly rejecting the null hypothesis of no significant effect of the interaction for a total of 60 participants. Moreover, the sample used generalizes well to the population of parents who are exposed to information, and misinformation, regarding the risks of vaccinating their children. However, as beliefs can change and evolve dynamically over time, prospective longitudinal research should be carried out to assess the robustness of changes in individual beliefs.

Taken together, the evidence from this study concurs well with the literature showing how people exposed to corrections based on the myths vs. fact format might systematically misremember the truth of misinformation and change their attitudes accordingly even after a short delay (Nyhan et al., 2014; Pluviano et al., 2017; Skurnik et al., 2005).

Worryingly, the take home message from Study 4 and Study 5 is that retractions may be ineffective. Even worse, the studies demonstrated that there can be situations, such as those involved with decision-making about vaccinations, where retractions may be entirely ineffective, as they ironically backfire and increase the very misconception they are trying to correct. Therefore, what might be a better way of

going about the debunking? Since research on autobiographical memory suggests that social input is a key source of information used for evaluating the occurrence of events and that false beliefs can increase when a credible source of information suggests that a certain event happened (Mazzoni, Loftus, & Kirsch, 2001; Scoboria, Jackson, Talarico, Hanczakowski, Wysman, & Mazzoni, 2014; Wade & Garry, 2005), researchers could investigate whether social variables affect also the degree of acceptance or rejection of misinformation. Of particular importance is how people respond to the credibility of different sources, that is whether and to what extent they are more swayed in changing their mind if the retraction they receive comes from a perceived credible source. In the next chapter, I examine this very problem, that is the social influence that the credibility of a source may have on the acceptance of suggested information.

Chapter 7

Study 5: Correcting vaccines misinformation: The effects of source expertise and trustworthiness

7.1 Introduction

Despite being lauded as one of the greatest public health achievements of the 20th century, vaccines are losing public confidence (Larson et al., 2011), to the extent that some experts have described the problem as "a crisis of public confidence" (Black & Rappuoli, 2010, p. 1) and a "vaccination backlash" (Shetty, 2010, p. 970). The most important factor driving this decline in confidence is the wide dissemination of misinformation about the safety and efficacy of vaccines (Myers & Pineda, 2009). As with several other instances of misinformation, vaccines misinformation is especially difficult to remove from memory because, even if individuals are presented with blatantly false information, their mind seems biased toward its retention and is highly resistant to correction attempts (Lewandowsky et al., 2012; Nyhan et al., 2014; Pluviano et al., 2017). An adding complexity is that people seem to understand information on the basis of the perceived credibility of its source, being unable to disregard misinformation if they receive a correction from a source perceived as not credible (Guillory & Geraci, 2013). Therefore, designing effective communication strategies for correcting vaccines misinformation supposes an understanding of how the target group might react to a certain type of source of information (Kumkale, Albarracín, & Seignourel, 2010). One critical aspect of this understanding is whether and for whom the credibility of the source of information matters, namely how people trust different sources involved with their vaccination decisions (Yaqub, Castle-Clarke, Sevdalis, & Chataway, 2014). Unfortunately, researchers and practitioners are finding it difficult to design effective pro-vaccination messages for two reasons. First, few principles of message persuasiveness derive from effective attempts to change anti-social or unhealthy attitudes and behaviours (Crano & Burgoon, 2002; McNeill,

Gravely, Hitchman, Bauld, Hammond, & Hartmann-Boyce, 2017), while many refer to quite distant contexts such as advertising (e.g., Gotlieb & Sarel, 2013; Nan, 2013). Therefore, the pro-vaccination messages are not properly informed by theory and previous research. Second, in many cases the messages can backfire and cause an increase in the very ill-founded beliefs targeted for change (Pluviano et al., 2017). The present study seeks to address the important yet neglected issue of the impact of source credibility in tailoring pro-vaccination messages.

Most theories in persuasion predict that highly credible sources produce more belief and attitude changes than less credible ones (Petty & Cacioppo, 1986; Pornpitakpan, 2004). However, source credibility is a complex concept. The most common notion of credibility encompasses two core dimensions: *expertise*, namely the extent to which the communicator is perceived to be capable of making correct assertions, and *trustworthiness*, that is the willingness of the communicator to provide the assertions he or she considers most valid (Hovland, Janis, & Kelley, 1953). The expertise and trustworthiness dimensions may have differential weights in affecting belief and attitude change and assessing them in combination may obscure the complexity of the source evaluation (Pornpitakpan, 2004). For example, Guillory and Geraci (2013) analysed the individual contribution of source trustworthiness and expertise in reducing political misinformation, revealing that source expertise was not sufficient to reduce erroneous inferences, while the trustworthiness of the source was the critical factor that led people to correct their inferences. They suggested that there could be situations in which expertise would be more relevant to the decision at hand as in medical decision making, encouraging further studies to test this hypothesis.

The current study provides the first empirical examination of whether erroneous inferences about vaccination could be effectively corrected by a source perceived as credible (i.e., expert or trustworthy). In particular, we seek to evaluate the relative effects of the source expertise and trustworthiness on people's ability to disregard misinformation and update their knowledge and memories, and subsequent effect of the source on people's stated intention to vaccinate their child.

7.1.1 Norming

Prior to running the actual experiments, a norming study was conducted to identify sources of information generally considered to be highly credible and not very credible within the health context. A separate group of participants, who did not take part in Experiment 5A or Experiment 5B, was used to this aim. This group consisted of 15 students from the University of Edinburgh (4 males, 11 females, mean age 22.4 years, age range 18-33 years), who participated on a voluntary basis and received course credit in exchange for their participation. Each participant read a fictitious story (see Appendix E) about a child presenting with ADHD (attention deficit hyperactivity disorder) after receiving the vaccine against "*Brainpox*", described as an illness that can be transmitted via airborne droplets and may cause symptoms such as fever, chills, and runny nose. Rare complications include convulsions, encephalitis, and even death.

The story was organized in 14 individual messages typed on separate pages and combined into a booklet, with 1 message per page. Participants were instructed to read through them, one at a time, at their own pace. Message no. 9 of the story was about a rumour of a possible link between the vaccine against *Brainpox* and ADHD, while message no. 13 revealed that this rumour had been shown to be untrue.

After reading the story, participants were given a list of sources of information that are frequently reported to be trusted by parents for vaccine-safety information (cf. Freed, Clark, Butchart, Singer, & Davis, 2011) and asked to judge how expert or trustworthy the correction in the story would be coming from each of the provided sources on a Likert scale ranging from 1 (= "*to little or no extent expert/trustworthy*") to 5 (= "*to a great extent expert/trustworthy*"). They first made expertise judgements for each of the sources and then they were given the same list of sources to rate on trustworthiness. According to the means of participants' ratings, sources of health information were differed as low-credibility ($M < 2$), neutral ($2 < M < 3$), and high-credibility ($3 < M < 4$) sources.

For Experiment 5A, I selected two sources of health information that differed on expertise, that is one source of information that normed high ("*Websites from doctor groups like the British Association of General Paediatrics*"; $M = 4.07$, $SD = .88$) and one source that normed low ("*Celebrities*"; $M = 1.33$, $SD = .62$) on expertise, but that were neutral on trustworthiness ($M = 2.73$, $SD = .7$ and $M = 2.06$, $SD = .97$,

respectively). Conversely, for Experiment 5B, I selected two sources of health information that differed on trustworthiness, that is one source of information that normed high ("*Family and friends*"; *M* = 3.13, *SD* = 1.06) and one source that normed low ("*Television programs*"; *M* = 1.47, *SD* = .64) on trustworthiness, but that were neutral on expertise (*M* = 2.13, *SD* = .83 and *M* = 2.13, *SD* = .62, respectively) (see Table 7.1 and Table 7.2).

Table 7.1. *Means and standard deviations for credibility ratings of sources of health information*

	Expertise		*Trustworthiness*	
Sources of health information	*M*	*SD*	*M*	*SD*
Parents who vaccinated their children	2.27	(.8)	2.93	(1.22)
Blogs from groups that support vaccines	2.2	(.56)	2.5	(.83)
Celebrities	1.33	(.62)	2.06	(.97)
Your personal doctor	4.07	(.46)	4.4	(.51)
Newspapers like The Daily Telegraph	2.87	(.99)	2.67	(.9)
Professors from a medical university	4.47	(.52)	4.2	(.68)
Websites from Government agencies like the Centers for Disease Control and Prevention (CDC)	4.4	(.63)	4.27	(.7)
Healthcare providers (doctors, nurses)	4.13	(.35)	4.27	(.6)
Family and friends	2.13	(.83)	3.13	(1.06)
The World Health Organization (WHO)	4.33	(.72)	4.33	(.62)
Social media	1.53	(.64)	2.27	(1.33)
Websites from doctor groups like the British Association of General Paediatrics (BAGP)	4.07	(.88)	2.73	(.7)
Radio	2.13	(.64)	2.27	(.88)
Tabloid like The Sun	1.53	(.74)	1.53	(.83)
Companies that make vaccines (Sanofi, Novartis, Pfizer, etc.)	2.53	(.64)	2.2	(.86)
Books	2.8	(.77)	2.8	(.77)
Medical and scientific journals like The New England Journal of Medicine	4.33	(.62)	3.93	(.7)
Churches or community groups	1.33	(.49)	1.53	(.64)
Wikipedia	2.13	(1.06)	2.27	(.96)

Internet in general	2.2	(.86)	2.13	(.74)
Websites from universities or medical schools like the Mayo Clinic	3.6	(.83)	3.67	(.62)
Television programs	2.13	(.62)	1.47	(.64)

Note: Expertise and trustworthiness of each source of information were rated on a 5-point Likert scale from 1 (= "to little or no extent") to 5 (= "to a great extent").

Table 7.2. *Selected sources for the correction statement*

	Expertise	*Trustworthiness*
Experiment 5A – on the effect of expertise		
<u>*Sources*</u>		
Websites from doctor groups like the British Association of General Paediatrics (*High expertise*)	4.07 (.88)	2.73 (7)
Celebrities (*Low expertise*)	1.33 (.62)	2.06 (.97)
Experiment 5B – on the effect of trustworthiness		
<u>*Sources*</u>		
Family and friends (*High trustworthiness*)	2.13 (.83)	3.13 (1.06)
Television programs (*Low trustworthiness*)	2.13 (.62)	1.47 (.64)

7.2 Experiment 5A

Both experiments reported in this chapter used a standard continued influence paradigm (Johnson & Seifert, 1994; Wilkes & Leatherbarrow, 1988), whereby participants are presented with one piece of information at a time about an unfolding fictional event. The report typically contains a target piece of mistaken information that is later corrected. Participants' understanding of the event is then assessed with an open-ended questionnaire consisting of factual and inference questions. To evaluate whether the correction was effective, the number of clear references to the target piece of mistaken information in participants' responses is tallied.

Experiment 5A examined the individual's ability to disregard vaccine misinformation and adjust behaviour accordingly, when the correction is provided by a source of information deemed to be high or low in expertise.

7.2.1 Method

Participants

A-priori power analysis (G*Power 3; Faul et al., 2007) for a one-way ANOVA with 3 groups suggested a minimum sample size of 159 participants to detect a medium size effect of $f = .25$, with $\alpha = .05$ and $1 - \beta = .80$. In line with previous literature (see: Guillory & Geraci, 2013), we decided to test a total of $N = 90$ participants, all undergraduate students from the University of Edinburgh (25 males, 65 females, mean age 18.91 years, age range 18-35 years), who participated on a voluntary basis and received course credit in exchange for their participation. Participants were tested individually. A quasi-random method of condition allocation was used whereby participants were assigned alternatively to 1 of 3 conditions, namely the *High-expertise Correction* condition, the *Low-expertise Correction* condition, or the *Baseline no-correction* condition (30 per condition). The study received ethical approval from the University of Edinburgh's Ethics Committee.

Study design

A between-subjects design was used with condition (two correction conditions and a baseline no-correction condition) as the independent variable, while the dependent variables were (a) the accuracy of recall (free-recall and fact-recall score), and most importantly, (b) the extent to which misinformation persists in one's memory (use of the original information to answer inference questions) and (c) the intention to vaccinate one's child (vaccination intent). For multiple comparisons between groups, Tukey's HSD correction method was applied. Significance was set at $p < .05$ for all analyses. Two principal hypotheses were formulated:

> *H1*: Participants will be less likely to use the original misinformation to answer inference questions when receiving a correction from a high-expert source than from a low-expert source.

H2: Participants who rely more on misinformation will report a lower intention to vaccinate their own child.

Hypothesis 1 derived from the literature on source credibility effects showing that highly credible sources have proven to be more persuasive than less credible sources (Hovland et al., 1953; Pornpitakpan, 2004). Hypothesis 2 was based upon recent studies showing the lingering effect of vaccine misinformation and the ineffectiveness of correction interventions in increasing the intent to vaccinate a future child (Nyhan & Reifler, 2015; Nyhan et al., 2014; Pluviano et al., 2017).

7.2.2 Procedure

Participants read a fictitious story about a child developing ADHD after receiving the vaccine against "*Brainpox*" (the full story is presented in Appendix E), described as a serious illness. This story contained a critical piece of information – a rumour claiming a link between this vaccine and ADHD. In the two correction conditions, the *High-* and *Low-expertise Correction* conditions, a message specifically asserted that this rumour was incorrect. In the baseline no-correction condition, this information was not corrected. For both correction conditions, participants received the correction from one of the sources of information as identified during the norming study.

As explained in the previous section, for Experiment 5A, in the *High-expertise Correction* condition the correction came from "*Websites from doctor groups like the British Association of General Paediatrics*" as a source with a high level of expertise (M = 4.07, SD = .88), while in the *Low-expertise Correction* condition the correction came from "*Celebrities*" as a source with a low level of expertise (M = 1.33, SD = .62). The trustworthiness of the high- (M = 2.73, SD = .7) and low-expert (M = 2.06, SD = .97) source of information did not differ; t(14) = 1.848, p = .086.

After reading the story, all participants were exposed to a rehearsal-preventing distractor task lasting 2 minutes, during which they were asked to count backwards by 3. Then, they were given a *free-recall test*, in which they were asked to write everything they remembered reading in the story as accurately as possible. After, participants completed a questionnaire (the questionnaire is presented in Appendix F) including specific questions about the story. The first eight questions (*fact-recall questions*) were designed so that participants could answer them by recalling the literal

content of the story, while the following eight (*inference questions*) were designed so that participants could answer them by using inferences about the story. Then followed, just for the participants in the correction conditions, a retraction-awareness question controlling for insufficient encoding, asking what was the message given by the source providing the correction. Finally, participants rated how likely they would be to give the vaccine against the illness at hand to their own child on a Likert scale ranging from 1 (= "*very unlikely*") to 6 (= "*very likely*").

7.2.3 Results

Coding procedure. A scorer checked all the participants' answers to the retraction-awareness question, including in the following analyses only data for those who correctly answered this question in order to ensure that results did not reflect differences in participants' ability to recall the retraction statement. All participants recalled the purpose of the message from the source of the correction. Free recall, factual questions, and inference questions were scored by different pairs of judges blind to condition allocation and acting independently. Inter-rater reliability was high (r = .93, .88, .90, respectively).

The free recall test was scored using "*idea units*". Each idea unit corresponded to one of the 14 messages in which the story was organised. An idea unit was recorded as being recalled and received a score of 1 if the participant reproduced all or substantial part of its content; otherwise it was scored as absent and received a score of 0. The highest possible individual score was therefore 14.

Factual questions were scored 1 for correct responses and 0 for incorrect responses. Responses containing partially correct information were given a score of 0.5. Since 8 factual recall questions were presented, the maximum possible score was 8.

Inference questions were scored 0 or 1. Using a strict scoring system, any mention of the vaccine causing ADHD was considered a reference to the original and incorrect information and was scored as 1, while 0 was assigned to all "other" responses, including comments about the benefits of vaccines or worries over their safety but not the use of the original and incorrect information (the alleged link between the vaccine and ADHD). Since 8 inference questions were presented, the

maximum score achievable was 8. Means and standard deviations for Experiment 5A are presented in Table 7.3.

Table 7.3. *Means and Standard Deviations for the experimental conditions in Experiment 5A*

	High-expertise Correction (n = 30)	Low-expertise Correction (n = 30)	Baseline No-correction (n = 30)
Outcome	*M (SD)*	*M (SD)*	*M (SD)*
Free-recall accuracy	10.33 (1.81)	10.47 (1.48)	10.03 (1.96)
Factual questions	6.33 (1.13)	6.83 (.9)	6.48 (1.15)
Inference questions	1.17 (1.7)	1.13 (1.33)	2.17 (1.72)
Vaccination intent	5.03 (1.16)	5.13 (1.28)	4.57 (1.61)

Note. Means and standard deviations of free-recall accuracy rates (out of a maximum of 14), factual and inference questions' scores (out of a maximum of 8), and vaccination intent (measured on a Likert scale ranging from 1 = "very unlikely" to 6 = "very likely") for the *High*- and *Low-expertise Correction* conditions and the *Baseline No-correction* condition.

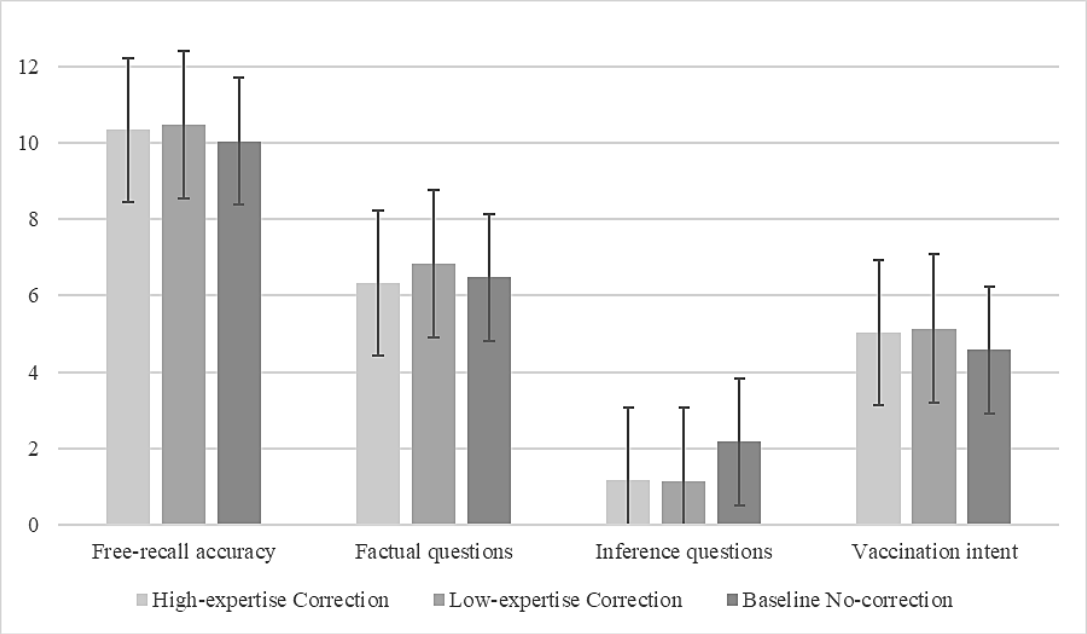
Accuracy of recall. Results from the free recall test revealed that participants' overall recall performance did not differ across conditions, $F(2, 87) = .478$, $p = .622$. Likewise, there was no difference in participants' ability to answer factual questions across conditions, $F(2, 87) = 1.734$, $p = .183$ (Figure 7.1).

Inferential reasoning. Participants' responses to inference questions were influenced by condition, $F(2, 87) = 4.058$, $p = .021$, $\eta^2 = .085$ (Figure 7.1). Multiple comparisons using Tukey's HSD test showed that participants in the Baseline No-correction condition were more likely to refer to the original incorrect information to answer inference questions in comparison to the *High*- ($M = 1$, $SE = .41$, $p = .045$) and *Low-expertise Correction* ($M = 1.03$, $SE = .41$, $p = .037$) conditions.

Vaccination intent. Even though there was no effect of condition on vaccination intentions, $F(2, 87) = 1.476$, $p = .234$ (Figure 7.1), there was a significant negative

correlation between reference to the original incorrect information across conditions and vaccination intention, r = -.561, p < .01, showing that the more participants used misinformation to answer inference questions, the less likely they were to state an intention to vaccinate their children.

Figure 7.1. Mean scores for the key outcomes across conditions



7.3 Experiment 5B

Experiment 5B examined the individual's capability to disregard misinformation and adjust one's behaviour accordingly, when the correction is provided by a source of information deemed to be high or low in trustworthiness.

7.3.1 Method

Participants

90 undergraduates (32 males, 58 females, mean age 19.43 years, age range 17-26 years) from the University of Edinburgh were recruited for this study in exchange for course credit and, as in Experiment 5A, were quasi-randomly assigned to 1 of the 3 conditions, namely the *High-trustworthiness Correction* condition, the *Low-*

trustworthiness Correction condition, or the *Baseline No-correction* condition (30 per condition). None took part in Experiment 5A.

Study design

The study design was the same as in Experiment 5A. Two principal hypotheses were formulated:

> H1: Participants will be less likely to use the original misinformation to answer inference questions when receiving a correction from a high-trustworthiness source than from a low-trustworthiness source.
>
> H2: Participants who rely more on misinformation will report a lower intention to vaccinate their own child.

7.3.2 Procedure

Study materials and procedure mirrored those in Experiment 5A with one exception: as detailed in the previous section about the norming study, in the *High-trustworthiness Correction* condition the correction came from "*Family and friends*" as a source of information with a high level of trustworthiness (M = 3.13, SD = 1.06), while in the *Low-trustworthiness Correction* condition the correction came from "*Television programs*" as a source with a low level of trustworthiness (M = 1.47, SD = .64). Source expertise of the high- (M = 2.13, SD = .83) and low-trustworthy (M = 2.13, SD = .62) source was held constant across the two correction conditions.

7.3.3 Results

Coding procedure. The coding procedure was identical to that in Experiment 5A. A scorer checked all of the participants' answers to the retraction-awareness question. Once again, all of the participants recalled the content of the correction statement. Significance was set at $p < .05$ for all analyses. Inter-rater reliability for free recall, factual questions, and inference questions as assessed by different couples of judges blind to condition allocation was found to be high (r = .87, .93, .91, respectively). Means and standard deviations for Experiment 5B are presented in Table 7.4.

Table 7.4. *Means and Standard Deviations for the experimental conditions in Experiment 5B*

	High-trustworthiness Correction (n = 30)	Low-trustworthiness Correction (n = 30)	Baseline No-correction (n = 30)
Outcome	*M (SD)*	*M (SD)*	*M (SD)*
Free-recall accuracy	10.4 (1.87)	9.93 (1.8)	9.47 (1.46)
Factual questions	6.67 (.94)	6.7 (.83)	6.47 (1.17)
Inference questions	.5 (1.04)	1.7 (1.18)	1.93 (1.8)
Vaccination intent	5.4 (.93)	5 (1.36)	5.03 (1.16)

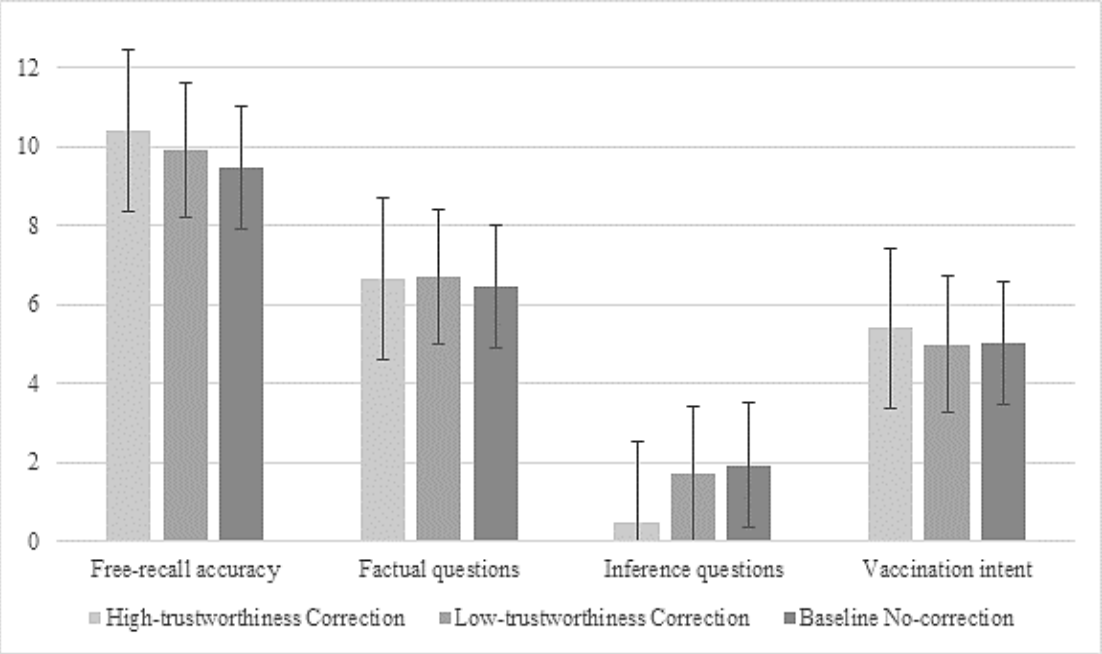
Note. Means and standard deviations of free recall accuracy rates (out of a maximum of 14), factual and inference questions' scores (out of a maximum of 8), and vaccination intent (measured on a Likert scale ranging from 1 = "very unlikely" to 6 = "very likely") for the *High-* and *Low-trustworthiness Correction* conditions and the *Baseline No-correction* condition.

Accuracy of recall. As in Experiment 5A, results from the free recall test showed that the overall recall performance did not differ across conditions, $F(2, 87) = 2.216$, $p = .115$ (Figure 7.2). Likewise, there was no difference in participants' ability to recall factual questions across conditions, $F(2, 87) = .489$, $p = .615$ (Figure 7.2).

Inferential reasoning. Participants' responses to inference questions were influenced by condition, $F(2, 87) = 9.319$, $p < .001$, $\eta^2 = .176$ (Figure 7.2). Multiple comparisons using Tukey's HSD test showed that participants in the *High-trustworthiness Correction* condition were less likely to refer to the original incorrect information to answer inference questions in comparison to the *Low-trustworthiness Correction* condition ($M = -1.2$, $SE = .36$, $p = .003$) and the *Baseline No-correction* condition ($M = -1.43$, $SE = .3$, $p < .001$). Use of the original information to answer inference questions did not differ across the *Low-trustworthiness Correction* condition and the baseline no-correction condition, $F < 1$.

Vaccination intent. Analogous to Experiment 5A, even though there was no effect of condition on vaccination intentions, $F(2, 87) = 1.088$, $p = .341$ (Figure 7.2), there was a significant negative correlation between reference to the original incorrect information across conditions and vaccination intention, $r = -.358$, $p < .01$, showing that the more participants used misinformation to answer inference questions, the less likely they were to report that they would vaccinate their children.

Figure 7.2. Mean scores for the key outcomes across conditions



7.4 General discussion

In conclusion, all evidence seems to indicate that debunking misinformation is no easy matter (Cook & Lewandowsky, 2011). Building relations based on trust is key to ensure high vaccination coverage. In two experiments, we manipulated the credibility of the source of a correction to evaluate the differential impact of source expertise (Experiment 5A) and trustworthiness (Experiment 5B) on the persistence of vaccine misinformation.

Results from Experiment 5A suggest that simply providing a correction reduced participants' use of the original information, as participants in both correction conditions were less likely to continue using the original incorrect information to

answer inference questions compared to participants in the baseline no-correction condition. However, our first hypothesis was not confirmed because the overall reference to misinformation did not differ across the two correction groups; indeed, when the correction in the story came from a more expert (but not more trustworthy) source, participants were just as likely to rely on erroneous information when making inferences about the story as those who received a correction from a less expert source. Supporting the first hypothesis laid out for Experiment 5B, participants were able to reduce their use of the original incorrect information when the correction came from a highly trustworthy source. This was confirmed by the fact that the use of the original information to answer inference questions did not differ across participants exposed to a low-trustworthy correction or to no correction at all. Thus, this finding suggests that source trustworthiness (and not expertise) is crucial in reducing people's reliance on misinformation.

Some studies corroborate that source trustworthiness is more important than source expertise in reducing misconceptions; therefore, corrections of misinformation should come from a trusted source (Trembath, Paynter, Keen, & Ecker, 2016). In a cross-cultural experiment evaluating different combinations of high and low expertise and high and low trustworthiness, McGinnies and Ward (1980) found that a trustworthy source was more persuasive regardless of whether it was expert or not. A recent study by Swire and colleagues (2017) corroborates the view that people use sources of information they believe trustworthy, though not necessarily expert, to guide their evaluation of what is true or false and do not necessarily insist on veracity as a prerequisite for supporting a particular viewpoint.

Both experiments reported here supported our prediction that the continued influence of misinformation would be negatively associated with vaccination intention, so that those who continued to rely on invalidated information were also less likely to state an intention to vaccinate their own child. Therefore, somehow the corrections we provided, regardless of their degree of credibility, did not positively affect the reported intent to vaccinate one's child. This can be partly explained by the role that "belief perseverance" may play during information processing; when confronted with new information that contradicts one's own beliefs, people can unexpectedly hold on even more to their initial beliefs (Anderson, Lepper, & Ross,

1980; Kunda, 1990). In fact, one of the most potent backfire effects of corrective information strategies occurs with topics that tie in with people's "worldviews" (Cook & Lewandowsky, 2011). Future research should be done to investigate whether vaccine misinformation correlates with actual uptake and to what extent deeply-held beliefs could be affected by a correction perceived to come from a trustworthy source.

Our sample consisted of university students who have not been exposed to real decision making about vaccinating their children; this may limit the generalizability of our results. Also, overall inference scores were relatively low, showing that even in the no-correction condition, participants did not much rely on misinformation in answering inference questions. Likewise, the overall vaccination intentions were quite high, suggesting that our sample was biased towards those with more positive views of vaccines. In conclusion, the present study adds to the growing literature demonstrating the powerful, lingering effect of misinformation in memory, showing how effective correction can be extremely difficult. In the specific case of health information, our research showed that corrections are effective as long as they come from a perceived trustworthy source. This finding is noteworthy to better comprehend the loss of public confidence in science and experts.

The contributions reported thus far in Part Two of this Thesis have exemplified the problems associated with encountering misinformation, highlighting how people seem to rely on the content of what they read or hear without careful consideration of whether it is relevant and valid, and behave according to patently incorrect information. Studies 4, 5, and 6 have demonstrated in fact that people remain confident in misinformation even in the face of sophisticated correction attempts, and even if the correction comes from an expert source. Why this is so? People, of course, may hold different degrees of background knowledge and a number of different beliefs about the topic at hand. In the next chapter we consider how pre-existing beliefs may dictate the degree by which people rely on misinformation, questioning whether memory updating is more laborious for people with high vs. little background knowledge.

Chapter 8

Study 6: Forming and updating beliefs and future intentions

8.1 Introduction

In the so-called "post-truth" era, it is critically important to differentiate real from unreal, to correctly assess what is true and what is false (Lewandowsky, Ecker, & Cook, 2017). Yet, our ability to form and update beliefs about the world goes awry (Pennycook, Cannon, & Rand, 2018). Current public discourse – on topics ranging from politics to vaccines, from genetically modified food to human-caused climate change – suggests that on many occasions we may go with our gut rather than rely on established facts based on scientific evidence, with alarming consequences not just for the individual but for the society as a whole (Kahneman, 2011; Schwarz & Newman, 2017). Worse, as extensively discussed in Studies 3, 4 and 5, people may irrationally cling to false information even in the face of new, updated and correct information, a phenomenon known as *continued influence effect* (Seifert, 2002).

There is a long tradition of work in cognitive science explaining the difficulties in memory and belief updating in terms of Festinger's pioneering theory of cognitive dissonance (1957), whereby people are biased reasoners who selectively attend to, process and recall information. As mentioned in the Introduction to Part Two of this Thesis, there is a strong tendency to automatically favor information that supports our prior expectations, known as *confirmation bias* (Klayman, 1995; Nickerson, 1998). When we consider issues that we feel strongly about, confirmation bias may turn into *motivated reasoning*, whereby people tend to reject the veracity of information that conflicts with their priors (Cooper, 2007; Kunda, 1990). Under certain circumstances, individuals may, in fact, display a tendency to cling more strongly to their initial beliefs even after receiving new information that contradicts or disconfirms these beliefs, a tendency known as *belief perseverance* (Lewandowsky et al., 2012, Nyhan & Reifler, 2010). Conversely, those with relatively little background knowledge and/or no deeply

held beliefs about the topic at hand may update their mental representations more easily when persuaded to do so.

To test whether this is true in the case of vaccines misinformation, here I confronted misconceptions about the measles, mumps, and rubella (MMR) vaccine and the Zika virus, which have captivated global attention and are surrounded by misinformation, rumors, and even conspiracy theories (Avery, 2017; Poland & Spier, 2010). Though both equally real and worrying, these two cases may differ in terms of their rootedness in people's mind, as the MMR controversy has a long tradition of deceptions and ill-founded beliefs, of which the most enduring avers that the MMR vaccine is linked to autism, whereas the Zika virus crisis represents a novel emergency about which knowledge and ill-founded beliefs may be limited in comparison (PAHO, 2016; Poland & Jacobson, 2011; Weldon et al., 2018). From a practical standpoint, confronting these two cases of vaccine misinformation could be of particular relevance for health communicators to prevent the spill-over effect from misbeliefs about one vaccine on intention to use another. In fact, in the absence of deeply ingrained beliefs about Zika virus, individuals may base their intentions to vaccinate against it on beliefs about other vaccines, such as the misbelief that MMR causes autism (Ophir & Jamieson, 2018).

In the following section, I explain how the MMR vaccine and the Zika virus represent two peculiar cases of broken trust. Then, two experiments are presented, which examined misconceptions about the MMR vaccine and Zika virus as motivated by a poor risk understanding (Experiment 6A) or the exposure to conspiracy theories (Experiment 6B). A general discussion concludes this chapter.

8.1.1 Misinformation about MMR vaccine and Zika virus: Two cases of broken trust

A key issue in vaccine acceptance is public mistrust in science and experts. Many events have the potential to erode public trust in vaccines and in the authorities delivering them (WHO, 2017). Sometimes, it is a new critical study that spreads misinformation about a vaccine. An example is the now discredited study suggesting a causal link between the MMR vaccine and autism, which originated the current MMR vaccine scare and reduced vaccine uptake in several countries (Offit & Coffin,

2013). Even though researchers rejected the hypothesis that the MMR vaccine could trigger autism, "with the explosion of 'contrary' expertise online…many parents see even the most respected vaccine experts' perspective on the issue as just one more opinion'' (Gross, 2009, p. 6; Kaufman, 2007).

Another departure point for the possible emergence of health misinformation are scientific uncertainties about a novel or re-emerging infectious disease (TELL ME, 2015), as in the case of Zika virus. Zika is spread mostly by the bite of an infected *Aedes* species mosquito, which is found throughout the tropics. Common Zika symptoms include mild fever, rash, headache, joint pain, conjunctivitis, and muscle pain. However, the major concern is the impact that Zika can have during pregnancy, as a pregnant woman can pass the virus to her fetus causing serious birth defects. To date, no vaccine or treatment is available and the most effective public health measures include controlling the mosquito population and preventing people from direct exposure to mosquitoes (Chang, Ortiz, Ansari, & Gershwin, 2016). Since its outbreak, Zika has been surrounded by uncertainty. Unfortunately, missing information about the disease easily evolved into misinformation, especially on the internet (Venkatraman, Mukhija, Kumar, & Nagpal, 2016).

The MMR and Zika controversies demonstrate how encouraging trust in vaccines can be difficult. As explained below, the harmful effects of vaccine misinformation are particularly pronounced when a personal risk is involved (e.g., "vaccines cause adverse events") or the misinformation is packaged as a conspiracy theory (e.g., "vaccines are part of a conspiracy to make money for pharmaceutical companies") (Lewandowsky et al., 2017; Myers & Pineda, 2009).

8.2 Experiment 6A

Risk perceptions are generally defined as people's subjective judgements about the likelihood of negative occurrences (e.g., diseases, death) and are portrayed as having two dimensions: the cognitive dimension, which relates to how much people know and understand about risks, and the emotional dimension, pertaining to how people feel about them (Paek & Howe, 2017).

Several theoretical models have been developed to explain how people perceive and process information about risks, as well as how they act on its basis (De

Martino, Kumaran, Seymour, & Dolan, 2006; Reyna & Rivers, 2008; Roeser, Hillerbrand, Sandin, & Peterson, 2012). A central tenet of the rational choice model of decision-making is that people evaluate the possibility of outcomes after they calculate potential costs and benefits (Simon, 1955, 1956). However, mainly experts tend to engage in such analytic and effortful behavior, relying on scientific information and objective assessment. And, under certain circumstances, even experts fail to comprehend real risks (Gigerenzer, 2014). By contrast, laypeople have been found to evaluate risks mostly according to their subjective experiences or emotions and relying on all sorts of bias and heuristics (Kahneman, Slovic, & Tversky, 1982; Loewenstein, Weber, Hsee, & Welch, 2001; Weinstein, 1980).

Targeting risk perceptions is key in health communication as much empirical evidence demonstrates that risk perceptions are important precursors of future actions; thus, interventions that change risk perceptions subsequently change health behaviors (for a meta-analysis on how risk appraisals may change people's intentions and behavior, see: Sheeran, Harris, & Epton, 2014). Therefore, Experiment 6A examined misconceptions about the MMR vaccine and Zika virus as motivated by a poor risk understanding, inducing people to underestimate the risks that diseases may pose and to give disproportionate weight to unproven vaccine adverse events.

In particular, we made a series of predictions. First, as misinformation has proved to negatively impact on beliefs and attitudes toward vaccination (Nyhan & Reifler, 2015; Nyhan et al., 2014; Pluviano et al., 2017), we anticipated that:

> *Hypothesis 1*: Misconceptions about the MMR vaccine and Zika virus would be higher when misinformation was presented than when no misinformation was presented.

Then, we supposed that the cases of the MMR vaccine and Zika virus might differ in terms of the cognitive processing underlying people's beliefs, in that convictions in unproven vaccine-autism theories, because of their rootedness in people's minds, might be more resistant to correction attempts than false beliefs about Zika virus, a relatively novel disease with limited availability of scientific evidence from which to draw conclusions. Therefore, we expected that participants would be relatively familiar with the MMR vaccine misconceptions, whereas the Zika virus misconceptions would be relatively unfamiliar. Accordingly, we proposed that:

Hypothesis 2: Misconceptions would be higher in the case of the MMR vaccine than in the case of Zika virus.

Moreover, as previous research has shown that misinformation may negatively impact on parents' stated intention to vaccinate their children (Nyhan & Reifler, 2015; Nyhan et al., 2014; Pluviano et al., 2017), we also proposed that:

Hypothesis 3: Misconceptions about the MMR vaccine and Zika virus would be negatively associated with the stated intention to vaccinate, so that participants who had more misconceptions would report a lower intention to vaccinate their child.

Finally, as lack of confidence may influence the effectiveness of the messages deemed at correcting misconceptions (Hovland et al., 1953; Pluviano et al., under review), we also proposed that:

Hypothesis 4: Credibility evaluations of public health experts would be negatively associated with misconceptions and vaccines hesitancy, so that participants who put less trust in the source providing the correction would have more misconceptions and report a lower intention to vaccinate their child.

8.2.1 Method

Participants

A-priori power analysis (G*Power 3; Faul et al., 2007) for a one-way ANOVA with 2 groups suggested a minimum sample size of 128 participants to detect a medium size effect of $f = .25$, with $\alpha = .05$ and $1 - \beta = .80$. We decided to test 130 students from the University of Florence, half randomly assigned to the *Baseline no-misinformation* condition (20 males and 45 females, average age M = 24.81, SD = 2.95) and half to the *Misinformation* condition (32 males and 33 females, average age M = 25.15, SD = 3.1). They all participated on a voluntary basis and were tested in groups. To protect the independence and privacy of their responses, participants were requested not to talk to each other while reading the stories and filling out the questionnaires and a proper seating distance was maintained between them. Participants were unaware of

the other experimental condition and also researchers were blind to assignment. Data collection was conducted from December 2017 to March 2018.

8.2.2 Procedure

All participants were presented with two fictitious stories (full stories are presented in Appendix G). The first story was about a baby developing autism after receiving the MMR vaccine. The second story was about a baby developing epilepsy after receiving a fictitious vaccine against Zika virus. In the *Misinformation* condition, both stories contained a critical piece of information, which was later retracted by public health experts. In the first story about the MMR vaccine, there was a rumor about the alleged link between the MMR vaccine and autism, while in the second story about Zika virus there was a rumor about the alleged link between Zika virus and epilepsy. In the *Baseline no-misinformation* condition, there was no reference to these rumors or to their correction. After reading the stories, all participants were asked to complete a short distraction task to prevent rehearsal of the stories. Then, they were given a free recall test, in which they were asked to write everything they remembered reading in the stories as accurately as possible. After the free-recall test, participants completed a questionnaire (see Appendix I) assessing misconceptions about the MMR vaccine and Zika virus, the intention to vaccinate one's child, negative attitudes towards vaccination, and the perceived credibility of the correction received from public health experts (this latter just in the *Misinformation* condition). In particular, in the questionnaire, after providing some demographic details (sex, age, education level), participants were asked whether they had any children and had ever delayed or refused a recommended vaccine for their child(ren). Then, various scales followed:

Misconceptions about the risks associated with the MMR and Zika virus vaccine. Misconceptions about the MMR vaccine were evaluated by two questions used in previous studies (Freed et al., 2010; Nyhan et al., 2014; Pluviano et al., 2017). First, participants were asked to indicate whether they agree or disagree that "MMR vaccine causes autism in healthy children" on a 5-point scale from "strongly disagree" (1) to "strongly agree" (5). Then, they were asked to indicate the perceived likelihood that "children will suffer serious side effects from MMR vaccine" on a 6-point scale from

"very unlikely" (1) to "very likely" (6). These two items were averaged, with a higher score indicating greater misconceptions about MMR vaccine.

Misconceptions about Zika virus were also evaluated by two questions. First, participants were asked to indicate whether they agree or disagree that "Zika virus vaccine causes epilepsy in healthy children" on a 5-point scale from "strongly disagree" (1) to "strongly agree" (5). Then, they were asked to indicate the perceived likelihood that "children will suffer serious side effects from Zika virus vaccine" on a 6-point scale from "very unlikely" (1) to "very likely" (6). These two items were combined into a single index, with a higher score indicating greater misconceptions about the fictitious Zika virus vaccine.

Vaccines hesitancy. Vaccination intent was evaluated by asking participants how likely they would be to give the MMR vaccine to their child(ren) on a 6-point scale from "very likely" (1) to "very unlikely" (6), a question which has been used in previous studies (Freed et al., 2010; Nyhan et al., 2014; Pluviano et al., 2017).

Then, participants were asked to evaluate how likely they would be to give a possible vaccine against Zika virus to their child(ren) on the same 6-point scale from "very likely" (1) to "very unlikely" (6).

Negative attitudes towards vaccination. Attitudes towards vaccination were evaluated by 8 questions, which have been used in previous studies (Freed et al., 2010; Nyhan et al., 2014; Pluviano et al., 2017). These questions covered common attitudes from both the pro- (e.g., "Getting vaccines is a good way to protect my future child(ren) from disease") and the anti-vaccination side (e.g., "Some vaccines cause autism in healthy children"). Participants were asked to indicate their degree of agreement with each statement on a 5-point Likert scale, ranging from "strongly disagree" (1) to "strongly agree" (5). After reverse coding, average scores were computed, so that higher means indicated more negative attitudes towards vaccination.

Credibility evaluations of public health experts. Participants in the *Misinformation* condition were also asked to evaluate the credibility of the correction received from public health experts. Two out of the three subdimensions composing Ohanian's (1990) scale were used, namely the *expertise* and *trustworthiness* subscales. We chose

these two subscales because extant literature indicates that the notion of credibility encompasses two core dimensions: *expertise*, namely the extent to which the communicator is perceived to be capable of making correct assertions, and *trustworthiness*, that is the willingness of the communicator to provide the assertions he or she considers most valid (Hovland et al., 1953). Both Ohanian's (1990) subscales constituted of five pairs of oppositional adjectives (antonyms) rated on a 7-point scale like a semantic differential. The descriptive pairs for measuring expertise included: an expert – not an expert, inexperienced – experienced, unknowledgeable – knowledgeable, qualified – unqualified, and unskilled – skilled. The descriptive pairs that measure trustworthiness were: dependable – undependable, dishonest – honest, unreliable – reliable, insincere – sincere, and trustworthy – untrustworthy. After reverse coding, average scores were computed for both subscales, with scores ranging from 1 to 7, so that higher means indicated a higher credibility rating.

8.2.3 Results

Descriptive statistics for Experiment 6A are reported in Table 8.1.

Table 8.1. *Descriptive statistics for the outcomes in Experiment 6A*

	Baseline no-misinformation condition			Misinformation condition		
Outcomes	*M*	*SD*	Range	*M*	*SD*	Range
Free-recall accuracy	22.03	2.07	19-26	21.1	2.07	18-26
Misconceptions about the risks associated with the MMR vaccine	1.57	.21	1-2	3.21	.52	2-4.5
Misconceptions about the risks associated with the Zika virus vaccine	2.18	.57	1-3.5	3.11	.64	2-4.5
MMR Hesitancy	1.43	.5	1-2	2.4	.55	2-4
Zika Hesitancy	2.21	.62	1-5	3.58	1.06	2-5
Negative attitudes towards vaccination	2.82	.18	2.5-3.38	3.21	.23	2.75-3.63

Perceived expertise of public health experts	-	-	-	3.94	.29	3.2-4.6
Perceived trustworthiness of public health experts	-	-	-	3.38	.25	2.8-4

The free-recall test was scored using "idea units" (see Wilkes & Leatherbarrow, 1988). Each idea unit corresponded to one of the 14 messages in which each story was organised. An idea unit was recorded as being recalled and received a score of 1 if the participant reproduced all or substantial part of its content; otherwise it was scored as absent and received a score of 0. Since all participants read two stories, the highest possible individual score on the free-recall test was 28. Results revealed that participants' overall recall performance did not differ across conditions, $F(1, 129) = .352$, $p = .554$.

A series of ANOVAs was performed to test our hypotheses. Figure 8.1 displays the results relevant to Hypotheses 1 and 2. First, we tested Hypothesis 1, which posited that misconceptions about the MMR vaccine and Zika virus would be higher in the Misinformation than in the Baseline-no misinformation condition. As expected, significant differences in misconceptions about the MMR vaccine [$F(1, 129) = 551.967$, $p < .001$, $\eta^2 = .812$] and Zika virus [$F(1, 129) = 76.404$, $p < .001$, $\eta^2 = .374$] were found, with participants in the Misinformation condition having higher misconceptions ($M = 3.21$, $SD = .52$ for the MMR vaccine; $M = 3.11$, $SD = .64$ for Zika virus) than those in the Baseline-no misinformation condition ($M = 1.57$, $SD = .21$ for the MMR vaccine; $M = 2.18$, $SD = .57$ for Zika virus).

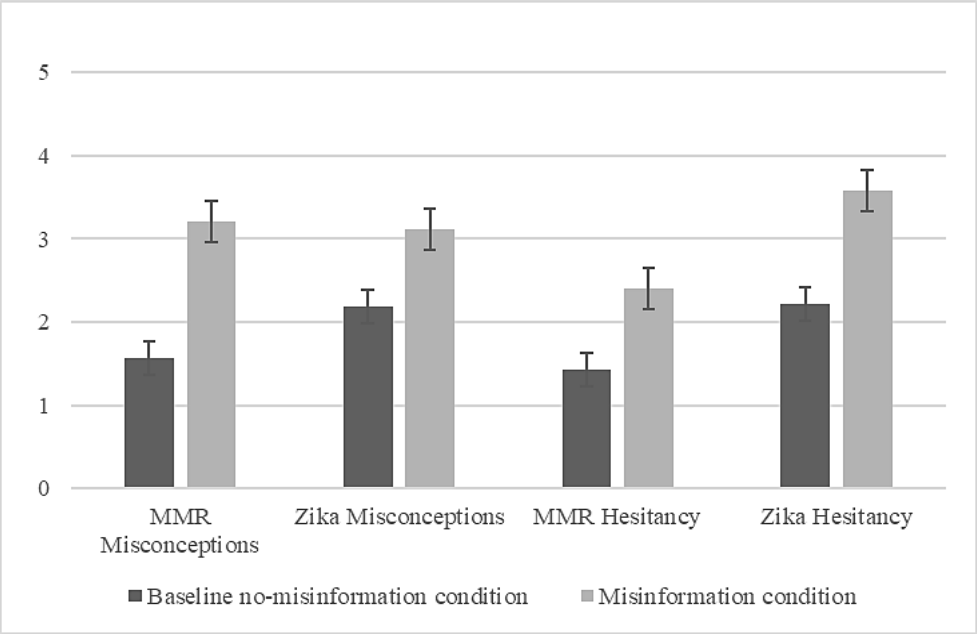
Next, we tested Hypothesis 2, which predicted that misconceptions would be higher in the case of the MMR vaccine than in the case of Zika virus. The analyses did not support Hypothesis 2. In fact, a within-subjects ANOVA conducted to determine whether there was a statistically significant difference between MMR and Zika misconceptions was significant [$F(1, 129) = 11.895$, $p = .001$, $\eta^2 = .084$], with participants having lower misconceptions when questioned about their beliefs about the MMR vaccine ($M = 2.4$, $SD = .92$) as opposed to their beliefs about Zika virus ($M = 2.65$, $SD = .76$).

Then, we tested Hypothesis 3, which posited that vaccines hesitancy would be higher in the Misinformation than in the Baseline-no misinformation condition.

Significant differences in MMR [$F(1, 129) = 109.964$, $p < .001$, $\eta^2 = .462$] and Zika [$F(1, 129) = 80.595$, $p < .001$, $\eta^2 = .386$] vaccine hesitancy were found, with participants in the Misinformation condition being more hesitant towards the MMR vaccine and a possible shot against Zika virus (M = 2.4, SD = .55 for the MMR vaccine; M = 3.58, SD = 1.05 for Zika virus) than participants in the Baseline-no misinformation condition (M = 1.43, SD = .5 for the MMR vaccine; M = 2.21, SD = .62 for Zika virus). The results also indicated that there was a significant difference in negative attitudes towards vaccination [$F(1, 129) = 118.123$, $p < .001$, $\eta^2 = .48$], with participants in the Misinformation condition having more negative attitudes (M = 3.21, SD = .23) than those in the Baseline-no misinformation condition (M = 2.82, SD = .18). As further confirmation of the expected misinformation effect, MMR misconceptions positively correlated with MMR hesitancy ($r = .665$, $p < .01$) and negative attitudes towards vaccination ($r = .65$, $p < .01$); similarly, Zika misconceptions positively correlated with Zika hesitancy ($r = .197$, $p < .05$) and negative attitudes towards vaccination ($r = .356$, $p < .01$), so that participants having higher misconceptions about the MMR vaccine and Zika virus reported a lower intention to vaccinate their child and more negative attitudes towards vaccination in general.

Finally, we tested Hypothesis 4, which predicted that credibility evaluations of public health experts would be negatively associated with misconceptions and vaccines hesitancy. The analyses partially supported Hypothesis 4. The perceived expertise of the source providing the correction negatively correlated with MMR vaccine hesitancy ($r = -.289$, $p < .05$), so that the more the perceived expertise of the source, the higher the vaccination intent. Instead, the perceived trustworthiness of the source providing the correction negatively correlated with Zika misconceptions ($r = -.354$, $p < .01$), so that the more the perceived trustworthiness of the source, the less misconceptions about Zika virus.

Figure 8.1. *MMR and Zika misconceptions, along with MMR and Zika hesitancy, across conditions in Experiment 6A*



8.3 Experiment 6B

Besides biased risk appraisal, a key psychological factor that may motivate people to reject scientific consensus around vaccination is represented by conspiratorial thinking, namely the tendency to explain events as the secret acts of powerful, malevolent forces (Grimes, 2016; Hornsey, Harris, & Fielding, 2018). An emerging literature pointed out indeed that parents who believe in anti-vaccine conspiracy theories are less likely to vaccinate their child (Jolley & Douglas, 2014; Lewandowsky, Gignac, & Oberauer, 2013). Understanding conspiracy theories therefore becomes crucial for health communicators. For this reason, Experiment 6B examined the persistence of misconceptions about the MMR vaccine and Zika virus as motivated by the exposure to conspiracy theories. This experiment employed most of the hypotheses (Hypotheses 1, 3 and 4) tested in Experiment 6A. However, this time we could not rule out the possibility that misconceptions about the MMR vaccine and Zika virus as motivated by conspiracy theories were equivalent, because the idea that vaccines are part of a medical/pharmaceutical/governmental conspiracy may be widespread both in the case of "already known" vaccines as the MMR vaccine and in the case of "new"

vaccines as a possible vaccine against Zika virus. Therefore, we posed a further research question:

> Are conspiracy misconceptions about the MMR vaccine and Zika virus different?

8.3.1 Method

Participants

Similarly to Experiment 6A, we tested 130 students from the University of Florence, half randomly assigned to the *Baseline no-misinformation* condition (27 males and 38 females, average age M = 23.06, SD = 2.77) and half to the *Misinformation* condition (21 males and 44 females, average age M = 24.6, SD = 3.15). None of the participants in this experiment had taken part in Experiment 6A. Data collection was conducted from December 2017 to March 2018.

8.3.2 Procedure

All participants were presented with two fictitious stories (full stories are presented in Appendix G). The first story was about a baby developing measles because he was not immunized with the MMR vaccine. The second story was about a baby been diagnosed with Guillain-Barré syndrome (GBS) after a mosquito bite. In the *Misinformation* condition, both stories contained a critical piece of information, which was later retracted by public health experts. In particular, in both stories there were rumors claiming the MMR and Zika virus vaccines were just part of a conspiracy to make money for pharmaceutical companies. In the *Baseline no-misinformation* condition, there was no reference to these rumors or to their correction. As in Experiment 1, after reading the stories, all participants were asked to complete a short distraction task to prevent rehearsal of the stories. Then, they were given a free-recall test, in which they were asked to write everything they remembered reading in the stories as accurately as possible. After the free-recall test, participants completed a questionnaire (the questionnaire is presented in Appendix H) as in Experiment 6A. Scales assessing the intention to vaccinate one's child, negative attitudes towards vaccination, and the perceived credibility of the correction received from public health experts (this latter

just in the Misinformation condition) were the same as those administered in Experiment 6A. However, misconceptions about the MMR vaccine and Zika virus were assessed by means of different questions. In particular, conspiracy misconceptions about the MMR vaccine and Zika virus were evaluated by means of two questions. Participants were asked to indicate whether they agree or disagree that "viral experts are in the pocket of pharmaceutical companies" and "vaccines are nothing more than a pharmaceutical company conspiracy to make money" on a 5-point scale from "strongly disagree" (1) to "strongly agree" (5). These two items were averaged, with a higher score indicating greater conspiracy misconceptions about the MMR vaccine and Zika virus, respectively.

8.3.3 Results

Descriptive statistics for Experiment 6B are reported in Table 8.2.

Table 8.2. *Descriptive statistics for the outcomes in Experiment 6B*

	Baseline no-misinformation condition			Misinformation condition		
Outcomes	*M*	*SD*	Range	*M*	*SD*	Range
Free-recall accuracy	22.91	1.88	19-26	22.98	1.96	19-26
Conspiracy misconceptions about the MMR vaccine	1.61	.43	1-3	2.98	.91	1.5-5
Conspiracy misconceptions about the Zika virus vaccine	2.02	.5	1-3	3.14	.87	2-5
MMR Hesitancy	2.51	.64	2-4	4.72	.89	2-6
Zika Hesitancy	2.94	.58	2-4	4.26	1.21	2-6
Negative attitudes towards vaccination	2.17	.2	1.63-2.75	2.51	.28	2-3.38
Perceived expertise of public health experts	-	-	-	2.84	.39	2.2-3.8
Perceived trustworthiness of public health experts	-	-	-	1.61	.45	1-2.4

Similarly to Experiment 6A, the free-recall test was scored using "idea units". Results revealed that participants' overall recall performance did not differ across conditions, $F(1, 129) = .052$, $p = .82$.

A series of ANOVAs was performed to test our hypotheses. Figure 8.2 displays results relevant to Hypothesis 1 and to the novel Research question. First, we tested Hypothesis 1, which posited that misconceptions about the MMR vaccine and Zika virus would be higher in the Misinformation than in the Baseline-no misinformation condition. As expected, significant differences in misconceptions about the MMR vaccine [$F(1, 129) = 121.843$, $p < .001$, $\eta^2 = .488$] and Zika virus [$F(1, 129) = 79.659$, $p < .001$, $\eta^2 = .384$] were found, with participants in the Misinformation condition having higher misconceptions (M = 2.98, SD = .91 for the MMR vaccine; M = 3.14, SD = .87 for Zika virus) that those in the Baseline-no misinformation condition (M = 1.61, SD = .43 for the MMR vaccine; M = 2.02, SD = .5 for Zika virus).

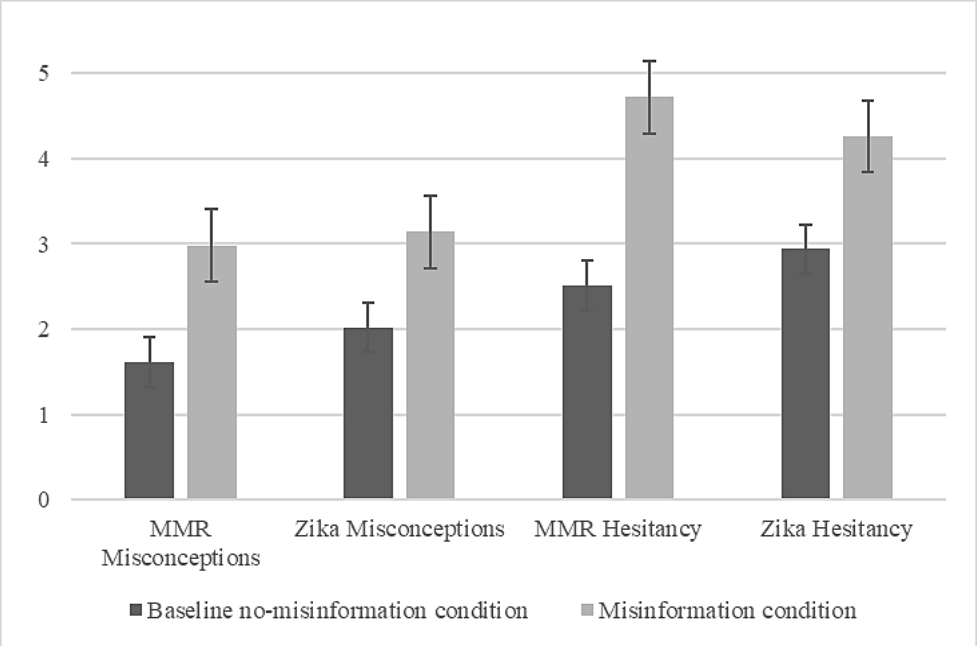
Next, to answer the new Research question, which asked whether conspiracy misconceptions about the MMR vaccine and Zika virus would differ, a within-subjects ANOVA was conducted. The results were significant [$F(129) = 10.102$, $p = .002$, $\eta^2 = .073$], with participants having lower misconceptions when questioned about their beliefs about the MMR vaccine (M = 2.29, SD = .99) as opposed to their beliefs about Zika virus (M = 2.58, SD = .9).

Then, we tested Hypothesis 3, which posited that vaccines hesitancy would be higher in the Misinformation than in the Baseline-no misinformation condition. Significant differences in the MMR [$F(1, 129) = 264.258$, $p < .001$, $\eta^2 = .674$] and Zika [$F(1, 129) = 62.612$, $p < .001$, $\eta^2 = .328$] vaccine hesitancy were found, with participants in the Misinformation condition being more hesitant towards the MMR vaccine and a possible shot against Zika virus (M = 4.72, SD = .89 for the MMR vaccine; M = 4.23, SD = 1.21 for Zika virus) than participants in the Baseline-no misinformation condition (M = 2.51, SD = .64 for the MMR vaccine; M = 2.94, SD = .58 for Zika virus). The results also indicated that there was a significant difference in negative attitudes towards vaccination [$F(1, 129) = 63.802$, $p < .001$, $\eta^2 = .333$], with participants in the Misinformation condition having more negative attitudes (M = 2.17, SD = .2) than those in the Baseline-no misinformation condition (M = 2.82, SD = .18). As further confirmation of the expected misinformation effect, MMR misconceptions

positively correlated with MMR hesitancy (r = .67, p < .01) and negative attitudes towards vaccination (r = .355, p < .01); similarly, Zika misconceptions positively correlated with Zika hesitancy (r = .335, p < .01) and negative attitudes towards vaccination (r = .355, p < .01), so that participants having higher misconceptions about the MMR vaccine and Zika virus reported a lower intention to vaccinate their child and more negative attitudes towards vaccination in general.

Finally, we tested Hypothesis 4, which predicted that credibility evaluations of public health experts would be negatively associated with misconceptions and vaccines hesitancy. The analyses partially supported Hypothesis 4. The perceived expertise of the source providing the correction negatively correlated with negative attitudes towards vaccination (r = -.246, p < .05), so that the greater the perceived expertise of the source, the more vaccination complacency. Instead, the perceived trustworthiness of the source providing the correction negatively correlated with Zika vaccine hesitancy (r = -.36, p < .01), so that the more the perceived trustworthiness of the source, the less Zika vaccine hesitancy.

Figure 8.2. *MMR and Zika misconceptions, along with MMR and Zika hesitancy, across conditions in Experiment 6B*



8.4 General discussion

The present study contributes to the literature on how to effectively counteract vaccines misinformation and promote evidence-based decision-making by presenting new findings concerning how people may be differently affected by misinformation according to their prior knowledge and deeply held beliefs about a specific content. In two experiments, we confronted the persistence of misconceptions about the MMR vaccine and Zika virus as motivated by a poor risk understanding (Experiment 6A) and exposure to conspiracy theories (Experiment 6B).

First, the findings confirmed Hypothesis 1 about the continued influence effect of misinformation. Both in Experiment 6A and 6B, MMR and Zika misconceptions were higher in the Misinformation condition as compared to the Baseline-no misinformation condition. Moreover, corroborating Hypothesis 3, both in Experiment 6A and 6B vaccines hesitancy was higher in the Misinformation than in the Baseline-no misinformation condition, corroborating the large amount of evidence about the limited effect of debunking efforts (Cook & Lewandowsky, 2011; Lewandowsky et al., 2012). More importantly, in contrast with Hypothesis 2 in Experiment 6A assuming that Zika virus misconceptions are not deeply ingrained, misconceptions were lower in the case of the MMR vaccine than in the case of Zika virus. The same happened in Experiment 6B. One plausible explanation is that Zika virus represents a peculiar case showing how missing information can easily evolve into misinformation. As anticipated in the Introduction, Zika is a relatively novel disease that may have received less coverage in traditional media outlets than the MMR vaccine, except for the abounding misinformation in the Internet. While the evidence about the safety of the MMR vaccine is solid (DeStefano & Thompson, 2004), scientists are still learning about Zika, with the public and the media struggling to keep up (Bode & Grava, 2015, 2017). This unstable situation may have intensified the negative impact of misinformation about Zika compared to other diseases. Some evidence seems to corroborate this reasoning. For example, a meta-analysis of the efficacy of messages countering misinformation pointed out that, when trying to set the record straight, simply labelling the misinformation as wrong is less effective that debunking it with new details (Chan, Jones, Hall Jamieson, & Albarracín, 2017). In fact, a key element for an effective rebuttal is replacing misinformation with an alternative causal account

covering the "gap" created in people's understanding or mental models of the events. In Experiment 6A, although the correction we provided did not feature a detailed explanation of the reasons why the link between MMR and autism was false, at least participants were informed that "signs of autism typically appear around the same time that children are recommended to receive the MMR vaccine". Instead, no explanation of the alleged link between the hypothetical Zika vaccine and epilepsy was provided; participants were just advised that there was no connection between the two. Therefore, in Experiment 6A people might have been more resistant to the misinformation related to the MMR vaccine because they might have been already exposed (both inside and outside the laboratory) to corrections detailing why the link between the MMR vaccine and autism was false. Conversely, in the case of Zika, they could have continued to rely on misinformation in order to account for otherwise unexplained events (if Zika does not explain epilepsy, what does?).

Similarly, reference (or absence of reference) to causal accounts could explain the results of Experiment 6B, showing that conspiracy theory endorsement was higher for Zika than MMR. Indeed, conspiracy theories flourish when there is missing information as in the case of Zika, because people tend to think there is always a "cover-up", something that the government wants to hide (Nyhan et al., 2016). Missing information might also more easily turn into misinformation and conspiracy ideation because of the feeling of lack of control (Whitson & Galinsky, 2008). Indeed, conspiracy beliefs may be described as giving "causes and motives to events that are more rationally seen as accidents…[in order to] bring the disturbing vagaries of reality under…control" (Pipes, 1997, p. 181).

Some limitations of the present study are important to mention. One concerns the use of similar questions for different texts, which might have resulted in some kind of context effect, with prior questions having the potential to affect participants' responses to later questions in the questionnaires administered. Moreover, as correlational designs do not allow conclusions about cause and effect, firmer conclusions about the causality of the relationships that we observed between perceived source credibility and vaccines misconceptions and hesitancy need further experimental work.

Returning to our main findings, partially confirming Hypothesis 4, the results provided in these experiments illustrate the importance of a trusted source communicating the scientific consensus about vaccines; at least in the case of Zika virus, a trusted source may indeed diminish vaccines misconceptions (Experiment 6A) and increase the stated intention to vaccinate one's child (Experiment 6B). In fact, to enhance the effectiveness of science communication, experts recommend to use "simple clear messages, repeated often, by a variety of trusted sources" (Cook, van der Linden, Maibach, & Lewandowsky, 2018, p. 14). It is also important to mention that the perceived trustworthiness of public health experts was very low among respondents in this study. This could be partially explained by the crisis of public confidence in vaccines, which is leading to long-term decline in vaccines uptake and associated diseases outbreaks (WHO, 2017).

General discussion

Understanding human agency requires first and foremost understanding intentions because of their intrinsic relation to the actions and activities that we perform in our everyday lives (Brandimonte et al., 1996). The present Thesis addressed delayed intentions, namely those intentions whose fulfilment is, by definition, postponed at some designated moment in the near or distant future. In particular, the focus was on the complex nature of prospective memory and on the difficulties associated with the retrieval and realization of these delayed intentions. The general aim of this Thesis was in fact to investigate some key causes leading to forgetting and misremembering one's intended actions. Two main factors affecting the fulfilment of a delayed intention were investigated, namely stress and misinformation.

Drawing on an open debate about prospective memory decline under stress conditions, Part One of this Thesis suggests that stress may have a remarkable, disruptive effect on prospective memory functioning. In fact, Study 1 and Study 2 highlighted that both daily and work stress may increase the likelihood of prospective memory errors in a strict sense – namely forgetting to carry out intended actions at the appointed time and place. Specifically, Study 1 revealed that high-stressed individuals reported a substantial higher frequency of both general cognitive failures and prospective memory errors in everyday life, compared to low-stressed individuals. In the proposed model, besides stress, potential drivers of prospective memory failures appear to be age, mental health (e.g., negative symptoms such as anxiety and depression) and reliance memory strategies (e.g., using other people as memory aids). These latter could also buffer the negative effect of stress on prospective memory errors, so that leaning on reliance memory strategies might help in reducing prospective memory errors. Study 2 corroborated the adverse effect of stress on prospective memory functioning, showing how work stress and burnout in the healthcare context may contribute to forgetting clinical tasks, which may result in potential adverse events jeopardizing patient safety.

In Part Two of this Thesis I argued that a great deal about prospective memory errors may be learned from the studies on the continued influence effect of

misinformation. False information, in fact, may distort one's future intentions and plans, to the extent that even if a person understands and remembers a subsequent retraction, his/her future intentions, even inadvertently, may not change accordingly. The misinformation effect is rather ubiquitous and robust, as it occurs nearly all the time and for all events for which misinformation is provided. The findings reported in Study 3 to Study 6 proved that misinformation is particularly lingering in the case of vaccines misconceptions. As showed in Study 3, common strategies employed for correcting misinformation about the dangers of vaccination may have the opposite effect and reinforce ill-founded beliefs, such as that vaccines cause autism. Study 4 corroborated that a popular technique based on countering false information in ways that repeat it actually amplifies false information, making it familiar and therefore more acceptable. Altogether, the findings presented in these two studies offer a useful example of how factual information is misremembered over time. In fact, even after a short delay, facts tend to fade from the memory, leaving behind popular misconceptions. Study 5 and Study 6 provided further insight into the reasons why people continue to rely on misinformation even if they remember and understand a subsequent retraction. In particular, the findings reported in Study 5 suggest that source trustworthiness is crucial in reducing people's reliance on misinformation, while Study 6 indicates that missing information can easily evolve into misinformation.

The overall theme of the studies presented in this Thesis supports the idea that "human memory is not a recording device, but rather a process of (re)construction that is vulnerable to both internal and external influences" (Van Damme & Smets, 2014, p. 310). Therefore, forgetting and/or misremembering one's intended actions are the inevitable result of the limitations of human information processing. The question then becomes: what can be done to counteract our own fallible humanity?

As shown in Study 1, if the problem derives from forgetting delayed intentions because of daily stress, compensatory memory strategies based on relying on other people to remember things proved to buffer the disruptive effect of stress on prospective memory errors. Also external memory aids (e.g., shopping lists, calendars, notes and anything which disturbs the regular stream of events) could be of great value in enhancing prospective remembering in healthy people, especially when there is a lengthy time interval between encoding of the prospective memory task and carrying

out the task or in situations where internal aids (e.g., mentally rehearsing the list of items one intends to buy) cannot be trusted (Brandimonte, 2006; Mizuno, 2001). The same is true in complex working contexts, such as in aviation, where the use of external aids signalling when to act have proven to reduce prospective memory errors (Loft, Smith, & Bhaskara, 2011; Loft, Smith, & Remington, 2013), and in healthcare, where such failures could be reduced implementing checklists or distributing the prospective memory task in the sense that multiple agents (other doctors, nurses, equipment, IT) remind the person of the intended task (Grundgeiger et al., 2014).

As discussed in Part Two of this Thesis, the situation becomes much more nuanced when trying to repair the damage caused by misinformation on our memory (Mazzoni & Scoboria, 2007). Under such circumstances, there is no such thing as a memory aid or an explicit reminder signalling that facts are not always properly checked before information is disseminated that is capable of eliminating altogether the continued influence of misinformation (Ecker et al., 2010). Indeed, misinformation research shows that no corrective technique can reduce ill-founded beliefs to a base level, as if the misinformation was never previously mentioned (Swire & Ecker, 2018). For instance, in the Introduction to Part Two of this Thesis I mentioned that past research has shown that one of the most effective techniques for enhancing prospective memory is based on the notion of "implementation intentions"; generally, encouraging people to make a plan to accomplish a desired outcome may enhance the rate of goal attainment (Gollwitzer, 1999; Gollwitzer & Oettingen, 1998, 2007). In the context of vaccination, prompting individuals to write down the date and time when they planned to get their flu shot proved to increase vaccination rates (Milkman et al., 2011). However, understanding why parents do or do not accept vaccinations is complex. Creating cues and plans to reduce forgetfulness and procrastination may serve as a means to increase vaccination rates among those with favourable attitudes toward vaccination but may not be enough when parents are misinformed about vaccines.

Another point has to do with the strong innate mechanisms inducing people to preserve misinformation, even in the face of unequivocal evidence to the contrary. As anticipated in the Introduction to Part Two of this Thesis, as well as suggested by the pattern of results from Studies 3 to 6, people who have acquired false beliefs may stubbornly persist in holding them so as to avoid "cognitive dissonance", i.e. that

unpleasant state of having inconsistent thought, beliefs, or attitudes regarding behavioural decisions and attitude change (for reviews on motivated cognition, see Cooper, 2007; Kunda, 1990; for a review from a misinformation perspective, see Ecker, Swire, and Lewandowsky, 2014). A cornerstone of Festinger's dissonance theory (1957) is that people refrain from cognitive dissonance and actively seek out ways to relieve this discordance, engaging in particular avoidance techniques. A peculiar case of motivated cognition may arise when we are confronted with new information that contradicts an already held belief. Under certain circumstances, we may tend not to rationally compare the two opposing theses in front of us and resolve the inner conflict using available evidence. Rather, we may respond in the same way we react to a physical threat by instinctively fighting against the information that threatens our beliefs (Salingaros, 2014). In particular, strong believers may reject incongruent beliefs in order to maintain and preserve a pervasive worldview, whose dismissal would be too threatening for their identity or sense of self. This strategy may therefore be regarded as a kind of protective mechanism and add to the wide array of methods to reduce cognitive dissonance described by Festinger (1957).

The use of motivated reasoning to avoid cognitive dissonance induced by new, opposing information has been widely documented in the political realm; in particular, it has been demonstrated that people on the conservative side of politics tend to assimilate only those facts that confirm what they already believe (e.g., Nyhan & Reifler, 2010; Prasad et al., 2009). As regards vaccination decision-making, Nyhan et al. (2014) clearly showed that, when confronted with evidence against their strong belief that vaccine cause autism, "respondents brought to mind other concerns about vaccines to defend their anti-vaccination attitudes" (p. e840). Likewise, Voinson, Billiard and Alvergne (2015) reported that the overlapping notion of confirmation bias, i.e. the propensity to seek out information that confirms one's pre-existing belief (Klayman, 1995; Nickerson, 1998), can explain variation into vaccination coverage. Many others pointed out that vaccine hesitancy is a problem of biased reasoning (Brewer et al., 2017; Goldenberg, 2016), with vaccine refusers ignoring the rational findings of science and engaging in all types of tactics and tropes to favour their strongly held beliefs about vaccines (Kata, 2012). The cognitive phenomenon by which we may look for what confirms our beliefs and do not scrutinize contrary ideas

is only one among several, however, as other heuristics have been documented in previous research on vaccine acceptance. For instance, recent research demonstrated that anti-vaccination attitudes may be favoured by a feeling of "overconfidence", as people who know the least about the causes of autism and the possible side effects of vaccines are the most likely to think they know more or better than medical and scientific experts – a typical Dunning-Kruger effect (Motta, Callaghan, & Sylvester, 2018). Other studies reported a link between vaccine hesitancy and "omission bias", i.e., the tendency to prefer a potentially harmful inaction (an act of omission) over a potentially less harmful act (an act of commission), or "ambiguity aversion", i.e., the tendency to prefer a known risk (for instance, the risks related to getting Zika virus after a mosquito bite) to unknown risks (the more ambiguous risks from a new vaccine against Zika virus) (Dubov & Phung, 2015; Voinson et al., 2015). Together, studies like these show that people are biased reasoners. The implication is that researchers should remain cognizant of how internal processes may affect behavioural measures and be aware that even the most sophisticated and well-designed messages may not convince people because of the intricate ways in which their mind works (Strickland, Taber, & Lodge, 2011).

However, there are some recommendations that can serve as guidelines for mass communication as how best to counteract the fallouts from misinformation in the public sphere. As discussed earlier, misinformation is particularly difficult to correct if it comes from a trusted source (as revealed in Study 5) and is plausible, easy-to-understand, familiar (as suggested by the familiarity backfire effect in Study 3 and Study 4), or it concerns "uncertain" arguments about which it is easier for misinformers to cast doubt (as shown in Study 6). Therefore, communicators, as well as health professionals in the case of vaccines misinformation, should first endeavour to build trusting relationships. In particular, when a source bases its claims on evidence, adequately references the evidence, and presents data in an easily accessible way to minimize misinterpretations – and does this consistently – its perceived credibility increases and thus the corrections coming from this source tend to have a greater efficacy (Swire & Ecker, 2018). Then, when trying to set the record straight, communicators should focus on the facts, which should be communicated in a way that makes them easy to understand, as well as avoid unnecessary repetitions of

misinformation that lead people to more easily remember the very false claims (Nyhan & Reifler, 2012; Trembath et al., 2016). Another practical recommendation for reducing the prevalence of misinformation, particularly among people who held strong prior beliefs about the issue at hand and tend to select like-minded sources and reject unwelcome corrections, could be to encourage the public to employ scientific skepticism, "approaching claims with an open mind, and a willingness to accept only those claims that have survived scrutiny in rigorous scientific tests" (Schmaltz & Lilienfeld, 2014, p. 1). Consistent with Sagan's (1995) argument that critical thinking facilitates "baloney detection" and protects against the aggressive self-righteousness of one's mind, people engaging in true skepticism tend indeed to differentiate more accurately between truth and falsehood (Lewandowsky et al., 2016; Lewandowsky, Stritzke, Oberauer, & Morales, 2005, 2009). Finally, given the difficulties of improving human cognition, communicators should ensure the dissemination of high quality information and thus discourage the spread of misinformation in the first place.

APPENDIX A. Items and instructions for the scales used in Study 1

Perceived Stress Scale (PSS-10; Cohen & Williamson, 1988)

The questions in this scale ask you about your feelings and thoughts during the last month. In each case, you will be asked to indicate *how often* you felt or thought a certain way. For each question choose from the following alternatives: ⓪ = Never ① = Almost never ② = Sometimes ③ = Fairly often ④ = Very often		
1.	In the last month, how often have you been upset because of something that happened unexpectedly?	⓪ ① ② ③ ④
2.	In the last month, how often have you felt that you were unable to control the important things in your life?	⓪ ① ② ③ ④
3.	In the last month, how often have you felt nervous and "stressed"?	⓪ ① ② ③ ④
4.	In the last month, how often have you felt confident about your ability to handle your personal problems?	⓪ ① ② ③ ④
5.	In the last month, how often have you felt that things were going in your way?	⓪ ① ② ③ ④
6.	In the last month, how often have you found that you could not cope with all the things that you had to do?	⓪ ① ② ③ ④
7.	In the last month how often have you been able to control irritations in your life?	⓪ ① ② ③ ④
8.	In the last month, how often have you felt that you were on top of things?	⓪ ① ② ③ ④
9.	In the last month, how often have you been angered because of things that happened that were outside of your control?	⓪ ① ② ③ ④
10.	In the last month, how often have you felt difficulties were piling up so high to the point that you could not overcome them? [a]	⓪ ① ② ③ ④

Note: [a] Item modified for the purpose of the objective test of PM employed in this study.

Cognitive Failures Questionnaire (CFQ; Broadbent et al., 1982; Di Fabio et al., 2004)

The following questions are about minor mistakes which everyone makes from time to time, but some of which happen more often than others. We want to know *how often* these things have happened to you in the last six months. For each question choose from the following alternatives:

⓪ = Never ① = Very rarely ② = Occasionally
③ = Quite often ④ = Very often

1.	Do you read something and find you haven't been thinking about it and must read it again?	⓪	①	②	③	④
2.	Do you find you forget why you went from one part of the house to the other?	⓪	①	②	③	④
3.	Do you fail to notice signposts on the road?	⓪	①	②	③	④
4.	Do you find you confuse right and left when giving directions?	⓪	①	②	③	④
5.	Do you bump into people?	⓪	①	②	③	④
6.	Do you find you forget whether you've turned off a light or a fire or locked the door?	⓪	①	②	③	④
7.	Do you fail to listen to people's names when you are meeting them?	⓪	①	②	③	④
8.	Do you say something and realize afterwards that it might be taken as insulting?	⓪	①	②	③	④
9.	Do you fail to hear people speaking to you when you are doing something else?	⓪	①	②	③	④
10.	Do you lose your temper and regret it?	⓪	①	②	③	④
11.	Do you leave important letters unanswered for days?	⓪	①	②	③	④
12.	Do you find you forget which way to turn on a road you know well but rarely use?	⓪	①	②	③	④
13.	Do you fail to see what you want in a supermarket (although it's there)?	⓪	①	②	③	④
14.	Do you find yourself suddenly wondering whether you've used a word correctly?	⓪	①	②	③	④
15.	Do you have trouble making up your mind?	⓪	①	②	③	④
16.	Do you find you forget appointments?	⓪	①	②	③	④
17.	Do you forget where you put something like a newspaper or a book?	⓪	①	②	③	④
18.	Do you find you accidentally throw away the thing you want and keep what you meant to throw away - as in the example of throwing away the matchbox and putting the used match in your pocket?	⓪	①	②	③	④
19.	Do you daydream when you ought to be listening to something?	⓪	①	②	③	④
20.	Do you find you forget people's names?	⓪	①	②	③	④

21. Do you start doing one thing at home and get distracted into doing something else (unintentionally)?	⓪ ① ② ③ ④
22. Do you find you can't quite remember something although it's 'on the tip of your tongue'?	⓪ ① ② ③ ④
23. Do you find you forget what you came to the shops to buy?	⓪ ① ② ③ ④
24. Do you drop things?	⓪ ① ② ③ ④
25. Do you find you can't think of anything to say?	⓪ ① ② ③ ④

Prospective and Retrospective Memory Questionnaire (PRMQ; Smith et al., 2000)

As before, the following questions are about minor mistakes which everyone makes from time to time. We want to know *how often* these things have happened to you. For each question choose from the following alternatives:

① = Never ② = Rarely ③ = Sometimes
④ = Quite often ⑤ = Very often

1. Do you decide to do something in a few minutes' time and then forget to do it?	① ② ③ ④ ⑤
2. Do you fail to recognise a place you have visited before?	① ② ③ ④ ⑤
3. Do you fail to do something you were supposed to do a few minutes later even though it's there in front of you, like take a pill or turn off the kettle?	① ② ③ ④ ⑤
4. Do you forget something that you were told few minutes before?	① ② ③ ④ ⑤
5. Do you forget appointments if you are not prompted by someone else or by a reminder such as a calendar or diary?	① ② ③ ④ ⑤
6. Do you fail to recognise a character in a radio or television show from scene to scene?	① ② ③ ④ ⑤
7. Do you forget to buy something you planned to buy, like a birthday card, even when you see the shop?	① ② ③ ④ ⑤
8. Do you fail to recall things that have happened to you in the last few days?	① ② ③ ④ ⑤
9. Do you repeat the same story to the same person on different occasions?	① ② ③ ④ ⑤
10. Do you intended to take something with you, before leaving a room or going out, but minutes later leave it behind, even though it's there in front of you?	① ② ③ ④ ⑤
11. Do you mislay something that you have just put down, lie a magazine or glasses?	① ② ③ ④ ⑤
12. Do you fail to mention or give something to a visitor that you were asked to pass on?	① ② ③ ④ ⑤

13. Do you look at something without realising you have seen it moments before?	① ② ③ ④ ⑤
14. If you tried to contact a friend or relative who was out, would you forget to try again later?	① ② ③ ④ ⑤
15. Do you forget what you watched on television the previous day?	① ② ③ ④ ⑤
16. Do you forget to tell someone something you had meant to mention a few minutes ago?	① ② ③ ④ ⑤

Note: Items 1, 3, 5, 7, 10, 12, 14, and 16 compose the ProM subscale, while items 2, 4, 6, 8, 9, 11, 13, and 15 constitute the RetM subscale.

Memory Compensation Questionnaire (MCQ; Dixon & Bäckman, 1993; de Frias & Dixon, 2005)

The following questions are about common behaviours that one may have. For each question choose from the following alternatives: ⓪ = Never ① = Very rarely ② = Occasionally ③ = Quite often ④ = Always	
1. Do you use shopping lists when you go shopping?	⓪ ① ② ③ ④
2. When you want to remember an important appointment do you ask somebody else (for example, spouse or friend) to remind you?	⓪ ① ② ③ ④
3. When you are reading a book, do you use a bookmark to indicate the point where you stopped reading last time? [a]	⓪ ① ② ③ ④
4. When an interesting TV program is going to be on in the next few days do you ask somebody else to help you remember (for example, spouse or friend)?	⓪ ① ② ③ ④
5. When you want to remember an event such as a birthday, do you ask somebody else (for example, spouse or friend) to help you remember?	⓪ ① ② ③ ④
6. Do you post notes on a board or other prominent place to help you remember things for the future (for example, meetings or dates)?	⓪ ① ② ③ ④
7. When you want to remember the name of a particular person, do you ask somebody else (for example, spouse or friend) to help you remember?	⓪ ① ② ③ ④
8. Do you sometimes ask someone (for example, spouse or friend) to help you remember when you are going to start a trip?	⓪ ① ② ③ ④
9. Do you put things (for example, glasses or keys) in particular places to remember where they are for future purposes?	⓪ ① ② ③ ④

10. Do you put things in obvious places (for example, briefcase in front of the door) in order to remember them when you're going out?	⓪ ① ② ③ ④
11. When you want to remember something from a TV program do you use "memory tricks" like grouping or repeating to yourself?	⓪ ① ② ③ ④
12. Do you take your time to go through and reconstruct an event you want to remember?	⓪ ① ② ③ ④
13. Do you write down appointments (for example, with the hairdresser or the dentist) in a notebook or calendar?	⓪ ① ② ③ ④
14. Before an important day do you think about or plan the things you have to do?	⓪ ① ② ③ ④
15. Do you note birthdays in a notebook or calendar in order to remember them?	⓪ ① ② ③ ④
16. Do you repeat telephone numbers to yourself in order to remember them well?	⓪ ① ② ③ ④
17. Do you write down telephone numbers in a calendar or notebook in order to remember them?	⓪ ① ② ③ ④
18. When you want to remember the name of a person do you try to associate the name with the person's face?	⓪ ① ② ③ ④
19. When you want to remember something that happened in a particular day do you review and reconstruct the events of that day in order to help you remember?	⓪ ① ② ③ ④
20. Do you use letters as cues (in other words, go through the alphabet) when you want to remember the name of a person, a city, or something else?	⓪ ① ② ③ ④
21. When you want to remember something do you try to relate it to something else you know well in order to remember it better?	⓪ ① ② ③ ④
22. Do you use mental images or pictures to remember some types of information?	⓪ ① ② ③ ④
23. Do you repeat important appointments to yourself in order to remember them as well as possible?	⓪ ① ② ③ ④

Note: Items 1, 3, 6, 9, 10, 13, 15, and 17 compose the External subscale, items 11, 12, 14, 16, 18, 19, 20, 21, 22, and 23 constitute the Internal subscale, while items 2, 4, 5, 7, 8 are included in the Reliance subscale; [a] Item modified for the purpose of the objective test of PM employed in this study.

Ego-Resiliency Scale (ER89; Block & Kramen, 1996; Caprara et al., 2003)

Please indicate the extent to which the following statements are true for you, using the following response scale: ① = Never ② = Very rarely ③ = Rarely ④ = Quite often ⑤ = Often ⑥ = Very often ⑦ = Always	
1. I am generous with my friends.	① ② ③ ④ ⑤ ⑥ ⑦

2. I quickly get over and recover from being startled.	① ② ③ ④ ⑤ ⑥ ⑦
3. I enjoy dealing with new and unusual situations.	① ② ③ ④ ⑤ ⑥ ⑦
4. I usually succeed in making a favorable impression on people.	① ② ③ ④ ⑤ ⑥ ⑦
5. I enjoy trying new foods I have never tasted before.	① ② ③ ④ ⑤ ⑥ ⑦
6. I am regarded as a very energetic person.	① ② ③ ④ ⑤ ⑥ ⑦
7. I like to take different paths to familiar places.	① ② ③ ④ ⑤ ⑥ ⑦
8. I am more curious than most people.	① ② ③ ④ ⑤ ⑥ ⑦
9. Most of the people I meet are likeable.	① ② ③ ④ ⑤ ⑥ ⑦
10. I usually think carefully about something before acting.	① ② ③ ④ ⑤ ⑥ ⑦
11. Seeing things from a different **point** of view can help us understand why people act the way they do. [a]	① ② ③ ④ ⑤ ⑥ ⑦
12. I like to do new and different things.	① ② ③ ④ ⑤ ⑥ ⑦
13. My daily life is full of things that keep me interested.	① ② ③ ④ ⑤ ⑥ ⑦
14. I would be willing to describe myself as a pretty "strong" personality.	① ② ③ ④ ⑤ ⑥ ⑦
15. I get over my anger at someone reasonably quickly.	① ② ③ ④ ⑤ ⑥ ⑦

Note: [a] Item added to the original scale for the purpose of the objective test of PM employed in this study but not included in the statistical analyses.

General Health Questionnaire (GH12; Goldberg & Williams, 1988)

Please answer the following questions about your health from your **POINT** of view. For each question choose from the following alternatives: ⓪ = Not at all ① = No more than usual ② = Rather more than usual ③ = More than usual	
1. In the last two weeks, how often have you lost sleep over worry?	⓪ ① ② ③
2. In the last two weeks, how often have you felt constantly under strain?	⓪ ① ② ③
3. In the last two weeks, how often have you felt you couldn't overcome difficulties?	⓪ ① ② ③
4. In the last two weeks, how often have you felt unhappy and depressed?	⓪ ① ② ③
5. In the last two weeks, how often have you lost confidence in yourself?	⓪ ① ② ③
6. In the last two weeks, how often have you thought of yourself as worthless?	⓪ ① ② ③

Now, please answer these questions choosing from the following alternatives: ⓪ = Much more than usual ① = Same as usual ② = Less than usual ③ = Much less than usual				
7. In the last two weeks, how often have you felt able to concentrate?	⓪	①	②	③
8. In the last two weeks, how often have you felt you were playing a useful part?	⓪	①	②	③
9. In the last two weeks, how often have you felt capable of making decisions?	⓪	①	②	③
10. In the last two weeks, how often have you felt able to enjoy day-to-day activities?	⓪	①	②	③
11. In the last two weeks, how often have you felt able to face problems?	⓪	①	②	③
12. In the last two weeks, how often have you felt reasonably happy?	⓪	①	②	③

APPENDIX B. Items and instructions for the scales used in Study 2

Need for Recovery Scale (Van Veldhoven & Meijman, 1994)

Please indicate the extent to which the following statements are true for you, using the following response scale: ① = Never ② = Sometimes ③ = Often ④ = Always	
1. I find it difficult to relax at the end of a working day.	① ② ③ ④
2. By the end of the working day, I feel really worn out.	① ② ③ ④
3. Because of my job, at the end of the working day I feel really exhausted.	① ② ③ ④
4. After the evening meal, I generally feel fit.	① ② ③ ④
5. In general, I only start to feel relaxed at the end of the second non-working day.	① ② ③ ④
6. I find it difficult to concentrate in my free time after work.	① ② ③ ④
7. I cannot really show much interest in other people when I have just come home myself.	① ② ③ ④
8. Generally, I need more than an hour before I feel completely recuperated after work.	① ② ③ ④
9. When I get home from work, I have a series of reoccurring thoughts about what I could do better at work.[a]	① ② ③ ④
10. When I get home from work, I need to be left in peace for a while.	① ② ③ ④
11. After a day's work, I often feel so tired that I cannot get involved in other activities.	① ② ③ ④
12. During the last part of the working day, a feeling of tiredness prevents me from doing my work as well as I normally would.	① ② ③ ④

Note: [a] Item added to the original scale for the purpose of the objective test of PM employed in this study but not included in the following analyses.

Oldenburg Burnout Inventory (OLBI; Demerouti et. al, 2001)

Below you can find a series of statements which you may agree or not agree with. Please indicate the extent to which the following statements are true for you, using the following response scale: ① = Strongly agree ② = Agree ③ = Disagree ④ = Strongly disagree	
1. I always find new and interesting aspects in my work.	① ② ③ ④
2. There are days when I feel tired before I arrive at work.	① ② ③ ④

3. It happens more and more often that I talk about my work in a negative way.	① ② ③ ④
4. After work, I tend to need more time than in the past in order to relax and feel better.	① ② ③ ④
5. I can tolerate the pressure of my work very well.	① ② ③ ④
6. Lately, I tend to think less at work and do my job almost mechanically.	① ② ③ ④
7. I find my work to be a positive challenge.	① ② ③ ④
8. During my work, I often feel emotionally drained.	① ② ③ ④
9. Over time, one can become disconnected from this type of work.	① ② ③ ④
10. After working, I have enough energy for my leisure activities.	① ② ③ ④
11. Sometimes I feel sickened by my work tasks.	① ② ③ ④
12. After my work, I usually feel worn out and weary.	① ② ③ ④
13. This is the only type of work that I can imagine myself doing.	① ② ③ ④
14. Usually, I can manage the amount of my work well.	① ② ③ ④
15. I feel more and more engaged in my work.	① ② ③ ④
16. When I work, I usually feel energized.	① ② ③ ④

Note: Exhaustion items are 2(R), 4(R), 5, 8(R), 10, 12(R), 14, 16, while disengagement items are 1, 3(R), 6(R), 7, 9(R), 11(R), 13, 15. (R) indicates items to be reversed so that higher scores indicate more burnout.

Cognitive Failures Questionnaire (CFQ; CFQ; Broadbent et al., 1982; Di Fabio et al., 2004)

The following questions are about minor mistakes which everyone makes from time to time, but some of which happen more often than others. We want to know *how often* these things have happened to you in the last six months. For each question choose from the following alternatives: ⓪ = Never ① = Very rarely ② = Occasionally ③ = Quite often ④ = Very often	
1. Do you read something and find you haven't been thinking about it and must read it again?	⓪ ① ② ③ ④
2. Do you find you forget why you went from one part of the house to the other?	⓪ ① ② ③ ④
3. Do you fail to notice signposts on the road?	⓪ ① ② ③ ④
4. Do you find you confuse right and left when giving directions?	⓪ ① ② ③ ④
5. Do you bump into people?	⓪ ① ② ③ ④
6. Do you find you forget whether you've turned off a light or a fire or locked the door?	⓪ ① ② ③ ④
7. Do you fail to listen to people's names when you are meeting them?	⓪ ① ② ③ ④

8. Do you say something and realize afterwards that it might be taken as insulting?	⓪ ① ② ③ ④
9. Do you fail to hear people speaking to you when you are doing something else?	⓪ ① ② ③ ④
10. Do you lose your temper and regret it?	⓪ ① ② ③ ④
11. Do you leave important letters unanswered for days?	⓪ ① ② ③ ④
12. Do you find you forget which way to turn on a road you know well but rarely use?	⓪ ① ② ③ ④
13. Do you fail to see what you want in a supermarket (although it's there)?	⓪ ① ② ③ ④
14. Do you find yourself suddenly wondering whether you've used a word correctly?	⓪ ① ② ③ ④
15. Do you have trouble making up your mind?	⓪ ① ② ③ ④
16. Do you find you forget appointments?	⓪ ① ② ③ ④
17. Do you forget where you put something like a newspaper or a book?	⓪ ① ② ③ ④
18. Do you find you accidentally throw away the thing you want and keep what you meant to throw away - as in the example of throwing away the matchbox and putting the used match in your pocket?	⓪ ① ② ③ ④
19. Do you daydream when you ought to be listening to something?	⓪ ① ② ③ ④
20. Your favourite TV **series** will be broadcast tomorrow night. Do you ever ask someone else (such as your spouse or a friend) to remind you? [a]	⓪ ① ② ③ ④
21. Do you find you forget people's names?	⓪ ① ② ③ ④
22. Do you start doing one thing at home and get distracted into doing something else (unintentionally)?	⓪ ① ② ③ ④
23. Do you find you can't quite remember something although it's 'on the tip of your tongue'?	⓪ ① ② ③ ④
24. Do you find you forget what you came to the shops to buy?	⓪ ① ② ③ ④
25. Do you drop things?	⓪ ① ② ③ ④
26. Do you find you can't think of anything to say?	⓪ ① ② ③ ④

Note: [a] Item added to the original scale for the purpose of the objective test of PM employed in this study but not included in the statistical analyses.

Prospective Memory subscale from the Prospective and Retrospective Memory Questionnaire (PRMQ ProM; Smith et al., 2000)

The following questions are about minor mistakes which everyone makes from time to time. We want to know *how often* these things have happened to you. For each question choose from the following alternatives:

① = Never ② = Rarely ③ = Sometimes
④ = Quite often ⑤ = Very often

1. Do you decide to do something in a few minutes' time and then forget to do it?	① ② ③ ④ ⑤
2. Do you fail to do something you were supposed to do a few minutes later even though it's there in front of you, like take a pill or turn off the kettle?	① ② ③ ④ ⑤
3. Do you forget appointments if you are not prompted by someone else or by a reminder such as a calendar or diary?	① ② ③ ④ ⑤
4. Do you forget to buy something you planned to buy, like a birthday card, even when you see the shop?	① ② ③ ④ ⑤
5. Do you intended to take something with you, before leaving a room or going out, but minutes later leave it behind, even though it's there in front of you?	① ② ③ ④ ⑤
6. Do you fail to mention or give something to a visitor that you were asked to pass on?	① ② ③ ④ ⑤
7. If you tried to contact a friend or relative who was out, would you forget to try again later?	① ② ③ ④ ⑤
8. Do you forget to tell someone something you had meant to mention a few minutes ago?	① ② ③ ④ ⑤

Item investigating the importance attributed to PM for daily practice

Please answer the following question at the best of your knowledge, using the following response scale:
① = Not important at all ② = Of little importance ③ = Of average importance ④ = Very important ⑤ = Absolutely essential

Prospective memory refers to situations in which an individual intends to perform an action at a later time. In your opinion, how much is important prospective memory for patient safety?	① ② ③ ④ ⑤

Self-developed scale modelled after Dismukes & Nowinski's (2007) taxonomy of PM tasks in the aviation setting

The following items are about situations which you may experience at work from time to time. We want to know how often these situations have happened to you in the last month. For each question choose from the following alternatives:
① = Never ② = Rarely ③ = Sometimes ④ = Quite often ⑤ = Very often

1.	You postponed some work task that is not habitually performed to resume it at later time. However, you cannot remember whether you eventually performed this task.	① ② ③ ④ ⑤
2.	While performing some work task, you were abruptly interrupted by other patients, co-workers, or events on the unit and you cannot remember whether you resumed the interrupted task at a later time.	① ② ③ ④ ⑤
3.	You made some error while performing a habitual work task, namely a task including steps that are normally performed in the same sequence.	① ② ③ ④ ⑤
4.	While performing some work task, circumstances required you to modify a well-established procedure but you unintentionally reverted to the normal procedure.	① ② ③ ④ ⑤
5.	You made some error while performing several work tasks concurrently.	① ② ③ ④ ⑤
6.	A **SERIES** of changes is occurring in your work.	① ② ③ ④ ⑤

Note: [a] Item added to the original scale for the purpose of the objective test of PM employed in this study but not included in the statistical analyses.

Gladstone Questionnaire (Gladstone, 1995)

The following items are about situations that may cause of medication errors. We want to know how often these situations usually happen. For each item, please place an "X" over the response that best corresponds to your opinion, using the following response scale:		
	① = Never ② = Rarely ③ = Sometimes ④ = Quite often ⑤ = Very often	
1.	Medication errors occur when the physician's writing on the doctor's order form is difficult to read or illegible.	① ② ③ ④ ⑤
2.	Medication errors occur when nurses are distracted by other patients, co-workers, or events on the unit.	① ② ③ ④ ⑤
3.	Medication errors occur when nurses are tired and exhausted.	① ② ③ ④ ⑤
4.	Medication errors occur when there is confusion between two drugs with similar names.	① ② ③ ④ ⑤
5.	Medication errors occur when the nurse miscalculates the dose.	① ② ③ ④ ⑤
6.	Medication errors occur when the physician prescribes the wrong dose.	① ② ③ ④ ⑤
7.	Medication errors occur when the nurse fails to check the patient's name-band with the Medication Administration Record (MAR).	① ② ③ ④ ⑤
8.	Medication errors occur when the nurse sets up or adjusts an infusion device incorrectly.	① ② ③ ④ ⑤

9. Medication errors occur when the medication label/packaging are of poor quality or are damaged.	① ② ③ ④ ⑤
10. Medication errors occur when nurses are confused by different types and functions of infusions devices.	① ② ③ ④ ⑤

The following items describe some events that you may encounter at work. For each item, please indicate whether the described event represents a medication error and whether it should be reported to the physician, ticking "*yes*" or "*no*".

1) A patient misses his midday dose of oral ampicillin because he was in x-ray for 3 hours.
a. Is this a medication error? YES NO
b. Would you report it to the physician? YES NO

2) Four patients on a busy surgical unit receive their 6 PM dose of IV antibiotics 4 hours late.
a. Is this a medication error? YES NO
b. Would you report it to the physician? YES NO

3) A patient receiving TPN feeding via an infusion pump is given 200 ml/hr instead of the correct rate of 125 ml/hr for the first 3 hours of the 24-h infusion. The pump was reset to the correct rate after the change of shift at 7 A when the oncoming nurse realized the pump was set at the incorrect rate.
a. Is this a medication error? YES NO
b. Would you report it to the physician? YES NO

4) A patient admitted with status asthmaticus on 08/13 at 2 AM is prescribed albuterol (ventolin) nebulizers every 4 h. The nurse omits the 6 AM dose on 08/13 as the patient is asleep.
a. Is this a medication error? YES NO
b. Would you report it to the physician? YES NO

5) A physician orders oxycodone hydrochloride and acetaminophen (Percocet) 1-2 tabs for post-operation pain every 4 h. At 4 pm the patient complains of pain, requests 1 pill and is medicated. At 6.30 pm the patient requests a second pain pill. The nurse administers the pill.
a. Is this a medication error? YES NO
b. Would you report it to the physician? YES NO

Finally, please indicate answer the following questions, ticking "*yes*" or "*no*".

I am usually sure what constitutes a medication error.	YES	NO
I am usually sure when a medication error should be reported using an incident report.	YES	NO
Some medication errors are not reported because nurses are afraid of the reaction they will receive from the nurse manager or co-workers.	YES	NO

Have you ever failed to report a medication error because you did not think the error was serious enough to warrant reporting?	YES	NO
Have you ever failed to report a medication error because you were afraid that you might be subject to disciplinary action or even lose your job?	YES	NO

APPENDIX C. Preliminary and post-manipulation surveys used in Study 3 and 4

Preliminary survey

Sex:
Age:
Educational level:

First, please put your sex, age, and educational level on the top of this page. Then, please read the following statements and check the box (one for each row) which best indicates your idea and/or behaviour.

	1 = Strongly Disagree	**2 = Disagree**	**3 = Neutral**	**4 = Agree**	**5 = Strongly Agree**
Getting vaccines is a good way to protect my future child(ren) from disease.	□	□	□	□	□
Generally I would do what my doctor recommends about vaccines for my future child(ren).	□	□	□	□	□
New vaccines are recommended only if they are as safe as older vaccines.	□	□	□	□	□
My future child(ren) will not need vaccines for diseases that are not common anymore.	□	□	□	□	□
Parents should have the right to refuse vaccines that are required for school for any reason.	□	□	□	□	□
So many children are vaccinated that my future child(ren) will be safe	□	□	□	□	□

from these illnesses even if I will not vaccinate them.					
I am concerned about serious adverse effects of vaccines.	□	□	□	□	□
Some vaccines cause autism in healthy children.	□	□	□	□	□

Post-manipulation survey

Now, please answer the following questions. For each item, check the box which best indicates your idea and/or behaviour.

	1 = Strongly Disagree	**2 = Disagree**	**3 = Neutral**	**4 = Agree**	**5 = Strongly Agree**
Some vaccines cause autism in healthy children.	□	□	□	□	□

	1 = Very Unlikely	**2 = Somewhat Unlikely**	**3 = Slightly Unlikely**	**4 = Slightly Likely**	**5 = Somewhat Likely**	**6 = Very Likely**
Just based on what you know, how likely is it that children who get the measles, mumps, and rubella vaccine – which is known	□	□	□	□	□	□

as the MMR vaccine – will suffer serious side effects?						
How likely is that you would give your future child(ren) the measles, mumps, and rubella vaccine, which is known as the MMR vaccine?	□	□	□	□	□	□

Finally, please indicate your email address and a password that we will use to match your answers in the first and second session of the study. Be sure to remember it for the second time we will meet again.

Email address:
Password:

APPENDIX D. Interventions used in Study 3

Myths vs. Facts Correction

In this experiment you will read a series of statements that contrast myths and facts about vaccines. You can go through them at your own pace.

1	MYTH	FACT
	It is well-known that better hygiene, sanitation, and nutrition are actually responsible for decreased infections, not vaccines. Therefore, vaccines are not necessary.	Many infections can spread regardless of improved sanitation. If people are not vaccinated, diseases that have become uncommon, such as polio, will quickly reappear.
2	MYTH	FACT
	Vaccines are risky. They have several damaging and long-term side-effects that are as yet unknown. Vaccination can even be fatal.	Vaccines are very safe. You are far more likely to be seriously injured by a vaccine-preventable disease than by a vaccine.
3	MYTH	FACT
	The combined vaccine against diphtheria, tetanus and pertussis (whooping cough) and the vaccine against poliomyelitis cause sudden infant death syndrome (SIDS).	There is no link between giving these vaccines and sudden infant death. It is only coincidental that these vaccines are administered at a time when babies can suffer SIDS.

4	MYTH	FACT
	Many diseases that can be preventable by vaccines, such as meningitis, are almost eradicated in my country. Therefore, there is no reason to be vaccinated, especially for uncommon diseases.	In a highly inter-connected world, the infectious agents that cause diseases, even if uncommon, continue to circulate, can easily cross geographical borders, and infect anyone who is not protected.
5	MYTH	FACT
	Vaccine-preventable childhood illnesses are not so serious. They are just an unfortunate fact of life that everyone has to face.	Illnesses such as measles, mumps and rubella are serious and can lead to severe complications, such as encephalitis.
6	MYTH	FACT
	Immunisation schedules are extremely daunting. Giving a child more than one vaccine at a time can overwhelm his or her immune system and increase the risk of harmful side-effects.	Giving several vaccines at the same time has no adverse effect. Rather, it implies fewer injections. Also, children are more likely to complete the recommended vaccinations on schedule.
7	MYTH	FACT
	Influenza, like several other common diseases, is not a big deal for most people. It is just a nuisance and the vaccine isn’t very effective.	Influenza is a serious disease that can even be fatal. Pregnant women, children, elderly are at higher risk of severe infection and death.

8 MYTH

Natural immunity is better than vaccine-acquired immunity. Indeed, catching a disease and then getting sick results in a stronger immunity to the disease than a vaccination.

FACT

Vaccines interact with the immune system to produce a response similar to that produced by the natural infection, but they protect against its potential severe complications.

9 MYTH

Aside from antigens and antibiotic, we do not know what goes into a vaccine. They can contain dangerous toxic chemicals, such as thiomersal.

FACT

Vaccines are safe. For example, there is no evidence to suggest that the amount of thiomersal contained in vaccines poses a health risk.

10 MYTH

A 1998 study showed that the MMR vaccine causes autism, because some signs of autism appear around the same age that children receive the MMR vaccine against measles, mumps, and rubella.

FACT

There is no evidence of a link between the MMR vaccine and autism. The 1998 study which first suggested this link was later found to be seriously flawed and the paper was retracted.

Visual Correction

In this experiment you will examine a series of tables which compare the negative consequences of some diseases such as measles, mumps and rubella with the potential problems caused by the MMR vaccine, injected to prevent these diseases. You can go through them at your own pace.

What are measles, mumps and rubella?

Measles, mumps and rubella are infectious diseases that are caused by three different viruses. They are spread when the viruses are passed from an infectious person to someone who is not immune to them. Rubella is also known as “German measles”.

What is the MMR vaccine?

MMR is the combined vaccine against measles, mumps and rubella. It contains live, weakened measles, mumps and rubella viruses. Over 90 countries around the world use MMR vaccine. Two doses of the vaccine are usually recommended to be given early in life.

MEASLES

Common symptoms of measles

These are usually mild symptoms and include fever, loss of appetite, rash, diarrhoea, runny nose, cough and red painful eyes. Children who get measles usually have to spend about 5 days in bed and have to take 10 to 14 days off from school, if there is no serious complication.

Complications of measles

These are usually serious conditions and include ear infections, pneumonia, fits or convulsions, croup, inflammation of the brain (encephalitis), which could result in hospitalisation. A late complication of measles is the so-called subacute sclerosing panencephalitis (SSPE), which causes progressive brain damage and nearly always results in death.

Now look at the following table that compares the potential problems caused by measles with the potential problems caused by the MMR vaccine.

Green - Common, usually mild symptoms that can be treated at home.

Yellow - Moderate complications that need medical attention but may not include hospitalisation.

Red - Serious complications that need urgent medical attention and could include hospitalization.

POTENTIAL RISKS IN A GROUP OF 100 CHILDREN UNDER 5 YEARS OF AGE WHO GET MEASLES	POTENTIAL RISKS IN A GROUP OF 100 CHILDREN WHO HAVE THE MMR VACCINE
	
Most children will have the common and usually mild **(in green)** symptoms of measles e.g. fever, cough, runny nose, red, painful eyes, rash. Some may have more than one of these symptoms at the same time.	Most will have common and usually mild **(in green)** symptoms of the MMR vaccine e.g. pain or swelling at the injection site, joint pain and stiffness. Some may have more than one of these symptoms at the same time.
26 in 100 may have moderate **(in yellow)** symptoms: ‣ **12** may have diarrhoea; ‣ **14** may get an ear infection.	**14** in 100 may have moderate **(in yellow)** symptoms: ‣ **4** may have high fever; ‣ **4** may be irritable; ‣ **1** may have swelling of salivary glands; ‣ **5** may have a non-infectious faint red rash.
15 in 100 may have serious **(in red)** symptoms ‣ **9** may get pneumonia ‣ **5** may have measles croup ‣ **1** may have fever-induced convulsion Some may be hospitalised for any of the above symptoms.	
Rare Complications **2 in 1,000** children may have inflammation of the brain (encephalitis). Encephalitis from any reason may result in children surviving with permanent brain damage or death.	**Rare Complications** Uncertain; a maximum of one child may develop encephalitis.
3 in 1,000 children develop thrombocytopenia (tendency for bruising or bleeding).	**26 in 1,000,000** children may have thrombocytopenia.
1 in 100, 000 children may get subacute sclerosing panencephalitis (SSPE), a late complication of measles, which causes progressive brain damage and nearly always results in death.	No children will get subacute sclerosing panencephalitis (SSPE).

MUMPS

Common symptoms of mumps

These are usually mild symptoms and include fever, mild headaches, abdominal pain, loss of appetite, painful and swollen glands in the cheeks, neck or under the jaw in 7 out of 10 people. These symptoms usually go away within 10 days or so, if there is no serious complication.

Complications of mumps

These are usually serious conditions and include inflammation of the pancreas (pancreatitis), partial or complete deafness and inflammation of the brain (encephalitis), which could result in hospitalisation. Complications are more serious after puberty. Boys (after puberty) and men may experience painful, swollen testicles, which very rarely causes infertility. Mumps may cause spontaneous miscarriage during the 1st three months of pregnancy. Mumps is the commonest cause of meningitis in the UK.

Now look at the following table that compares the potential problems caused by measles with the potential problems caused by the MMR vaccine.

Green - Common, usually mild symptoms that can be treated at home.
Yellow - Moderate complications that need medical attention but may not include hospitalisation.
Red - Serious complications that need urgent medical attention and could include hospitalization.

POTENTIAL RISKS IN A GROUP OF 100 CHILDREN UNDER 5 YEARS OF AGE AND ADOLESCENTS WHO GET MUMPS	POTENTIAL RISKS IN A GROUP OF 100 CHILDREN WHO HAVE THE MMR VACCINE
	
1/3 of children will have no symptoms. Most children will have the common and usually mild **(in green)** symptoms of mumps e.g. fever, tiredness, runny nose, loss of appetite, general aches and pains.**76** in 100 children may have swollen cheeks or swelling under the jaw.	Most will have common and usually mild **(in green)** symptoms of the MMR vaccine e.g. pain or swelling at the injection site, joint pain and stiffness. Some may have more than one of these symptoms at the same time.
Some may have more than one of these symptoms listed above at the same time **(in yellow).**	**14** in 100 may have moderate **(in yellow)** symptoms: • **4** may have high fever; • **4** may be irritable; • **1** may have swelling of salivary glands; • **5** may have a non-infectious faint red rash.
16 in 100 may have serious **(in red)** symptoms: • **4** may have inflamed pancreas (pancreatitis) causing pain and vomiting; • **8** may have mild and temporary inflammation of the lining of the brain (aseptic meningitis); • **4** may have temporary hearing loss.	
Rare Complications **3 in 1,000** children may have inflammation of the brain (encephalitis). **1 in 20,000** children may have permanent deafness, usually on one side.	**Rare Complications** **25 to 34 in 100,000** children may have fever-induced fits or convulsions. **1 in 1 million** children may have inflammation of the brain (encephalitis). Up to **4 in 1 million** children may get a severe allergic reaction (anaphylaxis). **4 in 100,000** children may have a temporary tendency for bruising or bleeding (thrombocytopenia)

RUBELLA

Common symptoms of rubella

These are usually mild symptoms and include fever, swollen glands, joint pain and a red rash around the ears and neck.

Complications of rubella

These are usually serious conditions and include a tendency to bleed or bruise (thrombocytopenia), deafness and inflammation of the brain (encephalitis), which could result in hospitalisation. Congenital rubella (which means rubella infection of an unborn child) is a very serious condition. If a woman catches rubella during the first 3 months of her pregnancy, the virus almost always causes serious birth defects (congenital abnormalities) in her unborn child. This can include deafness, blindness, heart defects or damage to the brain.

Now look at the following table that compares the potential problems caused by measles with the potential problems caused by the MMR vaccine.

Green - Common, usually mild symptoms that can be treated at home.
Yellow - Moderate complications that need medical attention but may not include hospitalisation.
Red - Serious complications that need urgent medical attention and could include hospitalization.

POTENTIAL RISKS IN A GROUP OF 100 CHILDREN UNDER 5 YEARS OF AGE WHO GET RUBELLA	POTENTIAL RISKS IN A GROUP OF 100 CHILDREN WHO HAVE THE MMR VACCINE
	
50 children will have the common and usually mild **(in green)**symptoms of rubella e.g. fever, tiredness, sore eyes, rash, painful and swollen glands.	Most will have common and usually mild **(in green)** symptoms of the MMR vaccine e.g. pain or swelling at the injection site, joint pain and stiffness. Some may have more than one of these symptoms at the same time.
Some may have more than one of these symptoms listed above at the same time **(in yellow)**	**14** in 100 may have moderate **(in yellow)** symptoms ‣ **4** may have high fever ‣ **4** may be irritable ‣ **1** may have swelling of salivary glands ‣ **5** may have a non-infectious faint red rash
Rare Complications **1 in 3,000** children may have a temporary tendency for bruising or bleeding (thrombocytopenia)**.** **1 in 6,000** children may have inflammation of the brain (encephalitis). Encephalitis from any reason may result in children surviving with permanent brain damage or death. **90% of babies** infected in the 1st trimester (i.e. 1st three months of pregnancy) will have major birth defects (congenital abnormalities) such as deafness, blindness, heart defects or damage to the brain. Very rarely, a person may get degenerative brain inflammation i.e. progressive rubella pan-encephalitis.	**Rare Complications** **25 to 34 in 100,000** children may have fever-induced fits or convulsions. **1 in 1 million** children may have inflammation of the brain (encephalitis). Encephalitis from any reason may result in children surviving with permanent brain damage or death. Up to **4 in 1 million** children may get a severe allergic reaction (anaphylaxis). Anaphylaxis from any reason, may result in death. Up to **4 in 100, 000** children may have a temporary tendency for bruising or bleeding (thrombocytopenia)

Fear Correction

In this experiment you will see some of the consequences you may face by choosing to not vaccinate your child.

Measles, mumps, and rubella are serious diseases. a combined shot — called *mmr* vaccine — can prevent these diseases. Ask your doctor for more information.

MEASLES

The measles virus can be spread very easily. Even being in the same room with a person with measles is enough to catch the disease. Symptoms include a rash, fever, cough and watery eyes. Measles also can cause pneumonia, brain damage, seizures or death.

Image available at: http://www.idph.state.il.us/about/imm unepics/measles.htm

MUMPS

The mumps virus causes fever, headaches and swollen salivary glands under the jaw. Children who get mumps may develop meningitis (inflammation of the covering of the brain and spinal cord) and encephalitis (inflammation of the brain). Mumps can also result in permanent hearing loss.

Image available at: http://www.idph.state.il.us/about/imm unepics/mumps.htm

RUBELLA

The rubella virus usually causes mild sickness with fever, swollen glands and a rash that last about three days. But, if a pregnant woman gets rubella, she can lose her baby, or the baby can be born blind, deaf, mentally retarded, with heart defects or other serious problems.

Image available at: http://www.idph.state.il.us/about/imm unepics/rubella.htm

Control

In this experiment you will read some fact sheets containing tips to help prevent medical errors and get safer healthcare. You can go through them at your own pace.

Materials for this intervention were drawn from:

https://www.ahrq.gov/sites/default/files/wysiwyg/patients-consumers/care-planning/errors/20tips/20tips.pdf [AHRQ Pub. No. 110089]

https://archive.ahrq.gov/patients-consumers/care-planning/errors/5steps/5steps.pdf [Pub No. AHRQ 04-M005]

APPENDIX E. Stories used in study 5

The story of Sylvia and her child

Message 1. It is a sunny morning in the spring of 2015. Sylvia, a young mother of a three-year-old boy, sits in a paediatrician's office with her wriggling son on her lap. She looks visibly worried.

Message 2. Her son has just received the vaccine against Brainpox, an illness that can be transmitted via airborne droplets and may cause symptoms such as fever, chills, and runny nose. Rare complications include convulsions, encephalitis (brain swelling), and even death.

Message 3. Two months before, Sylvia's family doctor had recommended this vaccine. But Sylvia thought her baby boy's immune system was not ready.

Message 4. "What if something goes wrong?", she brooded for hours. "It's just too many vaccines, too soon. And there's got to be a reason if there are so many cases of vaccine injuries".

Message 5. However, she had heard time and time again about stories where families chose not to vaccine their children and then suffered unimaginable consequences. Eventually, she decided to vaccinate her son.

Message 6. When they came back home from the doctor, her baby did not stop crying. The day after he had a fever. Sylvia was very worried but the doctor said that it was what normally happens when the body mounts its immune response to the vaccine.

Message 7. In the following months, Sylvia started noticing her son became more and more hyperactive. "He was always in constant motion, had trouble playing quietly, and did not listen to anything I said", she remembers.

Message 8. When her son was five, Sylvia took him to get tested. He was diagnosed with attention deficit hyperactivity disorder (ADHD).

Message 9. In the same period, a rumour about a link between the vaccine against Brainpox and ADHD spread rapidly.

Message 10. For some time, Sylvia was upset about her son's condition because she thought she somehow caused it.

Message 11. Today she admits her son was ‘different’ before he got the shot and, later, nothing has changed.

Message 12. “I had known for years that something was wrong. My son just didn't seem like other children. I couldn’t take my eye off him for one minute and I needed to check on him constantly”, she says.

Message 13. That rumour of a link between the vaccine against Brainpox and ADHD was eventually discredited.

Message 14. Today, Sylvia is in a support group to learn more about ADHD and how to parent a child who has ADHD. “Talking to someone who can offer guidance and support made a massive difference to both my child and me as parent”, she says.

Baseline no-correction condition

Message 13. “However, I am truly blessed to have my son. Although his behaviour is challenging, he has enriched my life”, she says.

Correction conditions

Message 13. (source of the correction goes here) reported that the rumour of a link between the vaccine against Brainpox and ADHD was eventually discredited.

APPENDIX F. Questionnaire items used in Study 5

Factual questions

1. When (season and year) did the mother take her child to vaccinate?
2. What was the baby's reaction after receiving the shot?
3. What did the doctor say?
4. What did Sylvia notice in the following months?
5. How old was the baby when he received the diagnosis?
6. What was his diagnosis?
7. How did the baby appear to his mother since he was very little?
8. How did the mother react to her child's diagnosis?

Inference questions

9. How do you think the baby's body responded to the vaccine?
10. Do you think the mother's decision to vaccinate her child was wise?
11. Is there any reason to believe that the vaccine was linked to the baby's condition?
12. What is a possible reason for why parents would not vaccinate their children?
13. Is there any reason to believe that the baby would not have an attention deficit hyperactivity disorder? If so, what?
14. Did the mother play any role in her child's disease? If so, what?
15. How do you think the mother felt about her child's disease?
16. Do you think if the mother could go back she would choose not to vaccinate her son? If so, why?

Retraction awareness question (only for Correction conditions)

What was the message given by (*source of the correction goes here*)?

17. How likely is it that you would give the vaccine against *Brainpox* to your child? Use the following response scale. Please place an "X" over the appropriate response.

□	□	□	□	□	□
1 = Very Unlikely	2 = Somewhat Unlikely	3 = Slightly Unlikely	4 = Slightly likely	5 = Somewhat Likely	6 = Very Likely

APPENDIX G. Stories used in Study 6

Experiment 6A – Baseline Condition

MMR vaccine: A mother's story

Jodie is a young mother living in London.

She followed the regular vaccination schedule for her son; so, when he was 15 months old, he took the MMR shot.

The MMR vaccine protects against measles, mumps, and rubella.

Serious complications of these diseases may include brain damage and even death.

Jodie remembers that her son was a healthy boy before receiving the MMR vaccine.

«He was a regular baby; he always smiled at me, used to say "mum" and played with his toys», Jodie says.

«After the MMR shot, he was a completely different boy», she admits, «he displayed behaviors I had never noticed before».

«He barely noticed if somebody was around him, didn't say "mum" anymore, and did not know how to play with a basic toy», she says.

Today Jodie's son has turned five and has been diagnosed with autism.

Autism is a complex neurodevelopmental disorder that is characterized by impaired social interaction and restricted and repetitive behavior.

«I love my son no matter how different he his», Jodie says.

Today, Jodie runs a charity and encourages parents of autistic children to share their stories.

«At the beginning, it was tough», Jodie recalls, «I had to adjust».

«Today, our family life is as rich and meaningful as any other», she says.

Zika virus: A mother's story

Claire is a young mother living in London.

She planned a family vacation to Mexico with her 2-year-old son.

Mexico is an area with risk of Zika virus.

Zika primarily spreads through a bite of an infected mosquito, which is found throughout the tropics. Common symptoms among Zika infected patients include mild fever, rash, headache, joint pain, conjunctivitis, and muscle pain.

Viral experts have recently developed a vaccine against Zika.

To protect her child, Claire decided to vaccinate him against Zika.

«My son means the world to me», she says, «I could not put him at risk».

A few weeks after the shot, Claire's son started having severe seizures.

«I was very scared and didn't know what to do», Claire remembers.

After neurological tests, her son was diagnosed with epilepsy.

Epilepsy is brain disorder in which a person has a tendency to have recurring seizures.

«Doctors have told me it could be a life-long condition affecting my child wellbeing», Claire says between sobs.

«Now they are trying to find the medication which works best for him», she says.

Experiment 6A – Misinformation Condition

MMR vaccine: A mother's story

Jodie is a young mother living in London.

She followed the regular vaccination schedule for her son; so, when he was 15 months old, he took the MMR shot.

The MMR vaccine protects against measles, mumps, and rubella.

Serious complications of these diseases may include brain damage and even death.

Jodie remembers that her son was a healthy boy before receiving the MMR vaccine.

«He was a regular baby; he always smiled at me, used to say "mum" and played with his toys», Jodie says.

«After the MMR shot, he was a completely different boy», she admits, «he displayed behaviors I had never noticed before».

«He barely noticed if somebody was around him, didn't say "mum" anymore, and did not know how to play with a basic toy», she says.

Today Jodie's son has turned five and has been diagnosed with autism.

Autism is a complex neurodevelopmental disorder that is characterized by impaired social interaction and restricted and repetitive behavior.

«I love my son no matter how different he his», Jodie says.

Today, Jodie runs a charity and encourages parents of autistic children to share their stories.

Some people are convinced that the MMR vaccine causes autism.

This rumor is not true: signs of autism typically appear around the same time that children are recommended to receive the MMR vaccine. CDC (Centers for Disease Control and Prevention) reports that the MMR vaccine is not responsible for increases in the number of children with autism.

Zika virus: A mother's story

Claire is a young mother living in London.

She planned a family vacation to Mexico with her 2-year-old son.

Mexico is an area with risk of Zika virus.

Zika primarily spreads through a bite of an infected mosquito, which is found throughout the tropics. Common symptoms among Zika infected patients include mild fever, rash, headache, joint pain, conjunctivitis, and muscle pain.

Viral experts have recently developed a vaccine against Zika.

To protect her child, Claire decided to vaccinate him against Zika.

«My son means the world to me», she says, «I could not put him at risk».

A few weeks after the shot, Claire's son started having severe seizures.

«I was very scared and didn't know what to do», Claire remembers.

After neurological tests, her son was diagnosed with epilepsy.

Epilepsy is brain disorder in which a person has a tendency to have recurring seizures.

Some people are convinced that the Zika vaccine causes epilepsy.

This rumor is not true: CDC (Centers for Disease Control and Prevention) reports that there is no link between the Zika vaccine and epilepsy.

Experiment 6B – Baseline Condition

MMR vaccine: A mother's story

Sharon is a young mother living in London.

Recently her 3-year-old son got measles because he was not immunized.

Measles is a highly contagious disease. It spreads through the air when an infected person coughs or sneezes.

Measles can be serious for young children. It can lead to pneumonia, encephalitis (swelling of the brain), and death.

«One day my son had a fever but that didn't worry me because he had always been a healthy baby», Sharon remembers.

«I started to worry when the fever didn't clear up and a painful rash began to spread over his body», she says.

Common symptoms of measles include fever, rash, cough, runny nose, and red eyes.

Sharon took her son to the hospital, where he stayed for some time.

Today, Sharon's son is home and healthy again.

«To see my son suffering like this was very difficult for me», Sharon admits, «he did not sleep for several days and cried all the time because of the pain».

The best protection against measles is the measles-mumps-rubella (MMR) vaccine.

A child needs two doses of MMR vaccine for best protection: the first dose at 12 through 15 months of age and the second dose at 4 through 6 years of age.

«I think my son was exposed to measles by someone at our church's youth group», Sharon says.

«Anyway, this horrible experience gave our family the opportunity to become closer», she says.

Zika virus: A mother's story

Gabriela is a young mother living in Brazil.

After a mosquito bite, her 3-year-old son has recently been diagnosed with Guillain-Barré syndrome (GBS).

GBS is a disorder in which the body's immune system attacks part of the nervous system.

GBS symptoms include weakness of the arms and legs and, in severe cases, can increase in intensity until certain muscles cannot be used at all and the person is almost totally paralyzed.

GBS can affect anybody. It can strike at any age and both sexes are equally prone to the disorder.

GBS is believed to be associated with Zika infection.

Zika primarily spreads through a bite of an infected mosquito, which is found throughout the tropics.

Common symptoms among Zika infected patients include mild fever, rash, headache, joint pain, conjunctivitis, and muscle pain.

«I can't give up», Gabriela says.

«Even if doctors have told me that my son's life expectancy can be very limited, I'm determined not to give up to my son without a fight», she says.

Today, Gabriela is in a support group with other mothers to learn more about her son's condition and how to cope with it.

Viral experts have recently developed a vaccine against Zika.

«I didn't even know what Zika was», Gabriela recalls.

«Now, I am trying to be strong for my child, although it is very hard», she says between sobs.

Experiment 6B – Misinformation Condition

MMR vaccine: A mother's story

Sharon is a young mother living in London.

Recently her 3-year-old son got measles because he was not immunized.

Measles is a highly contagious disease. It spreads through the air when an infected person coughs or sneezes.

Measles can be serious for young children. It can lead to pneumonia, encephalitis (swelling of the brain), and death.

«One day my son had a fever but that didn't worry me because he had always been a healthy baby», Sharon remembers.

«I started to worry when the fever didn't clear up and a painful rash began to spread over his body», she says.

Common symptoms of measles include fever, rash, cough, runny nose, and red eyes.

Sharon took her son to the hospital, where he stayed for some time.

Today, Sharon's son is home and healthy again.

«To see my son suffering like this was very difficult for me», Sharon admits, «he did not sleep for several days and cried all the time because of the pain».

The best protection against measles is the measles-mumps-rubella (MMR) vaccine.

A child needs two doses of MMR vaccine for best protection: the first dose at 12 through 15 months of age and the second dose at 4 through 6 years of age.

Some people are convinced that measles, mumps, and rubella are not serious diseases and the MMR vaccine is just part of a conspiracy to make money for pharmaceutical companies.

This rumor is not true: CDC (Centers for Disease Control and Prevention) reports that measles, mumps and rubella can have serious consequences. Besides, vaccine revenues are a tiny percentage of pharmaceutical companies' revenues.

Zika virus: A mother's story

Gabriela is a young mother living in Brazil.

After a mosquito bite, her 3-year-old son has recently been diagnosed with Guillain-Barré syndrome (GBS).

GBS is a disorder in which the body's immune system attacks part of the nervous system.

GB symptoms include weakness of the arms and legs and, in severe cases, can increase in intensity until certain muscles cannot be used at all and the person is almost totally paralyzed.

GBS can affect anybody. It can strike at any age and both sexes are equally prone to the disorder.

GBS is believed to be associated with Zika infection.

Zika primarily spreads through a bite of an infected mosquito, which is found throughout the tropics.

Common symptoms among Zika infected patients include mild fever, rash, headache, joint pain, conjunctivitis, and muscle pain.

«I can’t give up», Gabriela says.

«Even if doctors have told me that my son’s life expectancy can be very limited, I’m determined not to give up to my son without a fight», she says.

Today, Gabriela is in a support group with other mothers to learn more about her son’s condition and how to cope with it.

Viral experts have recently developed a vaccine against Zika.

Some people are convinced that Zika infection is not serious and the vaccine against Zika virus is just part of a conspiracy to make money for pharmaceutical companies.

This rumor is not true: CDC (Centers for Disease Control and Prevention) reports that people infected with Zika virus can suffer serious consequences. Besides, vaccine revenues are a tiny percentage of pharmaceutical companies’ revenues.

APPENDIX H. Questionnaires used in Study 6

Experiment 6A

This set of questions is about your personal information. Your answers are needed for descriptive purposes only. Please, remember that data will be treated anonymously.

1) Indicate your sex: ……
2) Indicate your age in years: ……...
3) Indicate your educational level choosing from the following options:
   □ Bachelor's degree
   □ Master's degree
   □ PhD
   □ Other
4) Have you got any children?
   □ Yes
   □ No
5) Have you ever delayed or refused a recommended vaccine for your child(ren)?
   □ Yes
   □ No

This next set of question is on vaccines. Please, read the following statements and check the box (<u>one</u> for each row) which best indicates your idea and/or behaviour.

	1 = Strongly Disagree	**2 = Disagree**	**3 = Neutral**	**4 = Agree**	**5 = Strongly Agree**
1) Getting vaccines is a good way to protect my future child(ren) from disease.	□	□	□	□	□
2) Generally, I would do what my doctor recommends about vaccines for my future child(ren).	□	□	□	□	□

3) New vaccines are recommended only if they are as safe as older vaccines.	□	□	□	□	□
4) My future child(ren) will not need vaccines for diseases that are not common anymore.	□	□	□	□	□
5) Parents should have the right to refuse vaccines that are required for school for any reason.	□	□	□	□	□
6) So many children are vaccinated that my future child(ren) will be safe from these illnesses even if I will not vaccinate them.	□	□	□	□	□
7) I am concerned about serious adverse effects of vaccines.	□	□	□	□	□
8) Some vaccines cause autism in healthy children.	□	□	□	□	□

This set of questions is about the MMR (measles, mumps, and rubella) vaccine. For each statement, please mark the response (<u>one</u> for each row) that is closest to your opinion.

	1 = Strongly Disagree	**2 = Disagree**	**3 = Neutral**	**4 = Agree**	**5 = Strongly Agree**
The MMR causes autism in healthy children.	□	□	□	□	□

	1 = Very Unlikely	**2 = Somewhat Unlikely**	**3 = Slightly Unlikely**	**4 = Slightly Likely**	**5 = Somewhat Likely**	**6 = Very Likely**
Just based on what you know, how likely is it that children who get the MMR vaccine will suffer serious side effects?	□	□	□	□	□	□

	1 = Very Likely	**2 = Somewhat Likely**	**3 = Slightly Likely**	**4 = Slightly Unlikely**	**5 = Somewhat Unlikely**	**6 = Very Unlikely**
How likely is that you would give your future child(ren) the MMR vaccine?	□	□	□	□	□	□

This set of questions is about Zika virus. For each statement, please mark the response (<u>one</u> for each row) that is closest to your opinion.

	1 = Strongly Disagree	**2 = Disagree**	**3 = Neutral**	**4 = Agree**	**5 = Strongly Agree**
Zika virus vaccine causes epilepsy in healthy children.	□	□	□	□	□

	1 = Very Unlikely	**2 = Somewhat Unlikely**	**3 = Slightly Unlikely**	**4 = Slightly Likely**	**5 = Somewhat Likely**	**6 = Very Likely**
Just based on what you know, how likely is it that children will suffer serious side effects from the vaccine against Zika virus?	□	□	□	□	□	□

	1 = Very Likely	**2 = Somewhat Likely**	**3 = Slightly Likely**	**4 = Slightly Unlikely**	**5 = Somewhat Unlikely**	**6 = Very Unlikely**
How likely is that you would give your	□	□	□	□	□	□

child(ren) a possible vaccine against Zika virus?						

*This section refers to the CDC (Centers for Disease Control and Prevention)'s information you have read. Below you can find some pairs of adjectives. For each pair of adjectives mark the point between them which reflects the extent to which you believe the adjective describes the CDC.

	1	**2**	**3**	**4**	**5**	**6**	**7**	
An Expert	□	□	□	□	□	□	□	Not an Expert
Inexperienced	□	□	□	□	□	□	□	Experienced
Unknowledgeable	□	□	□	□	□	□	□	Knowledgeable
Qualified	□	□	□	□	□	□	□	Unqualified
Unskilled	□	□	□	□	□	□	□	Skilled
Dependable	□	□	□	□	□	□	□	Undependable
Dishonest	□	□	□	□	□	□	□	Honest
Unreliable	□	□	□	□	□	□	□	Reliable
Insincere	□	□	□	□	□	□	□	Sincere
Trustworthy	□	□	□	□	□	□	□	Untrustworthy

**This section was administrated only in the Misinformation condition*

Experiment 6B

This set of questions is about your personal information. Your answers are needed for descriptive purposes only. Please, remember that data will be treated anonymously.

1) Indicate your sex: ……
2) Indicate your age in years: ……...
3) Indicate your educational level choosing from the following options:
   □ Bachelor's degree
   □ Master's degree
   □ PhD
   □ Other
4) Have you got any children?
   □ Yes
   □ No
5) Have you ever delayed or refused a recommended vaccine for your child(ren)?
   □ Yes
   □ No

This next set of question is on vaccines. Please, read the following statements and check the box (<u>one</u> for each row) which best indicates your idea and/or behaviour.

	1 = Strongly Disagree	**2 = Disagree**	**3 = Neutral**	**4 = Agree**	**5 = Strongly Agree**
1) Getting vaccines is a good way to protect my future child(ren) from disease.	□	□	□	□	□
2) Generally, I would do what my doctor recommends about vaccines for my future child(ren).	□	□	□	□	□

3) New vaccines are recommended only if they are as safe as older vaccines.	□	□	□	□	□
4) My future child(ren) will not need vaccines for diseases that are not common anymore.	□	□	□	□	□
5) Parents should have the right to refuse vaccines that are required for school for any reason.	□	□	□	□	□
6) So many children are vaccinated that my future child(ren) will be safe from these illnesses even if I will not vaccinate them.	□	□	□	□	□
7) I am concerned about serious adverse effects of vaccines.	□	□	□	□	□
8) Some vaccines cause autism in healthy children.	□	□	□	□	□

This set of questions is about the MMR (measles, mumps, and rubella) vaccine. For each statement, please mark the response (<u>one</u> for each row) that is closest to your opinion.

	1 = Strongly Disagree	**2 = Disagree**	**3 = Neutral**	**4 = Agree**	**5 = Strongly Agree**
Viral experts are in the pocket of pharmaceutical companies.	□	□	□	□	□
Vaccines are nothing more than a pharmaceutical company conspiracy to make money.	□	□	□	□	□

	1 = Very Likely	**2 = Somewhat Likely**	**3 = Slightly Likely**	**4 = Slightly Unlikely**	**5 = Somewhat Unlikely**	**6 = Very Unlikely**
How likely is that you would give your future child(ren) the MMR vaccine?	□	□	□	□	□	□

This set of questions is about Zika virus. For each statement, please mark the response (<u>one</u> for each row) that is closest to your opinion.

	1 = Strongly Disagree	**2 = Disagree**	**3 = Neutral**	**4 = Agree**	**5 = Strongly Agree**
Viral experts are in the pocket of pharmaceutical companies.	□	□	□	□	□
Vaccines are nothing more than a pharmaceutical company conspiracy to make money.	□	□	□	□	□

	1 = Very Likely	**2 = Somewhat Likely**	**3 = Slightly Likely**	**4 = Slightly Unlikely**	**5 = Somewhat Unlikely**	**6 = Very Unlikely**
How likely is that you would give your child(ren) a possible	□	□	□	□	□	□

vaccine against Zika virus?						

*This section refers to the CDC (Centers for Disease Control and Prevention)'s information you have read. Below you can find some pairs of adjectives. For each pair of adjectives mark the point between them which reflects the extent to which you believe the adjective describes the CDC.

	1	**2**	**3**	**4**	**5**	**6**	**7**	
An Expert	□	□	□	□	□	□	□	Not an Expert
Inexperienced	□	□	□	□	□	□	□	Experienced
Unknowledgeable	□	□	□	□	□	□	□	Knowledgeable
Qualified	□	□	□	□	□	□	□	Unqualified
Unskilled	□	□	□	□	□	□	□	Skilled
Dependable	□	□	□	□	□	□	□	Undependable
Dishonest	□	□	□	□	□	□	□	Honest
Unreliable	□	□	□	□	□	□	□	Reliable
Insincere	□	□	□	□	□	□	□	Sincere
Trustworthy	□	□	□	□	□	□	□	Untrustworthy

**This section was administrated only in the Misinformation condition*

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