MISCONCEPTIONS ABOUT THE SAFETY BENEFIT OF BOOSTER SEATS: THE EJECTION STEREOTYPE HYPOTHESIS

by

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Abstract

This dissertation explores whether Lakatos’ methodology of scientific research programs and Elster’s notion of causal explanations can be used to drive innovation in injury prevention research. For illustration purposes, the problem of low rates of booster seat use is applied to a case study.

Contrary to popular belief, the purpose seat belts is not solely to prevent people from being ejected out of the car, but to redirect crash forces to stronger parts of the body: hips and chest. Children between the ages of 4 and 8 years are usually too small to wear the seat belt across the hips and chest, and may end up with the straps on their bellies and neck. If a child wears it in this way, the seat belt directs crash forces to the child’s internal organs or spine, potentially causing fatal injuries. For this reason, children of these ages require a booster seat; a device that raises the child and ensures the seat belt is placed correctly across the hips and chest. Unfortunately, in Canada, 50% of children aged 4 to 8 years ride in cars strapped in seat belts, but without booster seats. To address this problem, I formulate a hypothesis that explains why booster seat use is infrequent: parents are prone to see injuries to vehicle occupants as resulting from ejection. This fixation on ejection makes them more concerned about the child being thrown through the windshield, and less worried about the dangers of early use of seat belts. I term this proposition the ejection stereotype hypothesis.

This dissertation spans over philosophy of science, psychology, decision science, visual arts, and injury prevention. After summarizing different views of scientific progress and discussing the philosophy of booster seat research, fuzzy-trace theory and the ejection stereotype are described. Next, a psychological study that reports a falsification test of the ejection stereotype is reported. Following, a visual arts project is described in terms of how
Tufte’s principles of information design were used to develop an infographic to correct the ejection stereotype. Finally, a proof-of-concept pilot study to test the efficacy of the infographic is reported.
Lay Summary

Canadian parents try their best to protect their children from injuries while they drive them to the daycare, a play date, or hockey practice. More than 90% of Canadian children riding in cars are estimated to be restrained in some way—either in a seat belt or a child safety seat. However, approximately 50% of these children are restrained in seat belts too early for their age and height. This practice is unsafe, because, when children are too small to use seat belts, the lap belt tends to rest on their bellies and, if the car crashes, it may cause injuries to the spine. The present dissertation explores new ways to encourage booster seat use, including the development of an infographic that explains why they are important. Results indicate that the infographic improves parents understanding of the safety benefit of booster seats and increases their intention to use them.
Preface

Takuro Ishikawa conducted the literature review, formulated the research problem, designed the studies, and performed data analysis. Andy Jiang co-wrote portions of the literature review in Chapter 3 and assisted with data collection for the study reported in Chapter 5. Portions of Chapters 3 through 5 are already published in Ishikawa T, Jiang A, Brussoni M, Reyna V, Weldon R, Bruce B, Pike I. Perceptions of Injury Risk Associated with Booster Seats and Seatbelts: the Ejection Stereotype Hypothesis. Hypothesis J. 2017;14(1):1-7. doi:10.5779/hypothesis.v14i1.455. Takuro Ishikawa wrote this article with Andy Jiang. The ejection stereotype hypothesis, described in this article, was co-developed with Dr. Valerie Reyna, and further refined by Drs. Mariana Brussoni, Rebecca Weldon, Beth Bruce, and Ian Pike. Dr. Mariana Brussoni edited the manuscript.

The study reported in Chapter 5 was co-designed with Dr. Valerie Reyna and Rebecca Weldon. Takuro Ishikawa co-designed the study reported in Chapter 7 with Drs. Ian Pike, William Picket, Nick Bansback, and Mariana Brussoni.

Data collection procedures involving human participants, reported in Chapters 4, 5, and 6 were approved by research ethics board of the University of British Columbia / BC Children’s and Women’s Hospital Research Ethics Board (certificate number H14-01569).
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Dedication

To my parents
1 Introduction

We scientists are often so engaged in research and the vicissitudes that accompany it, that we rarely dedicate time to reflect upon the high-level questions about the nature of our work: what is a scientific contribution? What is innovation? How can we achieve either of those? Are innovation and scientific progress the result of luck, pure genius, or the product of an inquiry process driven by logic and empirical testing? These reflections constitute the overarching themes in the present dissertation, because I believe that scientific progress and innovation should be the result of a systematic and iterative process of theory development and application.

Views on how scientific progress is accomplished come in different forms and flavours. It is beyond the scope of this dissertation to discuss all available views, their different
interpretations, and their merits. However, I will briefly describe the ones that have shaped my thinking and have informed my scholarly work, in order to provide context for the choices I made in the research described in the present document. I begin with philosopher of science, Karl Popper, who proposed that scientific progress is the result of a systematic process of formulating, testing, and improving theories. A theory, in his view, is a universal statement like “all swans are white.” Popper argued that it was unreasonable to require that scientific theories be empirically verifiable, since it is simply impossible to examine all swans in the universe to corroborate the theory. Instead, he proposed that theories should be falsifiable; that is, theories should be susceptible to empirical refutation. Hence, to be considered scientific, a theory should allow logical reasoning to derive an empirically testable prediction that threatens its purported universality. If, upon experimentation, data do not corroborate the prediction, then the theory would be refuted. If data are consistent with the prediction, then the theory is retained. Popper termed this process falsification. If falsified, a theory would be replaced by a new, more general model that accounts for everything its predecessor did, as well as the phenomena that brought about its demise. Modern cases of successful falsification in health research are scarce, but an example suffices to illustrate Popper’s view. A naive explanation as to why some parents do not restrain their children in car seats is that they are unaware of guidelines recommending them. This “awareness theory of car seat use” would be falsified if we find parents who do not restrain their child in a booster seat yet are aware of child safety seat guidelines. In such a case, additional explanations must be invoked, in order to account for the discrepancy; for example, financial barriers. Then, a new theory is formulated: one that implies booster seat use is a function of the interaction between knowledge of guidelines and financial constraints. This process of falsification then repeats in an endless loop of inquiry, discovery, and theory development. Importantly, the burden of falsification does not fall upon the critics of a theory, but on its proponents and supporters. Falsifying someone else’s theory does not lend support to one’s propositions. If someone else’s theory fails a falsification test it would only imply his or her
theory is incomplete; a conclusion that has no bearing on one’s own theory. If, for example, Darwin’s theory of evolution through natural selection were falsified today, its demise would not support in any way the creationist story.

Thomas Kuhn, had a different view of science. He characterized Popper’s view as idealistic and unrelated to the way science is practiced in the real world. For Kuhn, the history of science showed that scientific progress is actually not progress at all. Rather, it is a series of non-linear, epistemological revolutions, which neither entail accumulation of knowledge, nor build upon previous work. Kuhn termed these revolutions paradigm shifts. In simple terms, a scientific paradigm is a set of implicit and explicit norms, values, customs, practices, methods, expectations, guidelines, and views of what is scientifically acceptable, shared by a research community at a particular moment in history and regarding one or more research problems. Kuhn postulated that there are periods of normal science where a prevalent paradigm is maintained in the scientific community, even in the face of contrary evidence. Occasionally, the reigning paradigm is overturned and replaced by a new one. This process is not necessarily based on reason and evidence. Paradigm shifts occur because research priorities, values, views, and ways of solving problems in the scientific community change, partly as a result of research and technological developments, and partly because of economic, cultural, technological, and political factors. The inclusion and subsequent exclusion of homosexuality from the Diagnostic and Statistical Manual (DSM) of mental disorders, exemplifies this idea. The primary force behind the removal of homosexuality from the list of mental disorders was not research in psychiatry; it was gay activism. In fact, most of the evidence against the conceptualization of homosexuality as a mental disorder existed outside of psychiatry, but was ignored by the psychiatric community until 1973.
Imre Lakatos\textsuperscript{4} proposed the \textit{methodology of scientific programs}, which reconciled Popper’s notion of falsification with Kuhn’s view of scientific revolutions. Like Popper, Lakatos held theory development as the primary goal of a scientific enterprise. Unlike Popper, however, he believed that a theory did not need to be discarded upon falsification. In Lakatos’ model, researchers can retain theories, even in the face of contrary evidence. They do so by formulating auxiliary hypotheses that protect the main assumptions that form a theory, while they advance their research program and continue to improve and refine their ideas.\textsuperscript{4} For Lakatos,\textsuperscript{4} a research program working on a theory that leads to the discovery of novel, counterintuitive facts, far removed from the original research question, would be deemed progressive, while research programs on a theory that no longer predicts new phenomena would be deemed degenerative. Einstein’s theory of relativity epitomizes Lakatos’ view: the theory of general relativity, currently assumes that (1) space and time are actually one single entity called space-time, which (2) warps in the presence of mass. Using these two assumptions Einstein explained the phenomenon that we experience as gravity.\textsuperscript{5} Although these assumptions have never been directly tested,\textsuperscript{1} the theory of relativity is the current model of gravity, because, among other reasons, it has led to the discovery of novel, counterintuitive phenomena; for example, time dilation (i.e., time passes slower for an observer that is moving relative to a stationary one). Furthermore, it has also informed practical applications: satellites, for example, rely on relativity formulas to adjust their clocks, because time passes slower on them when compared to more stationary observers on Earth.\textsuperscript{5}

Jon Elster proposed that progress in the social sciences is achieved by formulating new, more sophisticated causal explanations of social phenomena.\textsuperscript{6} In simple terms, to explain an

\textsuperscript{1} The most direct evidence of Einstein’s theory of general relativity was collected through the famous Gravity Probe B experiment,\textsuperscript{129} which showed that gyroscopes placed on a space telescope pointed to a star would shift position in a manner consistent with Einstein’s equations. However successful, this experiment did not provide a direct evidence of the warping of space-time caused by Earth’s mass. Instead, it measured the effects of the assumed warping on the position of the gyroscopes.
event is to describe why it occurred by citing an earlier event as its cause.\textsuperscript{6} Events are the basic type of phenomena in social sciences. The enactment of booster seat legislation in British Columbia, Canada, and the resurgence of measles in North America are events. Depending on the researcher’s interest, these events can be cited as \textit{explananda} (the event under scrutiny) or as \textit{explanandum} (the cause).\textsuperscript{6} To explain events, a researcher must understand that causal explanations are different from correlations.\textsuperscript{6} For example, one might observe an increase in booster seat use within a jurisdiction and invoke the enactment of booster seat law that preceded it as the cause. However, both the legislative act and the widespread use of booster seats could be the result of a population change in attitudes towards booster seats caused by a third event: an effective advocacy campaign. Causal explanations must also be distinguished from statements of variance explained.\textsuperscript{6} For example, when studying vaccine hesitancy, researcher might find that age, education level, income, attitudes towards pharmaceutical corporations, political views, and religious denomination explain population variance in willingness to vaccinate children. Even if such a study found that these factors explain 100% of variance, these factors thus cited only explain variance in the population, but they do not explain the event itself. Causal explanations should also be distinguished from predictions.\textsuperscript{6} To state, for instance, that socioeconomic status predicts booster seat use is not the same as explaining why parents use or do not use booster seats. Predictions suffer from the same limitations as correlations in that both the predictor and the event can have a common cause. Finally, simply citing a cause is not the same as providing a causal explanation, even if the cause is correctly identified.\textsuperscript{5} To state, for example, that some parents do not vaccinate their children because they believe vaccines are harmful might the true. However, the statement does not describe the causal mechanism through which individuals' beliefs cause behavior. One mechanism could be \textit{rational choice},\textsuperscript{6–8} which describes behavior as the result of a deliberate, conscious decision that is informed by beliefs.
Elster defines *mechanisms* as “frequently occurring and easily recognizable causal patterns that are triggered under generally unknown conditions or with indeterminate consequences.” Mechanisms are easily recognizable patterns in the sense that they follow a distinct configuration that can be identified when studying an event. For example, when explaining why injuries in an amateur hockey league increased after use of safety equipment became mandatory, a researcher may observe that, after the rule was implemented, players engaged in riskier behaviour in the rink. For an injury prevention researcher, it is not difficult to invoke *risk compensation* as the causal mechanism explaining the surge in injuries in the league. Risk compensation refers to a tendency of people to adapt their behavior in response to changes in their perceived risk of injury. The implementation of a rule mandating the use of safety equipment could have reduced the perceived risk of injury, triggered the risk compensation mechanism, caused a surge in risk-taking behaviour on the ice rink, and, in turn, an increase in injuries. Even if this explanation is supported by evidence, researchers do not know exactly if the same condition would trigger risk compensation in other amateur sports leagues or whether it would have effects of similar direction and size. This is the reason mechanisms are considered to have generally unknown triggers and generally indeterminate consequences.

The degree to which a particular explanation should be accepted, according to Elster, depends on how much support it receives from below, above, and laterally. Support from below refers to support from the facts. Here, Elster borrows ideas from Lakatos and Popper. Researchers should be able to derive testable predictions from their proposed explanation beyond what it originally intended to explain; the farther removed the better, and the more novel, and counterintuitive the better. For example, the risk compensation explanation cited above would receive support from below if researchers confirm the counterintuitive prediction that individual investors in the stock market would purchase riskier financial instruments, after the
government introduced legislation that reduced the risk of losing money. *Support from above* means that an explanation can be deduced from a more general theory. For example, the rational choice explanation of vaccine hesitancy, is derived from the theory of rational choice. The theory states that individuals act deliberately and in a way that maximizes their utility, which is a function of their subjective beliefs and motivations. Parents who are motivated to protect their children from harm and who believe vaccines are harmful, would act accordingly and choose not to vaccinate their children. Explanations receive lateral support when alternative accounts of the event have been considered and discarded. For example, vaccine hesitancy could be explained as the result of regret avoidance (i.e., hesitating to make a choice to avoid regretting it later) or overestimation of small probabilities. Any of these explanations would have lateral support if the other explanations are considered and discarded; this includes of course, the possibility that vaccine hesitancy is caused by two or three mechanisms.

Elster’s view of progress in the social sciences has largely influenced my work. I, nonetheless, owe as much inspiration to Popper, Kuhn, and Lakatos. As will be evident in the present dissertation, the notions or paradigm, normal science, and research program largely inform the way I review and criticize research. When I review research literature on a problem, I try to identify the assumptions, expectations, established methods, and values that form the paradigm; I evaluate if researchers attempt to falsify hypotheses born out of previous studies; and I examine how a research community responds to contrary evidence. These views of scientific progress are expressed in my choice of theory, the formulation of my hypothesis, the design of my experiments, and even the way I interpret findings. Furthermore, when I conduct my own research, I try to use paradigms from other disciplines and rely on theories to formulate

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ii Granted, the Kuhnian view does not prescribe rules for choosing one theory over another, but the notion of scientific paradigms has influenced the way I seek innovation in science: striving to change scientific paradigms.
causal explanations, define my own research program, and produce novel solutions to real life problems.

I invite the reader to have these concepts in mind, when reviewing the present work.

1.1 Achieving progress in child passenger safety research

The overarching goal of this dissertation is to illustrate how theories with counterintuitive predictions, which often drive scientific progress, can also lead to innovative solutions to practical problems. In particular, this dissertation uses a relatively unknown model of health behaviour, fuzzy-trace theory, to shed light on a behavioural health problem: how to increase booster seat use.

It is important to note that this endeavor entails the application of a different scientific paradigm; one that is informed by the ideas of ideas of Popper, Lakatos, and Elster. This scientific paradigm may be new to public health researchers, but it is far from novel in other scientific disciplines, including physics, psychology, sociology, economics, and molecular biology. For simplicity, whenever I need to collectively cite the notions of scientific progress of Popper, Kuhn, Lakatos, and Elster, I will use the term Lakatos-Elster paradigm.

Booster seats are a safety device to prevent injuries to children riding in motor vehicles. When children do not have sufficient height or weight to wear an adult seat belt, typically, the lap belt rests on their bellies and the shoulder belt cuts across their necks. See panel a) in Figure 1.1. Some parents place the shoulder belt behind the child’s back or under the child’s arm, as shown in panels b) and c) in Figure 1.1. When used in these ways, during a vehicle

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iii Lakatos reconciled the Kuhnian and Popperian views, and Elster integrated the Lakatosian view of scientific progress with the concept of causal explanations.
collision, seat belts can cause severe abdominal injury,\textsuperscript{13–15} spinal cord damage,\textsuperscript{16,17} injuries to the face and brain,\textsuperscript{18} and possibly death.\textsuperscript{19} During a collision, booster seats can prevent these types of injuries by elevating the child and ensuring the shoulder belt rests on the shoulder and the lap belt is placed across the hips. See panel d). In this way, booster seats redirect crash forces to stronger anatomical structures of the body: ribcage and pelvis.\textsuperscript{13,15,20–22}

![Figure 1.1 Seat belt fit with and without booster seat](image)

There are three types of child restraints. \textit{Rear-facing} or infant seats are recommended for infants between 1 and 2 years old (approximately), because they have relatively large heads,

\textsuperscript{iv} Images used with permission. Original illustrations: Centre for Injury Research and Prevention, The Children’s Hospital of Philadelphia\textregistered. Changes made to original images: green colour added to all images and shoulder belt in figure d) was moved away from the neck. Use and changes with permission. Adapted by: Bronwen Barnett, BC Injury Research and Prevention Unit.
and because their weak necks and spines place them at higher risk of head or spinal injury during a crash. *Forward-facing* seats are designed for children 2 to 4 years old approximately, who have stronger necks and back muscles. Finally, *booster seats* are required for children 4 to 8 years old, because they are often too small to properly fit in seat belts.\(^{23}\)

Child seat restraint use is the highest in high income countries like Sweden, the United Kingdom, the United States, and Canada, with most children under four years (74% to 97% approximately) restrained in a child restraint specifically designed for their age and size.\(^{24-27}\) However, in these same countries, at least 37% of children between the ages of four and eight do not use a child restraint appropriate for their age and size (typically a booster seat).\(^{24-27}\)

Canada has made notable progress in the promotion of booster seat use. The country’s automobile research program has produced new booster seats that are easy to carry and install, as well as attractive to school-age children.\(^{28}\) Furthermore, ten provinces have now enacted laws mandating booster seat use,\(^{29}\) and evidence-based education programs have been developed and implemented throughout the country.\(^{30-32}\) Despite these advances, new approaches to encourage booster seat use are still required, because legislation has proven insufficient.\(^{33-35}\) For example, in 2010, more than 10 years after booster seats became mandatory in Ontario and Quebec, the rate of utilization in each of the two provinces was 25%.\(^{27}\)

It remains unclear why Canadian parents do not restrain their children in booster seats. Lack of legislation is an unlikely explanation, because booster seat use is low even in provinces where it is mandatory.\(^{27}\) Some researchers have suggested that parents are simply unaware of the risks of premature use of adult seat belts, or that they do not know that seat belts provide less than optimal protection.\(^{36}\) However, these explanations are insufficient, because even
parents who demonstrate awareness of booster seats guidelines or report owning a booster seat also report that they do not use it to restrain their children.\textsuperscript{37,38} One study found that parents’ perception of the benefit of booster seats is the single best predictor of consistent use.\textsuperscript{39} However, we currently have limited understanding of what causes perceived benefit of booster seats. Thus, we currently lack scientifically grounded strategies to improve it.

To illuminate the aforementioned counterintuitive findings, I have formulated a new causal explanation for infrequent use of booster seats. I postulate that the perceived benefit of booster seats is negatively affected by people’s tendency to view injuries to vehicle occupants primarily as ejection related and to view vehicle restraints (car seats and seat belts) as devices that mainly prevent ejection. This fixation on ejection takes parents’ attention away from the dangers of early and incorrect use of seat belts: “injuries to children riding in cars are ejection related; seat belts prevent ejection; therefore, seat belts alone are safe enough (i.e., booster seats are not needed).” I have termed this misconception \textit{ejection stereotype} and propose that it helps explain the counterintuitive findings mentioned above.

In Chapter 2, I review evidence of effectiveness of booster seats, which currently is considered inconclusive.\textsuperscript{40} Since the question of how to promote booster seat use is predicated on their effectiveness, it is important to discuss this evidence. Accordingly, the purpose of this chapter is to provide some context of the practical problem I am using to illustrate how theories with counterintuitive predictions can drive innovation in injury prevention. In this chapter, I also give readers the opportunity to familiarize with the \textit{Lakatos-Elster scientific paradigm}. To this end, I include a section where I use the Popperian,\textsuperscript{1} Kuhnian,\textsuperscript{2} and Lakatosian\textsuperscript{4} notion of scientific progress to evaluate the body of research on booster seat effectiveness.
In Chapter 3, I summarize and critique the current literature on booster seat use. My review of the literature differs from typical reviews of evidence in epidemiology or public health, because my focus is not on ascertaining the quality of the evidence (definition of variables, validity of data collection, control of confounders, risk of bias, or limitations). Instead, my review focuses on the assumptions about human behaviour and learning, causal explanations, the role of theory in research, and the way to achieve scientific progress. In other words, the purpose of this review is to illustrate how a literature review would be conducted under the Lakatos-Elster scientific paradigm.

In Chapter 4, I formulate the ejection stereotype hypothesis and use Elster’s criteria for causal explanations to examine how well supported my hypothesis is. I begin with a description of the theory that supports the ejection stereotype hypothesis, and describe causal mechanism involved. I then describe how the ejection stereotype hypothesis receives lateral support by discussing alternative explanations. In accordance with Lakatos’ standards for scientific progress, I end the chapter by deriving a testable, counterintuitive prediction, which is unrelated to the social phenomena it was created to explain. The purpose of the chapter is to describe the ejection stereotype hypothesis and examine it using Elster’s and Lakatos’ criteria for causal explanations in the social sciences.

In Chapter 5, I subject the ejection stereotype hypothesis to empirical testing through Popperian falsification, by empirically examining a counterintuitive prediction that it is detectable even among knowledgeable individuals. In other words, this empirical testing adheres to Elster’s notion of support from below and to Lakatos’ view of scientific progress through theories that lead to counterintuitive predictions. Accordingly, the purpose of this chapter is to provide evidence in support of the ejection stereotype.
In Chapter 6, I document the process of developing an infographic to correct the ejection stereotype and, ultimately, increase perceived benefit. The development of the infographic follows information design research methods, which may differ from those used in psychology or epidemiology. Thus, the reader must note that the methods used to develop the infographic do not constitute qualitative research as understood in public health and should not be read or interpreted as such. The emphasis of the chapter is on how the principles of information design were applied and tested. Accordingly, the purpose of this chapter is to describe how the principles of information design were used to create an infographic to communicate how booster prevent injuries to children riding in cars. In this chapter, the Lakatos-Elster scientific paradigm is not relevant, because the chapter reports a design process not a scientific process.

In Chapter 7, I report an online proof-of-concept pilot randomized control trial of the infographic, which uses a two-group parallel design. The main objective of the trial is to determine if further research on the development of booster seat use interventions based on the ejection stereotype hypothesis is justified. In this chapter, the Lakatos-Elster scientific paradigm is less relevant, because this study was not designed to test theoretical aspect of the ejection stereotype hypothesis or to provide additional evidence for it. Rather, it was designed to test a public health intervention inspired by the ejection stereotype hypothesis.

In Chapter 8, I summarize the ideas, findings and conclusions presented in this dissertation in relation with previous research, and outline future directions.

1.2 Warnings for the reader

This dissertation encompasses philosophy, psychology, decision science, information design, and epidemiology. Each of these disciplines operates with their own assumptions, methods, language, writing style, and standards of how to report studies. Although I made
efforts to cater to each discipline’s requirements, I also tempered these efforts with the need to ensure that audiences of different academic backgrounds understand the entire document. For this reason, readers may notice that, in some instances, I have avoided “correct” terminology of their discipline, or perhaps oversimplified concepts that involve complex meaning and nuances. This is also the reason study reports may contain “extra” sections that are not typically required or expected in their own disciplines or may be “missing” information that is normally required by journals of each discipline.
2 Current evidence about booster seat effectiveness

The effectiveness of booster seats has been widely studied in the past decade and studies have produced inconsistent results. For example, Arbogast et al.\textsuperscript{20} found that booster seats reduce the risk of injury by 45% compared to seatbelts, but a later study found no effect.\textsuperscript{41} These discrepancies were addressed in a recent systematic review that synthesized data from seven studies on booster seat use and injury incidence (11,660 cases), as well as four studies on booster seat use and fatalities (16,448 cases). Authors of the systematic review concluded that there is no evidence that booster seats reduce the risk of injury or fatality among children four to seven years old.\textsuperscript{40}

One month after the aforementioned systematic review was published, the American Academy of Pediatrics (AAP) released their most recent policy statement, in which they upheld the previous guideline indicating that booster seats should be used if the child no longer fits in a
forward facing seat and does not properly fit an adult seat belt.\textsuperscript{23} The accompanying technical report supporting the statement\textsuperscript{23} reviewed only three studies, two of which\textsuperscript{20,42} were included in the systematic review.\textsuperscript{40}

The contradiction between AAP guidelines and results from the systematic review raise questions that affect research programs on booster seat effectiveness, as well as research programs that hinge on their effectiveness. Indeed, if these devices do not reduce children’s risk of injury or death, then is it justified to invest time and financial resources to develop interventions to increase booster seat use? In this chapter, I discuss two different answers to this question: epistemological and methodological.

2.1 Rationale and objective

In this chapter, I review the literature on booster seat effectiveness, using Popper’s,\textsuperscript{1} Kuhn’s,\textsuperscript{2} and Lakatos’\textsuperscript{4} views of scientific progress. I then juxtapose this with a review of evidence as it is traditionally conducted in the public health paradigm. The objective of this chapter is to provide some context of the practical problem that I am using as an example to illustrate how theories with counterintuitive predictions can drive innovation in injury prevention. In this chapter, I also introduce the reader to the notion of scientific progress as understood in the \textit{Lakatos-Elster scientific paradigm}, and highlight how it differs from the public health paradigm. I begin with the epistemological case for booster seat effectiveness, where I examine whether research on booster seat effectiveness meets criteria for scientific progress established by Popper,\textsuperscript{1} Kuhn,\textsuperscript{2} and Lakatos.\textsuperscript{4} Following, I conduct a review of evidence that is more traditional in public health, and I finish this chapter with some comments on how the public health approach to scientific progress could benefit from incorporating the \textit{Lakatos-Elster scientific paradigm}. 
2.2 The epistemological case for booster seat effectiveness

The epistemological case for booster seat effectiveness examines the research program on booster seat effectiveness, using Popper’s,\(^1\) Kuhn’s,\(^2\) and Lakato’s\(^4\) notions of scientific progress. I do not include Elster’s model of causal explanations,\(^6\) because it only applies to social sciences and it is not relevant to a problem that is predominantly epidemiological.

According to Popper \(^1\), a theory, in its simplest form, is a universal statement. Thus, let the statement “booster seats prevent injuries and fatalities” be the theory under scrutiny.\(^\triangleright\) If we were to operate under Popper’s model of science,\(^1\) the theory of booster seats’ effectiveness should have been discarded already. Indeed, the effectiveness of booster seats was successfully falsified by results from the systematic review, because they contradict the statement.

If we were to operate under Kuhn’s model,\(^2\) we should examine if the booster seat research program is on the verge of experiencing a paradigm shift. This is unlikely, because paradigm shifts imply more than the overturn of an established theory. When a paradigm shift occurs, methods, assumptions, values and beliefs about what is considered good research are also overturned. This is not the case here. Even if the entire research community involved in the booster seat research program agreed to abandon the theory that booster seats prevent injuries and fatalities, the methods, assumptions, and values (which come primarily from epidemiology) would remain unchanged.

\(^\triangleright\) The statement “booster seats prevent injuries and fatalities” should be distinguished from the policy statement “booster seats should be used in order to prevent injuries and fatalities.” The former is a theory in the latter is not.
If we were to operate under Lakatos’ model, we should examine if the theory of booster seats effectiveness is worth keeping despite contrary evidence. This implies determining if the research program on booster seat effectiveness is progressive or degenerative. In the 15 years of research since the publication of the first study, the research program on booster seat effectiveness has not explored a single counterintuitive prediction derived from the theory, nor has it produced studies exploring extrapolations outside the problem of booster seats. This could potentially mean that the booster seat effectiveness program is degenerative and thus should be abandoned.

In conclusion, there are no epistemological grounds to continue the booster seat effectiveness research program in the face of contrary evidence. The theory that booster seats reduce injury and fatality risk, has not been modified, improved, or expanded in the face of conflicting results; the research program does not seem be undergoing a period of revolutionary science, as contrary evidence has not led to calls for a change in methods, standards, and values in the scientific community. Finally, the booster seat effectiveness research program has not pursued counterintuitive predictions or extrapolations outside the booster seats.

2.3 The methodological case for booster seat effectiveness

The methodological case of booster seat effectiveness focuses on the quality of the evidence, which has been synthesized in the aforementioned systematic review. Asbridge et al. electronically searched 17 data bases (including Medline, Embase, CINAHL, ProQuest, Transport Research International Documentation Online, Canadian Health Research Collection, ProQuest Dissertations & Theses Database, among others), conducted manual search of reference lists, and consulted with experts. The review included original, peer reviewed studies that: (1) used a population-based comparative approach; (2) focused on children four to 10
years involved in motor vehicle collisions; (3) compared the clear use of a booster seat of any style with other restraints; and (4) examined injury and mortality resulting from the collision. Laboratory, simulation, and case reports were excluded. Risk of bias in each study was assessed through consensus by two reviewers, using a standard tool and data extraction was completed independently by two reviewers. Studies were included in the analysis irrespective of their risk of bias, but the authors conducted a sensitivity analysis to assess whether studies with high risk of bias changed results. Data synthesis included meta-analysis to determine homogeneity of data, unadjusted and adjusted effect estimates were considered separately. In the latter case, estimates were adjusted for child age, sex, vehicle type. In addition, the authors separately synthesized studies that reported adjusted estimates and studies that did not.

This is a high quality systematic review, because it meets all nine criteria for quality established by Health Evidence. Indeed, Asbridge et al.: (1) defined participants, exposure, comparison, and outcomes; (2) outlined inclusion criteria, (3) conducted a comprehensive search strategy; (4) chose an adequate timeframe for the search strategy; (5) identified the level of evidence (observational studies); (6) conducted quality assessment of included studies; (7) made quality assessment transparent; (8) appropriately combined results across studies; and (9) adequately interpreted results based on data. Evidence from a systematic review, however, is only as robust as the data it includes. The authors recognized that their conclusions are limited by the quality of the original data. Most studies used data collected between the late 1990s and the mid-2000s, and information on factors that influence booster seat effectiveness was not available or coded in a useful way: children’s ages were collapsed into groups (e.g., three to eight years old) that did not correspond to restraint types (e.g., booster seats are required for children four to eight years old) and relevant information was missing: children’s height and weight, booster seat type, and correct use. Lack of information on correct use was particularly problematic in this systematic review, because it may directly influence results. For
example, two included studies, which examined injury outcomes by body location, reported high rates of head and facial injuries among children using booster seat and children using incorrect devices.\textsuperscript{20,41} This suggests that a significant portion of children using booster seats were wearing the shoulder belt behind their back, which is a common practice.\textsuperscript{45–47} Furthermore, when looking at injury outcomes in general, these studies aggregated upper and lower extremity injuries along with abdominal, thoracic, head, and facial injuries.\textsuperscript{20,41,48–52} This is problematic, because when booster seats are correctly used, they primarily prevent abdominal, neck, cervical, and head injuries, because they are designed to redistribute crash forces to the pelvis and ribcage.\textsuperscript{13,15,20–22} Hence, there is no reason to expect booster seats prevent upper and lower extremity injuries, particularly in comparison with seat belts. In addition, two of the studies that produced null results included shield booster seats (a seat with a cushioned bar in front the child’s chest) in the category of appropriate restraint.\textsuperscript{41,49} This is problematic because shield booster seats are not recommended, as their use is associated with an increased risk of injury.\textsuperscript{53} This type of booster seats has been discontinued in Canada.

The systematic review did not include two studies, totalling 123,976 individuals, which found protective effects of booster seats.\textsuperscript{40,54} The study by Caskey et al.\textsuperscript{54} was published after the review was concluded. They conducted a cross-sectional study using the United States National Automotive Sampling System-Crashworthiness Data System (NASS-CDS), which contains data from a sample of crashes (approximately 5,000 per year), with detailed information about the occupant, vehicle, crash, and environment. Crashes investigated are selected using a weighted, stratified, cluster probabilistic sampling method. They selected frontal crashes occurring between 2008 and 2015, involving vehicles of year model 2000 and later, where children aged five to 12 years old were seated in the back seat. Caskey et al. compared injury outcomes across three conditions un-restrained (no restraint/belt used), correctly used booster seat (sitting in booster seat with both the lap and shoulder belt on), and
adult seat belt only. A total of 348 cases, were included. After sample weighting, these cases represented 146,881 children. Caskey et al. found that, compared with children using booster seats, children using seat belts alone were five times more likely to sustain injuries, and children with no restraints were 19 times more likely to sustain injuries. These estimates were adjusted for child age, height, and weight, vehicle type (sedan, minivan, SUV, and truck), model year, and crash severity (delta-V or change in velocity). Caskey et al. found that abdominal injuries occurred at lower rates among children correctly using booster seats compared with children using adult seat belt only. No difference was found in rates of head injuries between children in booster seats and children in adult seat belts. This study included recent crash data involving recent vehicle models and authors controlled for important confounders in analysis. These results, however, are limited by the actual sample size: 348 children.

The study by Sauber-Schatz et al.\textsuperscript{55} may have been excluded from the systematic review,\textsuperscript{40} because the database they used did not allow them to distinguish whether children were riding in a booster seat or in another type of child restraint. They conducted a cross-sectional study using data from the United States Crash Outcome Data Evaluation System (CODES), which uses probabilistic linkage of crash and health care data to provide a more complete view of crashes, injury risk, protective factors, and health outcomes, and costs. The authors included child passengers aged one to 12 years, riding in passenger vehicles or light trucks, who were involved in crashes occurring on public roadways between 2005 and 2008. The study compared injury outcomes across three restraint conditions: child restraint or booster seat, adult seat belt, and no restraint. A total of 123,628 unique children were included in the analysis. Results indicate that children four to seven years old restrained in adult seat belts had similar rates of head injuries than children of the same ages restrained either a booster seat or other child restraint. In contrast, children four to seven years old restrained in adult seat belts were more likely to sustain any type of injury compared with children of the same ages
restrained in booster seats and child restraints. This study used a larger sample than that used by Sauber-Schatz et al.\textsuperscript{55}, but reported estimates are not adjusted for important confounders (child age, height, vehicle type, crash severity).

In conclusion, when considering both the strengths and limitations of the evidence of booster seat effectiveness, there are grounds to retain the theory that booster seats reduce injury and fatality risk. This determination is based on the limited quality of contrary evidence (included and not included in the systematic review); namely, data are old and include older vehicles and discontinued types of booster seats, lack relevant information (child age, height, weight, correct use, severity of the crash), and aggregates injury types and body locations that may not necessarily be prevented by booster seats.

2.4 The case for booster seat effectiveness: summary and comments

The body of booster seat effectiveness research exhibits signs consistent with a degenerative program.\textsuperscript{4} The same research question (do booster seats reduce injury risk?) has been addressed repeatedly with the same type of study (observational), but different data sources. Moreover, researchers have not responded to contrary evidence by refining and reformulating their theory, but by conducting further similar studies or performing a systematic review. Yet, subsequent studies or their corresponding systematic review suffer from the same limitations: poor data quality. Consequently, 12 years worth of research on booster seat effectiveness and 13 studies have amounted to inconclusive evidence. More problematically, the public health paradigm has produced no new content, hypotheses, or novel predictions. Aside from a call for better quality studies, researchers’ attempt at reconciling contrary evidence through a systematic review did not provide new research directions or methods.\textsuperscript{40}
The booster seat effectiveness research program can be revitalized by incorporating Lakatos’ methodology of scientific research programs. Under this paradigm the theory that “booster seats reduce the risk of injury and fatality” could be progressively revised, refined, and tested. Findings that contradict the theory would force modifications, expansions, or improvements of the original statement. For example, a more specific sub-statement could be added to the original theory: “booster seats are effective at reducing the risk of abdominal injuries.” Then, a Popperian falsification of this new statement would be conducted. One way to falsify this new theory would be to examine whether children who sustained head injuries and were restrained in an adult seat belt were more likely to sustain abdominal injuries compared to children who sustained head injuries but were reported to be in a booster seat. If there is no difference or if children restrained in booster seats were more likely to sustain abdominal injuries, then the new statement would be falsified. If children in booster seats were found to be less likely to sustain abdominal injuries then the new theory would have successfully passed a falsification test. This conclusion can be drawn, irrespective of whether the shoulder belt was correctly or incorrectly worn. Hence, this comparison can be done with data from published studies, despite the lack of information on shoulder belt use.

In reviewing the epistemological and the methodological cases for booster seat effectiveness, I conclude that there are still grounds to retain the theory that booster seats reduce injury and fatality risk, primarily based on the precautionary principle: at worse, evidence indicates that booster seats are not harmful, and, at best, they prevent abdominal and head injuries. Nevertheless, higher quality studies are needed. This could be done by striving to obtain better quality data, but this avenue is unrealistic given that this implies changing entire surveillance systems and protocols at institutions outside the control of researchers (e.g., the way police or medical emergency services collect and code data when they attend a crash). Alternatively, data quality limitations can be creatively, overcome by adopting Lakatos’
methodology of scientific research programs. In this scientific paradigm, researchers would use previous findings and their knowledge of data limitations to formulate specific hypotheses and specifying the conditions under which the hypothesis would be falsified.
3 Research on booster seat use

Research on booster seat use has followed the public health approach, which focuses on assessing prevalence of different kinds of injuries, identifying risk and protective factors, and developing and evaluating interventions. The results of this approach can be classified into four themes: (1) rates of booster seat use, (2) factors associated with booster seat use, (3) misuse of booster seats, (4) assessment of parents’ knowledge of guidelines and law, and (5) interventions to increase booster seat use.

3.1 Rationale and objective

The objective of this chapter is to illustrate how a literature review would be conducted under the Lakatos-Elster scientific paradigm. Accordingly, I summarize and critique the current literature on booster seat use in a way that deviates from traditional reviews in the public health approach. Rather than examining the quality of the evidence, I want to understand the
underlying assumptions about human behaviour and learning; whether those assumptions are based on theory; and whether authors postulate, test, and expand causal explanations; in other words, how progress has been achieved. For simplicity, I have intentionally omitted a review of methodological quality of studies. This is not because I believe methods are unimportant. To be sure, methods are crucial for scientific progress. However, methodological rigour does not guarantee scientific progress, because a study or set of studies can be methodologically sound and still contribute nothing to the progress of a discipline.

3.2 Studies on rates of booster seat use

Known as surveillance studies, these investigations do not seek to explain, predict, increase booster seat use, or correct misuse. Rather, the objective of these studies is to assess, and sometimes characterize, the prevalence of a behaviour in a population, within a geographical area, and at a moment in time. Two Canada-wide studies, for example, report both premature transition to seat belts and non-use of any kind of restraint for children 4 to 8 years. Collectively, the two studies reported a decrease in premature transition to seat belts from 63% in 2006 to 50% in 2010. These two studies conducted roadside observations of vehicles stopping at intersections selected through a probabilistic, stratified, cluster sampling method. Specially trained staff estimated children’s age-appropriate restrain status by looking through car windows, while the vehicles stopped at red lights. The first study included 13,500 children, aged zero to nine years, travelling in 10,084 vehicles, at 182 sites across Canada. The second study included 9,772 children, aged zero to nine years, travelling in 7,307 vehicles, at 170 sites across Canada. Studies using this methodology are expensive and provide limited data about the child’s age, height, weight. Nevertheless, they provide useful insight into the prevalence of booster seat use in a large geographic area.
More recent studies report that booster seat use rates continue to be low in North America relative to other car seats. Two studies involving car inspections, one in the province of Alberta and one in Michigan found booster seat use rates of 77% and 59%, respectively. In the former study researchers approached drivers at parking lots in childcare centres and invited them to participate in the study. Centres were selected using cluster probabilistic sampling where each childcare centre’s probability of being included in the study was proportional to the number of eligible children enrolled at each location. A total of 67 centres and 594 drivers with one or more children zero to nine years of age were included in the study. Correct restraint status of booster seat eligible children (determined by weight and age) was assessed according to a check list including items like seat belt being used; seat belt having a shoulder strap; seat belt is tight. In the Michigan study, inspections were conducted at community events (e.g., health fairs). The study included a total of 1,316 inspections. Participants in the study called ahead to make an appointment for the inspection where Certified Child Seat technicians would assess restrain status using a standard form that included child age, height, weight, as well as the brand, model number, the child restraint being used. This study included vehicles transporting children zero to nine years old (the child did not need to be present). Information on correct use focused on whether the child was using the appropriate child restraint, based on age, height, and weight. Studies using these methodologies can provide information about rates of booster seat use and correct use, at the cost of covering smaller geographical areas.

Telephone surveys with probabilistic sampling methods have also been conducted to assess prevalence booster seat use, either in small geographical areas or nationally. One cross-national study in the United States used data from the Second Injury Control and Risk Survey; a random-digit-dial (RDD) telephone survey conducted by the National Center for Injury Prevention and Control. They found booster use rates of 63%, 38%, 27%, and 20% among children aged five, six, seven, and eight respectively. Another cross-national study in the United
States used data from the Motor Vehicle Occupant Safety Survey; a national phone-based stratified RDD survey conducted by the National Highway Traffic Safety Administration (NHTSA). The study included responses from 891 drivers who reported to have a child four to five years old: 27% reported using a booster seat or child restraint on their child.

Overall, studies on rates of booster seat use make conclusions inductively, by studying a sample of units (intersections, vehicles, families) and generalizing findings to the population; hence, their reliance on probabilistic sampling methods. These studies are not designed and should not be expected to test hypotheses or theories, as their purpose is not to explain, predict, or change booster seat use, but to describe.

3.3 Studies on factors associated with use (or non-use)

Studies on factors associated with use (or non-use) have relied on cross-sectional designs and paper, telephone or online surveys to gather information. Most of these studies use convenience samples of caregivers (parents, drivers) approached at health care, childcare, educational or commercial facilities. In most cases, the association between the factor and the behaviour is correlational. Research on factors associated with booster seat use has consisted in repeating the same study, while changing the factors under investigation in each iteration. Thus, the contribution of each individual study amounts to the discovery of a factor or factors that had not been identified before. These discoveries can be classified as psychosocial, demographic, and situational.

*Psychosocial factors* that positively influence booster seat use include perceived safety benefit (i.e., the belief that booster seats are necessary to prevent injuries), social norms (i.e., beliefs about what parents are expected to do regarding booster seats), and perceived enforcement (e.g., belief that authorities are enforcing booster seat laws). Social norms
among children (e.g., children teasing those who use booster seats), cost (i.e., the perception that booster seats are expensive), and installation difficulty (i.e., the perception that booster seats take time to install or are difficult to fit in one’s vehicle), and children’s opposition to riding in a booster are all inversely related with use.\textsuperscript{39,60,61,63} Demographic factors that are positively associated with use include child age,\textsuperscript{39} driver’s sex, and racial minority status.\textsuperscript{59,64,65} The number of children requiring a booster seat in the family is positively associated with booster seat use among high income families,\textsuperscript{61} but negatively associated with use among low-income families.\textsuperscript{59} Situational factors are negatively associated with booster seat use and include carpooling, overcrowded vehicles, driving a short distance.\textsuperscript{66}

Table 3.1. Studies examining factors associated with booster seat use

<table>
<thead>
<tr>
<th>Authors</th>
<th>Design</th>
<th>Setting</th>
<th>Sampling</th>
<th>Participants</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ebel et al.\textsuperscript{63}</td>
<td>Cross-sectional survey</td>
<td>Childcare centers and elementary schools</td>
<td>Convenience</td>
<td>Drivers traveling with at least one booster seat eligible child</td>
<td>2,212</td>
</tr>
<tr>
<td>2. Bingham et al.\textsuperscript{61}</td>
<td>Cross-sectional survey</td>
<td>Not applicable (telephone survey)</td>
<td>Probabilistic stratified</td>
<td>Parents of child 4-8 years old</td>
<td>350</td>
</tr>
<tr>
<td>3. Winston et al.\textsuperscript{65}</td>
<td>Cross-sectional survey</td>
<td>State Farm Insurance Corporation</td>
<td>Probabilistic stratified cluster</td>
<td>Driver involved in a collision with a child 0 to 9 years</td>
<td>2,920</td>
</tr>
<tr>
<td>4. Snowdon et al.\textsuperscript{64}</td>
<td>Cross-sectional survey</td>
<td>Childcare centers and schools; hospital</td>
<td>Convenience</td>
<td>Caregivers of child 0-9 years old</td>
<td>1,957</td>
</tr>
<tr>
<td>5. Bruce et al.\textsuperscript{39}</td>
<td>Cross-sectional survey</td>
<td>Childcare centres, sporting events, dental offices and ambulatory care clinics</td>
<td>Convenience</td>
<td>Parents of child 4-9 years old</td>
<td>1,480</td>
</tr>
<tr>
<td>6. Cunningham et al.\textsuperscript{60}</td>
<td>Cross-sectional survey</td>
<td>Health, educational, recreational, or commercial sites</td>
<td>Convenience</td>
<td>Parents of child 4-9 years old</td>
<td>2,008</td>
</tr>
<tr>
<td>7. Keay et al.\textsuperscript{59}</td>
<td>Cross-sectional survey</td>
<td>Childcare centres</td>
<td>Convenience</td>
<td>Parents of child 2–5 years old</td>
<td>1,160</td>
</tr>
<tr>
<td>8. Aita-Levy &amp; Henderson\textsuperscript{62}</td>
<td>Cross-sectional survey</td>
<td>Emergency Department</td>
<td>Convenience</td>
<td>Caregivers of child 4-10 years old</td>
<td>100</td>
</tr>
<tr>
<td>9. McDonald et al.\textsuperscript{66}</td>
<td>Cross-sectional survey</td>
<td>Not applicable (online survey)</td>
<td>Convenience</td>
<td>Caregivers of child 4-10 years old</td>
<td>409</td>
</tr>
</tbody>
</table>
Table 3.1 describes characteristics of studies on factors associated with booster seat use. The pattern that emerges when all of these studies are considered together is: in the past 15 years, researchers have conducted survey studies with small variations on setting and jurisdictions, as well as the list of factors being investigated. Scientific progress has been achieved by progressively expanding the list of factors found to be associated with booster seat use. When evaluated under Elster’s model of causal explanations or Lakatos’ methodology of scientific research programs the picture is a little different: none of these studies provide causal explanations for their findings. In some cases, the factors are simply stated without any hypothesis of the mechanism connecting the factor with booster seat use. For example, Bingham et al. found that income and the number of children is positively correlated with booster seat use, but authors offer no explanation of the connection. In another case, Ebel et al. found that parental use of seat belt was associated with booster seat use, and hypothesized that: (1) both parental and child restrain use had a common cause: parents’ beliefs about booster seats; and (2) parental use of restraint could itself serve as a powerful example for younger and older children. This hypotheses, however, were not developed into an explanation, were not tested through falsification, nor were expanded, refined or explored in subsequent studies.

3.4 Studies on misuse of booster seats

Most studies on misuse focus on the prevalence of errors in the use of booster seats. These studies usually involve child restraint inspections in parking lots, hospitals, childcare centers, and community events (where people make appointments to get their restraint inspected by Certified Child Seat Technicians). Thus, researchers have the opportunity to interview the driver and check children’s restraint status, age, weight, and height. Several mistakes were found among children restrained in booster seats: putting the shoulder belt over the booster seat armrest, behind the child’s back, under the arm, or away from the middle of the
shoulder; lap belt not properly positioned across the hips, and lack of head restraint. One telephone survey reported similar mistakes: premature use of seatbelt, shoulder belt behind the back or under the arm; lap belt on the abdomen. Finally, one study set in fast food restaurants and discount department stores found that if the driver is between 15 and 24 years of age, the child is more likely to have at least one error; moreover, if the child weighs less than 40 pounds, there is a higher likelihood of a loose seat belt, a shoulder belt under the arm, or lap belt on the abdomen. Characteristics of the studies are presented in Table 3.2.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Design</th>
<th>Setting</th>
<th>Sampling</th>
<th>Unit of analysis</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Kroeker et al.</td>
<td>Cross-sectional</td>
<td>Community events</td>
<td>Convenience</td>
<td>Vehicle</td>
<td>1,316</td>
</tr>
<tr>
<td>3. O’Neal et al.</td>
<td>Cross-sectional</td>
<td>Fast food restaurants and discount department stores</td>
<td>Convenience</td>
<td>Children</td>
<td>564</td>
</tr>
<tr>
<td>4. Macy et al.</td>
<td>Telephone survey</td>
<td>Not applicable (telephone survey)</td>
<td>Phone-based stratified RDD survey</td>
<td>Drivers</td>
<td>891</td>
</tr>
<tr>
<td>5. Ebel et al.</td>
<td>Cross-sectional</td>
<td>Childcare centers and elementary schools</td>
<td>Convenience</td>
<td>Drivers</td>
<td>2,212</td>
</tr>
</tbody>
</table>

CSS = Child Safety Seat; RDD = Random Digit Dialing

When considered together, these studies replicate the pattern found in the previous sections. Several studies are conducted partly as surveillance studies assessing the prevalence of errors, and partly as correlational studies identifying factors associated with the presence of errors. As with studies on the factors associated with booster seat use, progress was achieved by changing settings and the variables collected. No causal explanations were proposed, tested through falsification, expanded or refined. Interestingly, the most common misuse of booster seats was riding on a booster seat with the shoulder belt behind the back; a result that was recurrent for more than a decade. When it was reported in 2003, Ebel et al., submitted that these parents may have the mistaken belief that low-back boosters do not require the
presence of a shoulder belt. Nevertheless, no subsequent study developed and tested this hypothesis. This 15-year-old finding (along with results from other studies) became the starting point of the causal explanation I am proposing in this document. (Section 4.5)

### 3.5 Studies on knowledge

Studies on knowledge often evaluate whether parents are aware of booster seat guidelines or regulations in their jurisdiction (i.e., age, weight, and height requirements to transition children from booster seats to seat belts). One study conducted in Alabama and one in Ontario found that most parents are either unaware or are confused about the age, weight, and height requirements for booster seats or seat belts.\(^{36,67}\) Furthermore, parents were reported to believe that children 4 to 8 years old are safe in seat belts.\(^{36}\) Finally, one survey study involving a 426 caregivers in Nova Scotia found a discrepancy between knowledge and practice: almost 50\% demonstrated knowledge of relevant recommendations and simultaneously reported not using booster seats to restrain their children.\(^{38}\) See Table 3.3 for study details.

**Table 3.3. Studies examining knowledge of booster seats**

<table>
<thead>
<tr>
<th>Authors</th>
<th>Design</th>
<th>Setting</th>
<th>Sampling</th>
<th>Unit of analysis</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cease et al.(^67)</td>
<td>Survey</td>
<td>Emergency Department</td>
<td>Convenience</td>
<td>Parents of child 0-13 years old</td>
<td>520</td>
</tr>
<tr>
<td>2. Snowdon et al.(^36)</td>
<td>Survey</td>
<td>School boards, childcare centres, hospitals</td>
<td>Convenience</td>
<td>Parents of child 0-9 years old</td>
<td>1,263</td>
</tr>
<tr>
<td>3. Yanchar et al.(^38)</td>
<td>Survey</td>
<td>Not applicable (telephone survey)</td>
<td>Phone-based RDD survey</td>
<td>Households with child 0-12 years old</td>
<td>426</td>
</tr>
</tbody>
</table>

\(\text{RDD} = \text{Random Digit Dialing}\)

When considered together, these three studies somewhat replicate the pattern seen throughout this section. Innovation is achieved by conducting similar studies in different populations, and the scientific contribution depends on whether researchers encounter
interesting results. It is important to note that Yanchar et al. conducted a follow-up study\textsuperscript{35} on their 2012 survey.\textsuperscript{38} This study is reviewed in the next section. Interestingly, all studies examining how much parents know about booster seats focused exclusively on guidelines. Studies on how much parents know about booster seat effectiveness, how they work, or why they are important are conspicuously absent.

3.6 Studies on interventions to increase booster seat use

Studies on behavioural interventions come in two forms: (a) effectiveness of booster seat legislation, and (b) effectiveness of programs aimed at increasing booster seat use by means of education, information distribution, or barrier removal.

3.6.1 Effectiveness of booster seat legislation

Farmer et al.\textsuperscript{68} used a case-control design that compared cases in jurisdictions with booster seat legislation against cases without legislation. The study analyzed crash data of 14,571 children aged 4 to 8 years involved in fatal motor vehicle collisions between 1995 and 2005, in the United States. Farmer et al.\textsuperscript{68} found that children in states with legislation were more likely to be restrained in a booster seat (or other type of child restraint) compared with their peers in states without law (adjusted Odds Ratio 4.44). Brixey et al.\textsuperscript{69} used data from the Milwaukee Safe Passenger survey, which collects self-reported use of booster seats. They compared rates of booster seat use among deprived communities five months before law enactment, during the seven-month grace period (before enforcement), and a year and a half after enforcement started. Booster seat use remained constant across the three time points (43%, 44%, and 42%, respectively), and usage was consistently below that of seats for infants (94% at all time points) and toddlers (65%, 63%, and 59%, at time points one through three, respectively). Brixey et al.\textsuperscript{70} conducted another prospective study at child care centres, community centres, and the primary pediatric hospital in Wisconsin. Parents were invited to
participate while they were arriving or leaving the parking lot and where included if they were riding with a child 4 to 7 years old. Trained staff evaluated whether the child was in a booster seat, but with the shoulder strap behind the back or under the arm, or with the lap belt on the belly. A total of 1,540 were inspected at five time points: (1) one year before law implementation, (2), one month before (3) three months after, (4) sixteen months after law implementation, and (5) twenty months after. Brixey et al.\textsuperscript{70} found a significant increase linear increase in booster seat use from 24\% one year before legislation, to 51\% in the last period. However, improvements in correct use were small (21\% in the first time point to 28\% in the last one).

Yanchar et al.\textsuperscript{35} used a telephone survey to evaluate the effects of booster seat legislation five years after Nova Scotia enacted a booster seat law. They conducted a random digit dialing telephone survey where they interviewed 453 households with at least one child under the age of 12 years. Respondents were asked questions about child restraints in general, and booster seats, in particular. Result from this study were compared with results from a previous survey conducted before booster seat law was implemented.\textsuperscript{38} Yanchar et al.\textsuperscript{35} found that parent reported age- and weight-appropriate choice of booster seat use increased from 58\% to 95\% after legislation.

Studies on the effect of legislation on booster seat use were conducted in isolation of each other. No hypothesized causal explanation was proposed even after publication of studies with contradictory results led by the same researcher.\textsuperscript{69,70} These two studies found that legislation had unintended consequences: in one, premature transition to booster seats was observed\textsuperscript{69}; in the other, legislation was found to increase racial disparities: booster seat use increased significantly less among racial minorities.\textsuperscript{70} Authors cite possible mechanisms
including culture and social norms, but these hypotheses have not been tested or expanded in subsequent studies.

3.6.2 Education, information distribution, or barrier removal interventions

A total of eight studies tested interventions to increase booster seat use by means of education, information distribution, or barrier removal. These studies are the most relevant to the present dissertation, which explores the development of behavioural interventions, using the Lakatos' methodology of scientific programs\(^4\) and Elster's notion of progress through causal explanations.\(^6\)

3.6.2.1 Interventions in stores

One early study is a master's thesis evaluating an intervention comprising a pamphlet, a coupon or a combination of both.\(^7\) The study was set in a store that sells merchandise for children, and included 128 parents, of children 3.5 to 8 years old. The study was conducted during a weekend. On Saturday, participants were assigned to the pamphlet only group or control group; on Sunday participants were assigned to the pamphlet + coupon or the coupon only group. The pamphlet provided parents with information on how adult seat belts do not fit correctly on children and how booster seats ameliorate the problem. The pamphlet also provided booster seat statistics and guidelines, as well as consequences for not using a booster seat, including a list of potential injuries (head, face, internal organ, neck and back muscles, and spine and extremity fractures). The pamphlet had a prominent warning reiterating guidelines and informing about the dangers of adult seat belts. In addition, the pamphlet told an emotional story of a child who was ejected from a vehicle and killed, because he or she was not using a booster seat and the adult seat belt was too loose. The study found that significantly more participants from the pamphlet + coupon, pamphlet only, and coupon only groups purchased a booster seat compared with the control group. Of the 37 participants who ultimately purchased a
booster seat at the store, 11 (34%) were in the coupon + pamphlet group, 12 (38%) in the pamphlet only group, 13 (41%) in the coupon only group, and 1 (3%) in the control group. The intervention in this study was loosely based on risk perception theory\textsuperscript{72,73} and assumed that, parents would be more likely to purchase if their perceived risk of injury to their children increased. Researchers further assumed that perceived risk could be modified by informing parents about injury statistics and the consequences of not restraining their children in booster seats.

3.6.2.2 \textit{Interventions in communities}

The assumption that beliefs can be changed by imparting information, permeates the entire body of research on behavioural interventions to increase booster seat use. For example, three studies testing multifaceted interventions included educational components that hinged on this assumption. Ebel et al.\textsuperscript{74} evaluated an intervention comprised of education, legislation, and coupons. It used the PRECEDE-PROCEDE approach to injury prevention\textsuperscript{75}, which begins by identifying predisposing, enabling, and reinforcing factors. Ebel et al.\textsuperscript{74} identified the following factors: awareness of the need for booster seats, motivational barriers to purchasing a seat, parent confidence in choosing and using a booster seat, and knowledge of the benefits of booster seat use and the consequences of not using one. Next, Ebel et al.\textsuperscript{74} developed a multicomponent intervention that targeted each of these factors. The intervention included the creation of a booster seat coalition, involved diverse stakeholders (educators, health care providers), and used several media channels to impart information (TV, radio, newsletters, flyers, brochure and classes). There were two parts to the education component: one targeting motivation and one targeting knowledge of guidelines, both of which were expected to improve parental decision making. The intervention was deployed in four communities in the Greater Seattle Area, Washington, and the study included eight communities in Oregon and Washington as control sites. At baseline, researchers assessed booster seat use status of 607 children in
intervention communities and 1,218 in the control communities. At follow up, researchers assessed 711 children in intervention communities and 1,073 in control communities. Restrain status was ascertained through parking lot surveys in 83 childcare centers and after school programs. After interventions, booster seat use increased from 13% to 26%. In control communities, it increased from 17.3% to 20.2%. The authors did not measure the impact of the intervention on the predisposing, enabling, and reinforcing factors that the intervention targeted. Consequently, the study provides evidence of effectiveness, but the causal mechanisms explaining how the intervention produced results are not explored.

Aitken et al. conducted a non-randomized trial in rural areas of Alabama, Arkansas, Illinois and Indiana, which hinged on the assumption that beliefs and behaviour can be changed by imparting information. Booster seat use was assessed through parking lot surveys conducted by a trained community member and supervised by research staff. At baseline, researchers assessed the booster seat use status of 511 children in intervention communities and 503 in control communities. At follow up, researchers assessed 409 children in intervention communities and 352 in control communities. Centered on community instructional baseball leagues, the intervention included the creation of a booster seat coalition, training of technicians, letters from coaches to parents, brochures, newspaper articles on the benefits of booster seats, endorsement by local spokespersons, and booster seat check-ups. Restraint use increased 10.2% in intervention and 1.7% in control communities. When considered state by state, the intervention was found effective in all states but Indiana, which experienced a 9.2% decrease in booster seat use. This study is another example of researchers reporting intervention effectiveness without postulating a causal mechanism through which the intervention is expected to produce results. Perceived benefit, barriers, and social norms are cited, but only to justify the components the intervention. As a result, when researchers
encountered null results, their comment in the discussion is limited to “for reasons that are not clear […] (Indiana) did not respond to the intervention.”

Yellman et al. evaluated an intervention set in eight schools located in economically disadvantaged areas of Dallas County. The intervention sought to increase booster seat use among children aged 4 to 7 years old. It comprised a “train-the-trainer” component through which school staff and volunteer parents became booster seat promoters; brief presentations for parents; bilingual factsheets; walk-around education conducted by booster seat promoters and law enforcement; booster seat inspection/installation events; fact sheets with information on types of booster seats, legislation, and standard guidelines; and tailored communications (recommendations based on their child’s age, height, and weight). The intervention was informed by the safe communities model with content adapted from the AAP and the U.S. National Highway and Traffic Safety Association. Booster seat use was assessed at schools by an expert who observed children’s restraint status as vehicles entered parking lots. A total of 5,965 children in eight intervention schools and 8,963 in 14 control schools were observed. After intervention, booster seat use increased by an average of 21% (from 5% to 26%) in intervention communities, compared to controls. This increase persisted over summer and into the new school year. As in the previous two studies, this study explicitly targeted psychosocial factors assumed to influence booster seat use (e.g., knowledge and social norms). However, no theory was presented to support those assumptions and the impact of the intervention on these factors or the impact of these factors on booster seat use was not evaluated.

3.6.2.3 Interventions in child care centres

Three studies examined interventions set in early childhood care settings. One examined the effects of an educational video presented to caregivers attending two child care centres in Virginia. Two other similar childcare centres were used as controls. A total of 226
(100 intervention; 126 control) caregivers participated in the study. The intervention was inspired by a concept from the Precaution Adoption Process Model; specifically, the notion that individuals need to recognize that a risk personally affects them as well as others, in order adopt precautionary measures. To elicit this state of risk awareness among parents of children, Will et al. used threat appeals (or scare tactics), which are theorized to be effective if: (a) the threat is high, but not so high that it elicits avoidance, and (b) the threat appeal is accompanied by messages that improve individuals’ self-efficacy (i.e., confidence that they can effectuate the recommended action). Accordingly, the video opens with threat appeal: a scene where a boy rides in the back seat of a car with the lap belt on his belly and the shoulder belt behind his back. The car then crashes, the boy lunges forward and hit his head on the rear of the front seat. Then, the child is seen in an ambulance as he loses consciousness. The video then combines narration, computer simulations, and crash-test footage showing what happens to child occupants who are unrestrained, restrained with adult seat belts only, and restrained with a booster seat. The video continues a self-efficacy section, where a mother demonstrates that booster seats are easy to install and describes techniques to persuade her daughter to use them. Following, a traffic safety advocate provides tips for parents and mentions how inexpensive booster seats are. The video ends with another threat appeal section, where an emergency doctor discusses his experience with injuries resulting from lack of booster seats. The closing scene reveals that the child from the opening scene became paralyzed. The video significantly increased safety knowledge, risk-reduction attitudes, and intention to use booster seats as well as sense of threat and self-efficacy. Parking lot observations of booster seat use showed an increase from 30% to 35% in booster seat use in the intervention group and a decrease from 36% to 29% in the control group. Unlike the previous studies, researchers in this investigation made use of a theory that implies mechanisms through which the intervention is expected to change behaviours: threat appeals combined with self-efficacy training.
Furthermore, the authors evaluated the effect of the intervention on both the psychosocial factors and behaviours.

A second intervention set in early childhood development settings was deployed at *Early Years Centers*; a community-based program to support families with young children, in Ontario. This 1-year longitudinal study examined the effectiveness of multi-media intervention program on parents’ knowledge of correct use of child restraints. A total of 201 parents of children aged 0 to 12 years participated in the study. No control group was included. In this study, Snowdon et al. examined a multi-media educational program that included training in correct use, as well as awareness of the risks of injuries to children riding in motor vehicles. The intervention sought to educate parents on correct use of child restraints (including booster seats), guidelines for transitioning children from one type of child restraint to the next, as well as awareness of the risk of injuries. Education comprised: (a) a computer simulation of the potential injury outcomes; (b) a story book encouraging parents to interact with children regarding vehicle safety; (c) facts and statistical risk information; (d) a fridge magnet with transition guidelines; and (e) a growth chart to help parents decide safe transitions from one type of child restraint to the next. Although the intervention was designed to address *learning styles*, it is unclear what the authors meant by learning styles nor which aspects or components of the intervention addressed each of these styles. One year after intervention, parents’ odds of remembering the correct weight and height to transition children to booster seats increased 1.5 and 2.0 times, respectively. The odds of parents recalling the correct weight and height to transition children from booster seats to seat belts more than doubled. Self-reported correct use of booster seats increased 1.7 times. In this study, Snowdon et al. developed an intervention to improve parents’ knowledge of appropriate booster seat use. The intervention hinges on the assumption that individuals are more likely to learn content imparted to them if the method of delivery of information caters to their learning style. However, the authors did not explain what
those learnings styles were or how the intervention was supposed to cater to each. If the notion of learning styles was fundamental to their intervention, they should have been described and also discussed in the conclusions. As above, researchers employ theory as a tool to design an intervention, rather than as integral to the program of research.

Thoreson et al.\textsuperscript{81} conducted the third childcare-based intervention; a cluster Randomized Control Trial (RCT), where 21 and 22 childcare centers were allocated to intervention and control arms. Based on the PRECEDE-PROCEED model\textsuperscript{75}, the intervention promoted awareness of and adherence to booster seat guidelines, and increased skills and self-efficacy by providing educational resources and training to child care staff. Staff were given resource kits with lesson plans, activities for children, and brochures. Researchers co-coordinated with staff to plan one parent education event per center, where researchers modelled techniques for discussing booster seats with parents. Centers distributed booster seats to parents and hosted holiday-themed booster seat promotion activities. Restrained status was evaluated through parking lot surveys. A total of 918 children in the intervention arm and 912 in the control arm were included. No differences in booster seat use rates were found at follow up between the intervention and control groups: 43\% and 44\%, respectively. Similarly, no differences were found in correct use of booster seats: 41\% and 43\%, respectively. The authors did not present any hypothesis as to why the intervention did not produce the expected effect. Again, the intervention was predicated on the assumption that imparting information through childcare staff would somehow change people’s knowledge and beliefs, and in turn, would increase booster seat use. However, instead of questioning this assumption, the authors speculated whether they had created the right combination of components to produce positive results.
### 3.6.2.4 Interventions in hospitals

One education intervention study was set in a pediatric hospital and specifically targeted economically disadvantaged families with children 4 to 7 years old, who presented to the Emergency Department (ED) without a booster seat. Two hundred twenty five participants were randomly allocated to either receive standard discharge instructions, a five-minute booster seat training, or training with a free booster seat installation (75 participants per arm). A five-minute training was provided by the child safety seat technician and the material included a handout, a video on the importance of booster seats and how they work, as well as instructions on how to obtain a booster seat or have their seat installation verified. The technician ended the instruction by answering questions. The third group had a booster seat installed in addition to the five-minute instruction. The video was borrowed from the Washington State Booster Seat coalition and consisted of silent footage showing a slow-motion picture of a frontal crash test involving an anthropomorphic test dummy representing a child restrained with the lap belt only (shoulder belt is behind the back). Participants were allowed to draw their own conclusions from the video. One month later, participants were surveyed by telephone, with 98% in the booster seat giveaway condition reporting still using the material, compared with 5% in each of the other two groups. As in previous studies, the intervention under study relied on the assumption that imparting information somehow improves parents’ knowledge, which, in turn, changes behaviours. Moreover, the intervention also relied on the assumption that presenting information in various forms (video, print, oral) is enough to improve knowledge. No theory of behaviour, learning, or education is employed to support these assumptions. Although the authors evaluated changes in knowledge and changes in behaviour, the causal connection between the two is not examined.
3.6.2.5  Education, information distribution, or barrier removal interventions: comments

Studies testing education interventions are particularly relevant to the present dissertation. In this section, I reviewed literature spanning close to two decades of research, encompassing a wide variety of approaches and settings. Some of the interventions reviewed were based on a theory of behaviour change. Although all of them relied on education, most of them implied the assumption that people learn information as it is presented.

In general, progress in the development of behavioural interventions to promote booster seat use was achieved by small increments: exploring different settings and circumstances that facilitate access to high-risk populations; testing different ways to impart information (multimedia, training staff, mass media). Two studies ventured in uncharted intervention settings (children’s baseball league, hospital) seeking new ways to reach racial minorities and economically disadvantaged groups. In the literature, it is evident that the research community does not appear to follow a progressive research program: many studies are virtually replications with minor changes to the component or the setting; hypotheses explaining why an intervention was effective (or not) are rarely presented and when hypotheses are formulated, they are not developed further or tested in subsequent studies.

3.7  Research on booster seat use: summary and commentary

The public health paradigm has led to useful findings on booster seat use and some of the challenges encountered in their use. Studies on booster seat use rates provide a picture of the current state of affairs on that front. Across studies, booster seat use was found to be low, particularly compared with utilization rates of child restraints for children younger than four years. Furthermore, booster seat use decreased as the age of the child increased, indicating a tendency for parents to transition children to seat belts earlier than recommended. Moreover, some children who rode in booster seats used them incorrectly (e.g., placing the seat belt
behind their backs), which reduces the effectiveness of the device (i.e., to redirect crash forces to the ribcage and pelvis). Research on booster seat use has also highlighted the importance of legislation and the need to increase parents’ knowledge of guidelines and perceived safety benefit of booster seats. Some studies have found that some parents exhibit inconsistencies in their attitudes and behaviours: parents simultaneously report knowing booster seat guidelines or owning a booster seat and yet not restraining their child in this device.

Overall, the body of research does not follow a research program, as defined by Lakatos. No unified theory has been developed to integrate these findings into a coherent whole or to produce new research questions or novel predictions that could advance knowledge. Moreover, researchers have proposed hypotheses to explain unexpected results, but these potential explanations are not developed or tested in subsequent studies. As a result, the literature appears as a collection of isolated studies were researchers identify a “niche” (e.g., a population group, a new set of potentially relevant factors associated with use) on which to conduct their research.

The body of research on interventions to increase booster seat use appears as a 15-year-long exercise of trial and error, where successful studies are emulated and deployed in different populations and settings to determine if they are effective elsewhere. It is particularly interesting, for example, that three multifaceted interventions were conducted in the span of 15 years (Ebel et al., Aitken et al., and Yellman et al.) and all three are virtually identical. In other words, these three studies did not produce new ideas for interventions. This lack of progress is also reflected in the rates of booster seat use these interventions achieved: 26%, 36%, and 26%, respectively.
In this dissertation, I explored whether a different approach has a place in injury prevention: I applied the methodology of scientific research programs and the model of causal explanations to the problem of booster seat use. I began by identifying some counterintuitive findings in the literature and ask a basic causal question: why. Why parents choose to restrain their child in a booster seat, but use it in a way that undermines its purpose: placing the lap and shoulder belts on the belly or behind the back. Why rates of booster seat use are low compared with child restraints for younger children, which are used at almost twice the rate.

A more perplexing question is why some parents demonstrate knowledge of guidelines, while simultaneously reporting not restraining their children in booster seats. In the pages that follow, I formulate a causal explanation to answer these questions, describe its theoretical underpinnings, and suggest a method for testing it via falsification.
4 Fuzzy-trace theory and the ejection stereotype hypothesis

4.1 Rationale and objective

Proposed by Valerie Reyna, Fuzzy-trace theory (FTT) is a psychological model of memory and reasoning that explains a wide range of phenomena in cognitive development, decision making, and health behaviour. Since the ejection stereotype is derived from FTT, a description of the theory and its relation with the ejection stereotype hypothesis is in order. Accordingly, the objective of this section is to introduce the reader to FTT and describe how the ejection stereotype hypothesis logically derives from it.

4.2 Fuzzy-trace theory

FTT is founded on two important core concepts: verbatim and gist representations. Verbatim representations refer to information memorized as exact words, numbers and pictures. It is considered surface information, because it is devoid of meaning or understanding of the
content. For example, classic psychological experiments on memory demonstrated that individuals can retain and recall lists of nonsense syllables (eu, oe, ie, oo). In contrast, gist representations refer to imprecise, fuzzy representations that capture the bottom-line, or “gist” meaning of information. For example, when reading a scientific paper, scholars often retain and recall the main points of the study, without memorizing the exact words or numbers reported.

While verbatim representations are literal, gist representations are interpretive. As such, gist representations are influenced by emotions, culture, mindset, level of education, experience, and psychological development. Consider, for example, a father who is presented with the following text: “compared with seat belts alone, booster seats reduce the risk of injury by an average of 45%.” The verbatim representation of this information will be a memory of the sentence word by word, number by number, and without any understanding of its meaning. In contrast, the gist representation of the same information would answer questions like “what does 45% risk reduction mean? Is 45% a lot or a little?” Depending on the father’s experience, values around children safety, education, and emotional reactions to a potential injury to his child, the interpretation of the information could range from: “booster seats afford very little additional protection from injuries” to “booster seats are absolutely necessary to protect my child.”

The first tenet of FTT is that verbatim and gist representations are stored, recalled, used, and forgotten roughly in parallel and independent of each other, even from the same stimulus. Independent means that sometimes gist and verbatim representations lead to the same behavioral response and sometimes they lead to different, even contradictory responses. For illustration purposes, assume that the father in our example interprets a 45% risk reduction as “the safety benefit of booster seats is low.” Further assume that this father has also memorized, word by word, number by number, the sentence: “compared with seat belts alone,
booster seats reduce the risk of injury by an average of 45%.” Now imagine that injury prevention researcher asks him two questions: (1) how important are booster seats for his child’s safety, and (2) by how much booster seats reduce the risk of injury compared with seat belts. According to FTT, the father in the example is likely to answer that booster seats are not important for his child’s safety, and yet, he would correctly recall that booster seats reduce the risk of injury by 45%. The father’s apparent inconsistency would stem from the fact that the question “how important are booster seats” elicits a gist representation (i.e., booster seats afford very little extra protection), whereas the question “by how much” elicits the verbatim representation (i.e., 45%). Thus, according to FTT, the father in the example can have contradictions between his knowledge and attitudes, and display them in the same interview, while being completely unaware of the inconsistency.

High-level cognitive processes such as memory, judgment, reasoning, and decision making can be gist or verbatim, depending on the representations being used.\textsuperscript{11,83,84} FTT research has shown that reliance on gist representations increases with age; thus, cognitive processes based on gist representations influence behaviour more than verbatim ones, particularly among adults.\textsuperscript{11} For example, FTT implies that the father in the example would not engage in quantitative cost benefit-calculations when dealing with a child who opposes booster seat use (e.g., 45% risk reduction versus being late and upset). Rather, the father is more likely to operate with his gist representation: “the safety benefit of booster seats is low.” Preference for gist processing does not imply that adults are incapable of, or that never engage in verbatim reasoning, judgment, or decision making. Adults can, and do, engage in verbatim processing, if a situation or problem demands. The father in the example is likely to engage in verbatim processing when completing a booster seat survey inquiring the height, weight, and age required for a child to use an adult seat belt.
Three final notes are in order to make a basic description of FTT: (1) gist and verbatim processes are to be understood as opposite ends of a spectrum, where reasoning, judgment, and decision making is carried out with different levels of precision. This implies that individuals form and use multiple representations of the same information, which vary in their degree of exactness. For example, risk of injury can be represented and used as “some risk versus no risk,” “low, medium, and high risk,” or “0 to 100% risk.” According to FTT, adults have a tendency to use the crudest representation that is sufficient to solve the problem at hand. (2) Gist processing is fast, automatic, intuitive, and unconscious, whereas verbatim processing is deliberate, effortful, and conscious. (3) Two types of gist must be distinguished: descriptive gist is what an individual with limited experience and knowledge would take to be the gist. For example, the father who interprets the 45% reduction injury risk afforded by booster seats as “the safety benefit of booster seats is low.” In contrast, prescriptive gist is what an individual with information and experience in the subject matter would take to be the gist. For example, an expert who understands a 45% reduction as a decrease in the risk of injuries caused by an ill-positioned seat belt (abdominal, spinal, neck, head injuries). This distinction notwithstanding, prescriptive gist does not imply that experts are immune to descriptive gist in their area of specialization. This idea will be discussed in the next section.

4.3 Why fuzzy-trace theory?

My choice of theory in the present dissertation was based on my views on scientific progress (see Chapter 1), particularly the methodology of scientific research programs and the concept of causal explanations. FTT is currently a progressive research program insofar as it has excess empirical content. This means that FTT makes hitherto unknown, counterintuitive predictions that have been empirically corroborated. To name a few: FTT predicted that false memories follow specific patterns based on the meaning of words, sentences, and narratives. FTT correctly predicts that false memories for narratives result from individuals recalling their
own inferences of a story as though they were details presented in the story. For example, after reading material containing the sentences “the bird is in the cage” and “the cage is under the table” people may incorrectly recall that they read the sentence “the bird is under the table.” The latter is, of course, the gist of the narrative; a logical inference from the previous statements. FTT also postulates that a person may have reliable gist recollections of an experience (e.g., that she was assaulted) while being confused about the details (e.g., the colour of the assailant’s car). These findings have consequential implications in law, as they put into question common wisdom views about witness credibility; for example, the idea that a testimony is less credible simply because the witness cannot provide an accurate verbatim account. 87

FTT also predicted that children are more likely to process risk information with more precision (i.e., finer-grained distinctions) than previously thought. 88 Reyna and Ellis 88 conducted experiments in which children were asked to choose between a sure bet and a gamble. Children were shown a wooden spinner on a blue board; sections of the board were covered with pieces of red cardboard representing probabilities of 1/2, 2/3, or 3/4 (see Figure 4.1).

Figure 4.1 Illustration of a spinner used to represent probabilities of 1/2, 2/3, and 3/4.

Children were also shown prizes: transparent bags with brightly colored superballs. The bags had different amounts of balls ranging from 2 to 120. Children were interviewed individually and where told they would be playing a game called “pick what you want.” They could choose between a sure bet, or they could use the spinner for a chance to win more balls,
at the risk of not winning anything. For example, they were asked to choose between getting one ball for certain versus a 1/2 probability of winning two balls with a 1/2 probability of winning zero balls. In other rounds, they were asked to choose between getting 30 balls with certainty versus a 1/4 probability of winning 120 balls with and a 3/4 chance of winning zero balls. Reyna and Ellis[^89] found that children were sensitive to differences in probabilities and prize sizes (number of balls) and that their choices entailed weighing prize sizes by the likelihood of getting them, in accordance with normative views of rational choice.

FTT also predicted that experts in sexually transmitted infections can have biased judgments of the risk reduction afforded by condoms, because of a tendency to see sexually transmitted infections (STI) as fluid born (and exclude from their estimates herpes simplex and human papillomavirus, which are transmitted through the skin): “STI are fluid born; condoms block fluid exchange; therefore, condoms prevent STI.”[^90,91]

In summary, FTT is an alternative theory of health behaviour that leads to the type of innovation and scientific progress described by Lakatos.[^4] It began as a theory of reasoning[^83] and then expanded to have demonstrated implications for cognitive development,[^86] law,[^87], and neuroscience.[^92] FTT has led hitherto unknown, counterintuitive findings about human cognition, and, thus has the potential to inspire new ways of addressing behaviour health problems.

### 4.4 Fuzzy-trace theory and risk perception

FTT postulates that misperceptions of the risk reduction associated with a particular safety device can be traced to four sources, of which only the first three are relevant to the present discussion[^90,91]: (1) knowledge deficits, (2) representational biases, (3) failures to retrieve relevant information, and (4) process interference. Knowledge Deficit is the simplest source of faulty estimation of risk reduction.[^90,91] If people do not know that seat belts can severely or
fatally injure children when they do not fit correctly (i.e., the shoulder belt on the shoulder and the lap belt across the hips), then they are likely to overestimate the safety benefit of seat belts and/or underestimate the reduction of injury risk afforded by booster seats. Knowledge deficit can be ameliorated simply by ensuring that individuals acquire and memorize relevant information (e.g., biomechanics of booster seats; injury rates for children restrained in booster seats versus those who are not).

Representational biases, unlike knowledge deficit, occur not because of the absence of information, but in spite of it. According to FTT, this occurs because individuals generally do not act upon memorized facts and figures. Instead, they tend to make judgments and decisions based on “fuzzy” memory traces that form the gist of relevant knowledge; the bottom-line meaning of the information. Recall the aforementioned example of a father who interprets a 45% reduction in injury risk as “booster seats are better, but seat belts alone are okay”. Despite possessing the correct information, this father is likely to restrain his child in a booster seat because his interpretation of the information (the gist) is incorrect.

Representational biases lead to a third source of error in estimating risk, failure to retrieve relevant information or retrieval errors. Retrieval errors occur when the person has knowledge of the relevant risks but fails to retrieve it. Different types of cues in the environment are better at eliciting certain type of content than others. For example, asking a person to estimate the risk of death for a 20-year-old man, typically elicits small figures because the young age suggests low probability of disease related death. However, asking a person to estimate the risk of death from violence, unintentional injuries, suicide, disease and all other causes, usually elicits bigger numbers because young males are seen as having an increased risk of death from intentional and unintentional injuries.
The fourth source of error is, process interference, which occurs when the person has the relevant knowledge, has formed the correct gist, has retrieved the relevant information, but fails to correctly reason with it. Consider a patient who was received a positive result from a test of disease x. The test has a sensitivity of 80% (i.e., a probability to give a positive result when the disease is present). What is, then, the probability that the patient has disease x? Experts with specialized relevant knowledge often give the incorrect answer: 80%. However, the correct probability of the patient having disease x is not estimated only by test results; the prevalence of the disease in the population should be considered as well. In this instance, process interference occurs because this problem requires reasoning that involves overlapping categories of events: patients with positive test results and patients with the disease. Process interference is the most difficult error to overcome and it is the most likely to be found among experts.\textsuperscript{90,91}

4.5 The ejection stereotype hypothesis

Because the gist is a subjective interpretation based on context, emotions, education, culture, experience, mindset, and development,\textsuperscript{11} sometimes people form an incorrect or stereotyped gist of the issue, which leads to biased judgments. This type of gist representations is called descriptive gist.\textsuperscript{84} For example, Reyna and Adam\textsuperscript{91} and Adam and Reyna\textsuperscript{90} demonstrated that the tendency to view sexually transmitted infections (STI) as primarily fluid-borne led knowledgeable individuals (i.e., healthcare professionals) to overestimate the effectiveness of condoms. Indeed, individuals who think of STI as primarily fluid-borne will consider only fluid-borne infections in their estimations (e.g., HIV, gonorrhea), neglecting STI that are transmitted through the skin (e.g., herpes simplex and human papillomavirus). As a result, these individuals are likely to overestimate the STI risk reduction afforded by condoms: STI are fluid-borne; condoms block fluids; therefore, condoms prevent all STI.
I propose that a similar representational bias may help explain why individuals misunderstand the need for and use of booster seats. I hypothesize that individuals may be prone to represent injuries to vehicle occupants as ejection related and, thus, overestimate the protection afforded by seat belts, while underestimating the safety benefit of booster seats: child passenger injuries are ejection related; seat belts prevent ejection; therefore, seat belts provide sufficient protection (i.e., booster seats are not needed). In effect, by focusing on preventing ejection, parents may overlook other injury hazards that need to be prevented; namely, injuries to the abdomen or the spine caused by incorrect positioning of the seat belt. I call this representational bias the *ejection stereotype*.

As a representational bias, the ejection stereotype must be distinguished from knowledge deficit: I am not proposing that individuals are simply unaware of the physics and mechanics relevant to booster seats, or the difference in injury rates between children who use booster seats versus those who do not. Rather, I submit that the ejection stereotype emerges because injuries caused by ejection are more salient than injuries caused by seat belts. In fact, ejection seems to be the preferred persuasion example of the consequences of not wearing proper restraints in the injury prevention community, as evident in the following excerpt from an academic article on child passenger safety: “the child will be hurled like a missile that bursts when it lands.”\(^93\) Moreover, three interventions to increase booster seat use (reviewed in section 3.6) used ejection examples\(^71\) or imagery consistent with ejection\(^79,82\) to increase perceived risk of injury or perceived benefits of booster seats.

The ejection stereotype hypothesis can explain, or partially explain, the counterintuitive findings listed in 3. First, the ejection stereotype hypothesis explains *errors in booster seat use*: putting the shoulder belt over the booster seat armrest, behind the child’s back, under the arm, or off the middle position; lap belt not properly positioned across the hips, and lack of head
restraint.\textsuperscript{45-47} Parents who restrain their children in booster seat in these ways are aware of recommendations or the law. However, the ejection stereotype implies that parents may be aware of guidelines and legislation, but still oblivious to the purpose of booster seats. As a result, they would restrain their child in a booster seat, but would allow him or her to ride with a shoulder belt behind the back. This is consistent with findings indicating that smaller children are more likely to ride in a booster seat with the shoulder belt under the arm or the lap belt on the abdomen.\textsuperscript{45} The ejection stereotype is not unique in explaining incorrect use of booster seats. Any health behaviour theory that considers knowledge as a determinant of correct use could invoke lack of knowledge to explain these errors. This explanation would be consistent with findings indicating that suboptimal use of booster seats is inversely associated with parents level of education.\textsuperscript{64,65,94}

The ejection stereotype also explains low rates of booster seat use compared with child restraints for younger children. While the mechanics of adult seat belts apply equally to all vehicle occupants, irrespective of their age and size, the notion that adult seat belts redirect crash forces to stronger parts of the body is crucial to understanding the safety benefit of booster seats. In contrast, this notion is just one of many reasons other types of child restraints are recommended for children under four years of age (e.g., infants and toddlers have big heads relative to their body and have weaker bones and muscles). Hence, even for parents who believe that seat belts only prevent ejection, the extra vulnerabilities of children under four years old justify the use child restraints. For older children, however, the ejection stereotype hypothesis implies that seat belts alone are capable of keeping the child inside the car and, thus, are safe enough. This explanation is consistent with a recurrent finding: booster seat use decreases as the child grows.\textsuperscript{45,60,74,95}
Finally, the ejection stereotype hypothesis explains *discrepancies between knowledge and practice* (i.e., knowing that booster seats are recommended, yet not using one) as found by Yanchar et al.\textsuperscript{38} FTT postulates that: (1) gist and verbatim representations are independent from one another, which means they can be correlated or contradictory, within the same individual; and (2) individuals are more likely to act upon their gist representations than upon their verbatim ones. If the gist representation about booster seats is consistent with their verbatim counterparts, then parents' knowledge and practice would be correlated. However, if the gist representation about booster seats is inconsistent with the verbatim counterpart, then parents are likely to exhibit behaviour that is inconsistent with their reported knowledge. The ejection stereotype hypothesis implies that parents’ gist representation of booster seat information is inconsistent with the verbatim information: the ejection stereotype leads to low perceived benefit (or low perceived reduction of injury risk) and, in turn, low booster seat use. These same individuals may simultaneously be aware of guidelines, which typically are imparted and evaluated in verbatim form. The ejection stereotype is not the only explanation that has been proposed to account for this discrepancy between knowledge and practice. Yanchar et al. found that the discrepancy disappeared after a booster seat law was implemented in the jurisdiction where the studies were conducted (Nova Scotia, Canada) leading authors to conclude that legislation was the missing piece connecting knowledge and practice.\textsuperscript{35} This account, however, does not meet Elster’s standards for causal explanations\textsuperscript{6}: citing a cause, the enactment of booster seat law, is insufficient. The actual mechanism, connecting the event and the cause must also be described.\textsuperscript{6} Since it is not described and tested it is unclear how the discrepancy between knowledge and practice disappeared. It could have disappeared simply because, once legislation was in place, survey respondents became less likely to report that they do not restrain their children in booster seats.
4.6 The ejection stereotype hypothesis: summary and comments

Fuzzy-trace theory is a psychological model of memory, cognitive development, reasoning, judgment, decision making, behaviour change, and health behaviour. As such, it explains more phenomena than related theories, which typically limit focus to one of these areas of inquiry. This feature makes FTT particularly useful in behavioural health research because it describes how individuals acquire, process, and use information, which is fundamental to developing effective interventions to change attitudes (e.g., risk perception, perceived benefit) and ultimately behaviour.

The ejection stereotype hypothesis, which is derived from FTT, represents a theoretical and practical leap forward in our current understanding of booster seat use. It enables researchers to distinguish between two separate causes of faulty judgments of the safety benefit afforded by booster seats: knowledge deficit, which is well known in the literature on booster seat use, and representational bias, which can lead even knowledgeable people to underestimate the benefit of booster seats. This distinction is important for public health practice because, without it, all misperceptions of the benefit of booster seats would be interpreted as knowledge deficit. As a result, prevention programs could inadvertently engage in unnecessary, costly, efforts to impart knowledge that people already have. The ejection stereotype implies that, in order to effectively educate the public about the safety benefits of booster seats, interventions should aim at correcting both the knowledge deficit and the ejection stereotype.

The ejection stereotype hypothesis can be studied and tested in many ways. For example, it is expected that even people who have relevant knowledge would still be prone to underestimating the safety benefit of booster seats. FTT predicts that experts who demonstrate relevant knowledge of child restraints may provide different estimates of the risk reduction afforded by booster seats, depending on how the question is formulated.
5 Testing the ejection stereotype hypothesis

5.1 Study rationale

In this section, I describe the psychological experiment I conducted to falsify the ejection stereotype, as stipulated by Popper\(^1\) and Elster.\(^6\) This falsification test examines two core tenets of the hypothesis: (1) that people have a representational bias (an incorrect gist) of injuries to child vehicle occupants as ejection related; and (2) that this representational bias, occurs despite knowledge. I chose to test these two postulates, because they differentiate my hypothesis from previous work: people can be fully aware of booster seat guidelines and associated injury risks and still believe they are unnecessary. Furthermore, given that these are core tenets of the ejection stereotype, their successful falsification would refute the entire hypothesis.
To falsify the ejection stereotype, I have designed a psychological experiment to test the prediction that, despite their knowledge, experts in child passenger safety would exhibit the ejection stereotype. That is, they would exhibit a representational bias that equates injuries to child vehicle occupants as ejection related. Venn diagrams in Figure 5.1 illustrate the rationale of this experiment. Rectangles include the list of potential injuries to child passengers in verbatim form.

![Venn Diagram](image)

**Figure 5.1.** Venn diagrams of the ejection stereotype hypothesis. Rectangles include the list of potential injuries to child passengers in verbatim form. Circles represent injuries included in a person’s gist representation. a) A person who does not know booster seats help prevent spinal and internal organ injuries. b) A person who learned the list of potential injuries in verbatim form but has the incorrect gist.

Circles represent injuries included in a person’s gist representation. Figure 5.1.A shows what a layperson would tend to believe: that serious injuries to children riding in cars are ejection related. This is the case of a person who believes booster seats have low safety benefit, as he or she does not know they help prevent spinal and internal organ injuries caused by ill-positioned adult seat belts. The text in gray indicates what the person should know but
does not. Figure 5.1.B shows a person who has verbatim knowledge that serious injuries to children riding in cars can be caused by both ejection and ill-positioned adult seat belts. The ejection stereotype implies that, despite verbatim knowledge, this individual would tend to use the incorrect gist representation (depicted in the blue circle) when making judgments and decisions about booster seats. Thus, if I ask this individual how much risk reduction booster seats afford, this person’s estimate of benefit Figure 5.1.B would be as low as the less knowledgeable person’s Figure 5.1.A. This occurs because questions of general risk, elicit gist representations. In contrast, if I ask this knowledgeable person how much booster seats reduce the risk of “spinal and internal organ injuries caused by seat belts, as well as injuries caused by ejection,” the person’s estimates would be higher. This occurs because questions of specific risk elicit verbatim representations. For a knowledgeable person, the verbatim representation comprises the complete list of injuries: both ejection and seat belt related. The ejection stereotype implies that, despite verbatim knowledge, this individual would tend to use the incorrect gist representation (depicted in the blue circle) when making judgments and decisions about booster seats.

The ejection stereotype also implies that a knowledgeable individual (Figure 5.1.B) would provide the same estimates of the reduction afforded by adult seat belts, irrespective of the wording of the question (general or specific). This occurs because the information outside the blue circle is irrelevant to estimate the risk reduction afforded by adult seat belts. Thus, the knowledgeable person’s answers to both the general and specific question are based only on the information contained in the blue circle.

In the present psychological experiment, I studied a sample of knowledgeable individuals: people working in child passenger safety (certified child seat technicians, injury
In other words, the present study focused on those individuals represented by Figure 5.1.B.

5.2 Study objectives and hypotheses

The objective of the study was to test three predictions derived from the ejection stereotype hypothesis: (1) when asked to estimate the risk reduction afforded by booster seats, experts will provide lower ratings when the question is worded in general form (gist eliciting), than when the question is worded in specific form (verbatim eliciting); (2) this effect will not be associated with their level of knowledge of child passenger safety; and (3) when asked to estimate the risk reduction afforded by booster seats, experts will provide the same ratings irrespective of whether the question was presented in general (gist eliciting) or specific form (verbatim eliciting).

Empirical examination of predictions 1 and 2 are falsification tests, because they specifically target two core tenets of the ejection stereotype: (1) that people have a representational bias (incorrect gist): (i.e., a tendency to view these injuries as ejection related); and (2) that this representation bias occurs despite knowledge. The ejection stereotype hypothesis would be supported if experts estimate the risk reduction afforded by booster seats to be lower when asked a general (gist eliciting) question compared with a specified (verbatim eliciting) question. If experts’ answers to these two types of questions are the same, then the ejection stereotype hypothesis would be refuted. Alternatively, if I find that experts indeed provide lower estimates when asked a general question compared with a specified question, but this difference is associated with the person’s knowledge of child passenger safety, then the knowledge independence tenet of the ejection stereotype hypothesis would be refuted. Consequently, there would be reasons to discontinue a research program on the ejection stereotype hypothesis. The empirical examination of prediction 3 is not a falsification test;
rather, it provides supporting evidence about the validity of the experiment. Knowledgeable individuals are predicted to give the same estimates of the injury risk reduction afforded by adult seat belts irrespective of the wording of the question (general of specific). Thus, if prediction 3 is not upheld, then there is a reasonable chance that something in the experiment went wrong. For example, that exposure to the first questions influenced responses to the subsequent questions.97,98

5.3 Methods

5.3.1 Participants

Participants were individuals working or volunteering in child passenger safety, on a part- or full-time basis. Participants were a convenience sample recruited via email using the BC Injury Research and Prevention Unit list serves and snowball sampling methods. Potential participants were sent an email inviting them to participate in the survey along with a link to an online survey and inviting them to share the link with their colleagues. Participants were included if they were fluent in English and lived in Canada. A total of 419 participants clicked link to the survey. Of those, 51 dropped after reading the consent letter, 60 were excluded because they did not work or volunteer in child passenger safety, and 51 partially completed the survey. The final analytical sample comprised 257 participants with complete data.

It is difficult to determine response rates, because an unknown number of participants shared the survey link by email and via Facebook (15 participants were referred to the survey by Facebook). Since I do not know the number of people who received a forwarded email or were exposed to a Facebook post with the survey link, it is not feasible to calculate an exact response rate. Table 5.1 summarizes the characteristics of the sample.
Table 5.1. Sample characteristics (n = 257)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>N (%) or Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex: Female</td>
<td>236 (91.8)</td>
</tr>
<tr>
<td>Age</td>
<td>38.3 (9.9)</td>
</tr>
<tr>
<td>Age range</td>
<td>21-67</td>
</tr>
<tr>
<td>Education level</td>
<td></td>
</tr>
<tr>
<td>Apprenticeship, trade, or high school</td>
<td>45 (17.6)</td>
</tr>
<tr>
<td>Bachelor</td>
<td>93 (36.3)</td>
</tr>
<tr>
<td>College, CEGEP or other non-university</td>
<td>78 (30.5)</td>
</tr>
<tr>
<td>Graduate</td>
<td>40 (15.6)</td>
</tr>
<tr>
<td>Level of Involvement in CPS</td>
<td></td>
</tr>
<tr>
<td>CPS work along with public health activities</td>
<td>54 (21.0)</td>
</tr>
<tr>
<td>CPS work along with unrelated activities</td>
<td>124 (48.2)</td>
</tr>
<tr>
<td>Work exclusively in CPS</td>
<td>79 (30.7)</td>
</tr>
<tr>
<td>Years of experience in CPS</td>
<td></td>
</tr>
<tr>
<td>5 years or less</td>
<td>162 (64.0)</td>
</tr>
<tr>
<td>6 to 10 years</td>
<td>59 (23.3)</td>
</tr>
<tr>
<td>More than 10 years</td>
<td>32 (12.6)</td>
</tr>
<tr>
<td>Type of involvement in CPS</td>
<td></td>
</tr>
<tr>
<td>Full time</td>
<td>79 (37.8)</td>
</tr>
<tr>
<td>Along with other public health activities</td>
<td>54 (21.0)</td>
</tr>
<tr>
<td>Along with unrelated activities</td>
<td>124 (48.2)</td>
</tr>
<tr>
<td>Certified Child Seat Technician: Yes</td>
<td>208 (81.6)</td>
</tr>
</tbody>
</table>

CPS = Child passenger safety

5.3.2 Design

The present study uses a design known in psychology as within-subjects, where participants act as their own controls. I chose this design because it enables me to demonstrate that the same individuals give different answers depending on whether a questionnaire item elicits gist or verbatim processes. Experts in child passenger safety were asked to estimate how much booster seats reduce the risk of injury (a general, gist eliciting question), followed by a general child passenger safety knowledge questionnaire. Next, they were asked to estimate how much booster seats reduce the risk of ejection related injuries, as well as spinal and internal organ injuries (a specified, verbatim eliciting question).

Admittedly, this design involves some threats to validity stemming from repeated observations: range effects (i.e., exposure to information during the experiment influences subsequent responses by lending contextual comparisons), learning and sensitization (e.g., gleaning key information from the baseline questions, which later influences responses to
follow-up questions), or demand effects (e.g., when participants surmise what researchers want in the first questions and changed subsequent answers as a result).\textsuperscript{97,98} However, these threats were controlled by placing the general (gist eliciting) questions first, before any item that could potentially elicit a verbatim response (e.g., unwittingly mentioning spinal and internal organ injuries caused by seat belts).

5.3.3 Measures

Outcome measures in this study were estimates of risk reduction afforded by \textbf{booster seats} and estimates of risk reduction afforded by \textbf{adult seat belts}. These were elicited from participants under two conditions: \textit{general (gist eliciting)} and \textit{specific (verbatim eliciting)}. Figure 5.2 shows the questionnaire items used to elicit estimates of risk reduction afforded by booster seats.

\begin{tabular}{|c|}
\hline
\textbf{Gist eliciting condition.} The girl in the picture meets the criteria for using a booster seat, and is riding on the back seat of a car. Compared to seat belts alone, the combination of seat belt and booster seats, used as shown in the picture, is $\text{[ ]}$\% effective in reducing the girl’s risk of injury. Please, indicate your personal estimate by moving the slider along the bar, which ranges from 0\% (not effective at all) to 100\% (completely effective):

\textbf{Verbatim eliciting condition:} While riding in a car, children need to be protected from injuries to the head, neck, spine, abdomen and internal organs, as well as other injuries resulting from ejection. The girl in the picture meets the criteria for using a booster seat, and is riding on the back seat of a car. Compared to seat belts alone, the combination of seat belt and booster seats, used as shown in the picture, is $\text{[ ]}$\% effective in reducing the girl’s risk of injury to the head, neck, spine, abdomen, internal organs, as well as injuries resulting from ejection. Please, indicate your personal estimate by moving the slider along the bar, which ranges from 0\% (not effective at all) to 100\% (completely effective).
\hline
\end{tabular}

Figure 5.2 Gist eliciting and verbatim eliciting questions for booster seats.\textsuperscript{vi}

\textsuperscript{vi} Used with permission. Original illustrations: Centre for Injury Research and Prevention, The Children’s Hospital of Philadelphia\textsuperscript{®} Changes made to original images: green colour added to all images and shoulder belt in figure d) was moved away from the neck. Use and changes with permission. Adapted by: Bronwen Barnett, BC Injury Research and Prevention Unit.
Figure 5.3 shows the questionnaire items used to elicit estimates of risk reduction afforded by adult seat belts.

**Gist eliciting condition.** The girl in the picture meets the criteria for using a booster seat, and is riding on the back seat of a car. When used as shown in the picture, the seat belt is [    ]% effective in reducing the girl’s risk of injury.

Please, indicate your personal estimate by moving the slider along the bar, which ranges from 0% (not effective at all) to 100% (completely effective):

**Verbatim eliciting condition:** While riding in a car, children need to be protected from injuries to the head, neck, spine, abdomen and internal organs, as well as other injuries resulting from ejection. The girl in the picture meets the criteria for using a booster seat, and is riding on the back seat of a car. When used as shown in the picture, the seat belt is [    ]% effective in reducing the girl’s risk of injury to the head, neck, spine, abdomen, internal organs, as well as injuries resulting from ejection. Please, indicate your personal estimate by moving the slider along the bar, which ranges from 0% (not effective at all) to 100% (completely effective):

Figure 5.3 Gist eliciting and verbatim eliciting questions for seat belts. vii

Participants’ knowledge of child passenger safety was ascertained with a six-item questionnaire assessing correct transition to and from booster seats as well as purpose of booster seats. This scale reported good fit in Confirmatory Factor Analysis: Root Mean Square Error of Approximation (RMSEA) = 0.066, confidence interval (CI): 0.029 - 0.103; Comparative Fit Index (CFI) = 0.922; Standardized Root Mean Square Residual (SRMR) = 0.151. For more details, see Appendix 1. Knowledge scale for professionals. Participants were asked to report their level of involvement in child passenger safety (full time, part-time, volunteer), whether they were certified child seat technicians, and years of experience (see Appendix 2 for full questionnaire).

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vi Used with permission. Original illustrations: Centre for Injury Research and Prevention, The Children’s Hospital of Philadelphia® Changes made to original images: green colour added to all images and shoulder belt in figure d) was moved away from the neck. Use and changes with permission. Adapted by: Bronwen Barnett, BC Injury Research and Prevention Unit.
5.3.4 Procedure

Participants first read a cover letter informing them that completion and submission of the survey would imply consent. Next, participants were presented two gist eliciting questions: one about the risk reduction afforded by seat belts and one about booster seats. The order of these two questions was randomized. Following, participants answered questions about their attitudes and knowledge of booster seats. Finally, participants were asked again to rate two verbatim eliciting questions: one about the risk reduction afforded by seat belts and one about booster seats. The order of this last pair of questions was randomized. The study protocol was approved by the research ethics board of the University of British Columbia / Children’s and Women’s Health Centre of British Columbia Research Ethics Board, certificate number H14-01569.

5.3.5 Analysis

Responses to the general (gist eliciting) versus specific (verbatim eliciting) questions regarding booster seats were compared through Wilcoxon Sign and Rank tests. The same statistic was used to compare responses to the general (gist eliciting) versus specific (verbatim eliciting) questions regarding adult seat belts. A Sample of 257 participants provided a 0.95 power for a Wilcoxon Sign and Rank tests to detect a small effect size (Cohen’s $f = 0.15$), with a two-tailed significance level set at $\alpha = 0.05$. These estimates were calculated using G*Power (Universität Düsseldorf). To determine if knowledge was associated with the ejection stereotype, the difference between the verbatim eliciting and the gist eliciting questions about booster seats was first calculated. Then, the number of correct responses were summed to create a knowledge score. The correlation between the two was examined through Kendall’s tau correlation statistic, because the distribution of knowledge scores was severely skewed. A sample of 257 participants provided a 0.90 power to detect a significant correlation of 0.20, with
a two-tailed significance level set at $\alpha = 0.05$. This power estimation was based on published guidelines.99

5.4 Results

Table 5.4 summarizes descriptive statistics of the main variables of interest. Median and interquartile ranges are presented because frequency distributions were skewed. As expected, professionals obtained high scores in knowledge of child passenger safety. Indeed, 78.2% correctly answered all or all but one of the knowledge questions, and 80% correctly answered that the main purpose of booster seats is to redirect crash forces to the hips and chest (not shown in table). Participants’ estimates of the risk reduction afforded by booster seats was negatively skewed in both conditions (gist eliciting and verbatim eliciting). The converse was true for estimates of risk reduction afforded by seat belts.

Table 5.2 Descriptive statistics \((n = 257)\)

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Median (IQR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants’ knowledge score (From 1 to 6)</td>
<td>5.0 (5.0 - 6.0)</td>
</tr>
<tr>
<td>Participants’ estimates of risk reduction afforded by booster seats (0 to 100%)</td>
<td>90.0 (80.0 - 100.0)</td>
</tr>
<tr>
<td>Gist eliciting condition</td>
<td>93.0 (85.0 - 100.0)</td>
</tr>
<tr>
<td>Verbatim eliciting condition</td>
<td>6.00 (0.0 - 15.0)</td>
</tr>
</tbody>
</table>

To test if participants gave different estimates of risk reduction afforded by booster seats depending on whether the question was verbatim eliciting or gist eliciting, I compared the two. Figure 5.5 is a density plot depicting the distribution of participants’ estimates. The blue line represents the distribution of estimates under the general condition and the magenta line represents the distribution under the specified condition. Overall, participants gave higher
estimates in the verbatim eliciting question (magenta), compared with the gist eliciting question (blue). A Wilcoxon Sign and Rank test (two-tailed), indicates that this difference is statistically significant ($z = 2.45, p < 0.01$). The effect size is $\eta^2 = 0.03$; 73 participants (28%) gave higher estimates in the gist version of the question, 137 (53%) gave the same ratings in both version of the question, and 47 (18%) gave lower estimates in the gist version of the question.

Figure 5.4 Frequency of participants’ estimates of injury risk reduction afforded by booster seats

To examine if knowledge of child passenger safety was inversely associated with this effect, I examined a correlation between participants’ knowledge scores and the difference between the specified and general estimates of risk reduction afforded by booster seats. Kendall’s tau correlation coefficient indicated the association was not statistically significant: $r_t = -0.04, p = 0.48$. To examine if experience was inversely associated with this effect, I tested a correlation between the number of years respondents worked or volunteered in CPS and the
difference between the specified and general estimates. Kendall’s tau correlation coefficient indicated the association was not statistically significant: $r_t = 0.02, p = 0.71$ (two-tailed).

As a form of control for possible biases stemming from the repeated observations, I examined if participants gave different estimates of risk reduction afforded by seat belts depending on whether the question was verbatim eliciting or gist eliciting. Figure 5.6 is a density plot depicting the distribution of participants’ estimates of the risk reduction afforded by seat belts. The blue line represents the distribution of estimates under the general condition and the magenta line represents the distribution under the specified condition. Both distributions are almost identical, which indicates that, as predicted, participants’ estimates of risk reduction afforded by seat belts did not depend on the type of question (verbatim versus gist eliciting). This was confirmed by a to-tailed Wilcoxon Sign and Rank test ($z = 0.13 \ p = 0.45$).
5.5 Discussion

The present study tested the ejection stereotype hypothesis; the proposition that people tend to erroneously view injuries to child vehicle occupants as ejection related, irrespective of their verbatim knowledge of child passenger safety.\textsuperscript{100} Taken together, results support the ejection stereotype hypothesis, insofar as they are consistent with two out of the three predictions derived from it.

The first prediction derived from the ejection stereotype hypothesis is that participants would produce different estimates of risk reduction afforded by booster seats, depending on how those estimates were elicited. Specifically, these estimates would be higher when participants are reminded of potential spinal and internal organ injuries. Results are consistent with this prediction. The effect size was $\eta^2 = 0.03$, which is considered small in psychological research.\textsuperscript{101} This modest effect size, however, tells a bigger story when considered along with other results. As Cortina and Landis point out\textsuperscript{102} a small effect should be considered important if three conditions are met: (1) it is found using inauspicious designs. The present study used a sample of experts; 78% of them correctly answered all five knowledge questions and 80% of them correctly answered that the main purpose of booster seats is to ensure the seat belt redirects crash forces to the hips and chest. In these circumstances, with such levels of expertise, the effect should have been zero. It was not. (2) The phenomenon is of great importance. Study participants are experts who conduct research and educate the public on booster seat. Thus, even if only 1% of experts were shown to have this representational bias, its multiplicative effect on the general population is larger. (3) The phenomenon challenges fundamental assumptions. The ejection stereotype challenges the expectation that experts should not have misconceptions of this kind. However, the ejection stereotype hypothesis predicts that this effect is independent of respondents’ knowledge of child passenger safety. This prediction was corroborated by study results.
As for threats to validity stemming from range, practice, sensitization, or demand effects, results indicate that these confounders were not present in the study. Recall that both booster seat questions are nearly identical to their corresponding seat belt questions. Had these effects occur as a result of the within-subjects design, they would have equally affected participants’ estimates of risk reduction for both booster seats and seat belts. More specifically: (1) if participants changed their estimates of risk reduction of booster seats merely because their first answer became a reference point for the second (range effects), then the same should have happened to risk reduction estimates of seat belts. (2) If participants changed their answers merely because the preceding questions in the survey helped them improve their estimates of risk reduction of booster seats (practice), then the same should have also occurred to risk reduction estimates regarding seat belts. (3) If participants estimated risk reduction of booster seats to be higher at follow up merely because they became more sensitive to differences in the wording of the question (sensitization), this should have also happened to risk reduction estimates of seat belts. Lastly, (4) If participants gave higher estimates at follow-up merely because the wording of survey questions made them believe the researcher was seeking that response (demand effects), then the same should have happened to estimate risk reduction estimates of seat belts.

The primary goal of this study was to falsify two tenets of the ejection stereotype: (1) that people gist processing has a representational bias, which equates injuries to child passengers as ejection related; and (2) that this representation bias occurs despite verbatim knowledge of child passenger safety. Accordingly, I used a sample of knowledgeable individuals: people working or volunteering in child passenger safety on a full- or part-time basis. Since it is not feasible to calculate a precise measure of participation rates, there is some uncertainty regarding generalizability of findings to the population of individuals working in child passenger safety.
The evidence presented here supports the ejection stereotype hypothesis and constitutes a leap forward in research on booster seat use. The distinction between gist and verbatim processing established by FTT as it relates to booster seat use had not been investigated prior to the present dissertation. Moreover, results from this study demonstrate that verbatim memorization of booster seat information is not enough to fully understand the safety benefit of booster seats. Gist learning, which forms the substance of the information is also necessary. Indeed, participants were all subject matter experts who demonstrated high levels of knowledge. Still, the present study found that 28% provided survey responses consistent with the ejection stereotype. Research on booster seat use to date has not made the distinction between verbatim and gist processes. Indeed, studies on the relationship between knowledge and use have either conflated these two distinct cognitive processes,\textsuperscript{39,60} or have focused only on verbatim learning (i.e., age, height, and weight to transition children to booster seats and to seat belts alone).\textsuperscript{35,36,38,67}

I should note that the present study and its results should not be taken as a denunciation or a measure of skill, dedication, or quality of the work conducted by participants in this study. Rather, it should be taken simply as evidence of how typical human beings retain and recall information.

In conclusion, this falsification test constitutes evidence in support of the ejection stereotype hypothesis. According to the Lakatos-Elster scientific paradigm, research advancing this hypothesis is worth pursuing further, since the test involved a counterintuitive prediction that proved correct. In the pages that follow, I describe how the ejection stereotype hypothesis led to the development of a novel approach to encourage booster seat use.
6 Development of an infographic to increase perceived benefit of booster seats

6.1 Rationale and objective

In the previous chapter, I used a falsification test to produce evidence to support the ejection stereotype hypothesis (a tendency to view injuries to vehicle occupants as ejection related) and how it is associated with a propensity to underestimate the risk reduction afforded by booster seats. The objective of this section is to describe how I used FTT and principles and methods of information design to develop an infographic to correct the ejection stereotype and improve people’s perception of the safety benefit of booster seats.

A fundamental principle of information design states that the message must be clearly defined. Many infographics fail to convey the desired information because the stories,
assertions, or conclusions are not clearly stated.\textsuperscript{103} This is where FTT is useful, because at its core, FTT trades with bottom-line messages that capture the essential meaning of information. In this present case, the communication piece should convey a prescriptive gist (i.e., what a knowledgeable person with experience would understand the gist is)\textsuperscript{84}: booster seats, when correctly used, ensure that crash forces are redirected to stronger parts of the body, the ribcage and pelvis.

\section{The design process}

Information design is the practice of structuring and arranging information in a way that enhances understanding.\textsuperscript{104} The process of information design is essentially the transformation of a complex message to suit the purpose, skills, experience, needs, and/or circumstances of the user. This is an iterative process of prototyping and testing, where results from one test become sources of inspiration for improvements in subsequent versions of the material.\textsuperscript{105}

I conducted prototype testing using an information design research method, known as \textit{diagnostic testing}.\textsuperscript{106} This is type of testing is conducted during the design process and its objective is to identify specific problems in a design\textsuperscript{106}; for example, whether the message was clearly communicated, of whether the intended audience used the material in an unexpected way. Diagnostics testing are conducted on members of the intended audience and involve a small group of users in each test; typically no more than five.\textsuperscript{106} Data for the present diagnostic testing was collected through focus groups and individual interviews.

It is important to note that the methodology of diagnostic testing in information design does not constitute qualitative research, as understood in the public health paradigm. Specifically, the use of focus groups or semi-structured interviews has a very specific objective
in this context: to identify design problems and inform subsequent design iterations. Thus, the chapter is formatted and organized for that purpose.

A total of three versions of the infographic were tested: Version 1, was tested in print in one focus group with fathers and mothers. Version 2 was evaluated in a focus group with mothers recruited in the same way. Since fathers proved difficult to recruit for focus groups, input from fathers was obtained through individual interviews that followed the same content of the focus groups. Version 3 of the infographic was embedded in an online survey on booster seats, and subsequently evaluated through individual cognitive interviews (participants are asked to go through the material and voice their reactions and thoughts) with mothers and fathers.

6.2.1 How parents were recruited

Eligible participants were parents of children 4 to 8 years old residing in the Greater Vancouver area, who spoke English, and drove with their children at least once a month. This cut-off point was chosen, because use of car seats is reported to be lower among families that drive their children less than once a week compared to more than once per week. Participants were recruited through snowball methods, Facebook and Twitter, as well as ads on the Brussoni Lab website (https://brussonilab.ca), local shops, community centres, and hospitals. These methods were approved by The University of British Columbia / BC Children’s and Women’s Hospital Research Ethics Board, certificate number H14-01569.

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viii This online survey was later used in a Randomized Control Trial to test the effectiveness of the infographic. See Chapter 7.
6.2.2 How the focus groups and interviews were conducted

After verifying eligibility, potential parents were sent an email invitation along with the consent form for them to review and sign. I began each focus group with an icebreaker, by asking parents to tell a funny anecdote about their children. If no one volunteered I told my own anecdote (this step was skipped in the individual interviews). Following, I asked parents to talk about their knowledge and beliefs about child passenger safety, seat belts, and booster seats. I also probed parents to obtain more details about their views on how seat belts and booster seats work, how they use booster seats, challenges and barriers to using them correctly, and potential misconceptions. Following, I showed them a print version of the infographic and asked parents their opinions on the wording, pictures, and design, as well their understanding, novelty, and usefulness of the bottom-line message of the material. If participants made comments pointing to specific parts of the graphic, I took notes on a copy of printed version of the infographic. If participants did not point to specific parts of the infographic, I would ask them to do it. Focus groups and interviews were digitally recorded. The focus group guide and the cognitive interview guides are included in appendices 3 and 4.

6.2.3 How information from diagnostic tests was analyzed

Given the visual nature of the material being evaluated, the primary data for diagnostic tests consisted of my notes of participants’ comments about the infographic. As suggested by Dyson\textsuperscript{106} and Stahl,\textsuperscript{108} the focus of this analysis was on issues that negatively affect clarity of the message. Audio recordings were reviewed to complement the notes, when needed. Analysis of these data followed the frameworks approach, where data are analyzed using pre-established categories, as well as emerging themes.\textsuperscript{108} Parents’ comments were categorized into two themes: comments about the concept (i.e., the bottom-line message) and comments about the execution (i.e., how well the infographic conveys the concept). These two themes are
not necessarily mutually exclusive, as some comments about the concept were more a consequence of execution issues.

6.3 Versions of the infographic and changes

6.3.1 Version 1

Version 1 of the infographic was a mock-up of a webpage displaying two basic illustrations next to two paragraphs explaining that: (a) seat belts redirect crash forces to the child’s ribcage and pelvis; (b) booster seats ensure children wear the seat belt correctly across the chest and hips; and (c) booster seats, used in combination with the seat belts, prevent injuries to head, neck, spine, abdomen, internal organs, as well as injuries resulting from ejection. The message of the infographic was: “booster seats protect children from injury by redirecting crash forces to stronger parts of the body: hips and chest.” See Figure 6.1.

Figure 6.1 Booster seat infographic Version 1
Diagnostic test of this infographic was conducted in a focus group with two fathers and two mothers. Concept comments included an initial positive reaction, where parents commented that the information was useful. One father disagreed with most participants in this respect and described the piece as having too much information, commenting: “just tell me what to do.” However, when explaining why he did not like the information, this father mentioned execution related comments. That is, he complained about the amount of text relative to the graphic and the language used to communicate the message (“the purpose of the seatbelt…”, “redirect crash forces”). In other words, this father primarily took issue with the execution, not the concept itself. In the conversation that ensued, other parents ended up agreeing with this father that they would like to see more instructions. Specifically, they said they would like to see a list of “do’s and don’ts;” not just an explanation of how booster seats work.

In terms of execution, Version 1 of the material was not well received. Overall, parents mentioned it contained too much text and that the text was not written in plain language (some parents took issue with the words “purpose” and “redirect”). The same father who criticized the content commented that he would not be motivated to read that much text.

6.3.2 Version 2

The next iteration of the infographic was informed by results from the first focus group. Given that the main design issue found in the first diagnostic test was the amount of text, I commissioned a visual artist to create the second version of the infographic. The artist received instructions to accurately represent sizes of children and adults relative to each other, and relative to the position of the lap and shoulder belts. The artist was also given a summary of Edward Tufte’s book *Visual Explanations*, as well as a copy of the book. Once the artist completed her work, I took images provided and arranged them into a *visual confection*; a set of visual elements that, when put together, represent causal explanations. See Figure 6.2. The
confection has an introduction on top and the rest was designed as a grid. Each column, was intended be read vertically (following the shaded arrow) and represented a causal story\textsuperscript{103}: “child was restrained in $x$ way, then the cars crashes, then the child’s body moves in $y$ way.” Labels in the middle described the injury mechanism. The top row of the grid, when read horizontally, juxtaposed different correct and incorrect ways to use restrain children, was well as the image of an adult using an adult seat belt for reference. The bottom row of the grid depicted what happens to the occupant in each of the different restraint conditions. The resulting visual confection juxtaposed five stories of what happens to an adult or a child across different restraint conditions. The stories were arranged horizontally to allow comparison. I also used green and magenta boxes to differentiate between correct and incorrect restraint conditions.

Figure 6.2 Booster seat infographic Version 2
In Version 2, I made sure to follow principles of visual explanations. I used multiple images depicting five different restraint conditions: (1) adult with a seat belt correctly placed; (2) child correctly restrained using a backless belt positioning booster seat; (3) child with adult seat belt only and shoulder belt across the neck; (4) child with adult seat belt only and shoulder belt under the arm; and (5) child with adult seat belt only and shoulder belt behind the back. I juxtaposed these images by arranging them horizontally (see Figure 6.3). Horizontal, broken lines were placed to elicit comparison. Key elements (the child and the lap belt) were repeated across images. The lap belts were horizontally aligned. This repetition of elements has the effect of enhancing the differences that I wanted to highlight; namely, the position of the lap and shoulder belts on the child’s body.

![Figure 6.3 Version 1.0, Top row of the grid](image)

I followed the same principle, in the bottom row of the grid, which juxtaposed multiple images of how bodies react in a collision in each of the five restraint conditions. See Figure 6.4. The repeated element was the seat.
Diagnostic tests of Version 2 of the infographic included a focus group with six mothers and individual interviews with five fathers. This time, concept comments revolved around two messages: how booster seats prevent injuries and correct versus incorrect ways to restrain children four to eight years old. Regarding the first message, parents indicated that this information was useful and important. Regarding the second concept, there was confusion among parents which was revealed by execution related comments: most parents thought the five images in the bottom row depicted a single story and, thus, were supposed to be read horizontally (see Figure 6.4). This created confusion about the actual message of the infographic and was the result of a common information design issue\textsuperscript{103}: the arrangement of images accidentally created unintended similarities and links between elements that were supposed to be independent. Indeed, the images at the bottom were more similar to one another compared with images on the top row: the depicted child was smaller, lines were thicker, and the seat belt was in a lighter shade of gray. In addition to this design issue, parents again complained about the amount of text, which was used to verbally describe how booster seats reduce injury risk. Parents also mentioned that the word "jackknifing" was confusing.

6.3.3 Version 3

For version 3, I redrew the artist’s illustrations in Adobe Illustrator and drew the back seat of the car, as well as the anchor points of the seat belt for reference. This time, the mechanism of injury and how booster seats prevent injuries were represented graphically and with less text. Accordingly, more principles of visual explanations were observed\textsuperscript{103}: I used text
to reinforce a concept that was graphically conveyed; I used line thickness to layer information and depict perspective; and I applied the principle of smallest effective difference to line thicknesses, colour palette, pointer lines, secondary elements, and background. In this way, I layered information to emphasize what should be notable: the seat belt applying force to spine, internal organs, and neck.

![Image: Three illustrations showing different techniques. (a) Multiple images; (b) ghost figure; (c) motion and impact lines.]

Figure 6.5. Two different illustration techniques. (a) multiple images; (b) ghost figure; (c) motion and impact lines.

The challenge for the final version was to devise a way to graphically describe the mechanics of internal organ and spinal injuries caused by the seat belt. I tried three illustration techniques: (1) multiple images, (2) ghost figures, and (3) motion and impact lines. I concluded that multiples and ghost figures fell short of conveying momentum and force, which are key to understand how seat belts cause injuries to children and how booster seats reduce injury risk. Hence, I opted for movement and impact lines, which more clearly depict how seat belt injuries occur. Figure 6.5 illustrates the difference between these three illustration techniques. The final infographic, version 3 (Appendix 5) was not further evaluated for concept and execution.
6.4 Discussion

In the present chapter, I report the development of an infographic to communicate how booster seats prevent injuries to children, by ensuring the seat belt redirects crash forces to stronger parts of the body: the ribcage and pelvis. I conducted an iterative process where different versions of the infographic were evaluated and improved. Importantly, principles of information design were observed: (e.g., repetition, juxtaposition, and minimal contrast). In addition, techniques from comic books were used to convey momentum and force (motion and impact lines). In terms of design and communication, the present infographic differs from previous, comparable interventions in three ways: (1) while videos provide a representation of crash forces acting on the entire body, the infographic shows how the lap and shoulder belt transfer kinetic energy to specific parts of the body. Videos may provide a realistic, complete view of what would happen in a crash, but in this case, a minimalist approach draws the audience attention to what is important. (2) Unlike videos, the infographic juxtaposes different restraint conditions allowing the audience to see how forces of the crash act on different parts of the body, depending on the restraint conditions: adult with a seat belt correctly placed; child correctly restrained using a booster seat; child with shoulder belt across the neck and lap belt on the belly; child with shoulder belt under the arm and lap belt on the belly; and child with shoulder belt behind the back and lap belt on the belly. (3) Previous interventions emphasize the safety benefits of booster seats by increasing perceived risk. In contrast, the infographic communicates safety benefits by showing how it diverts crash forces to stronger anatomical structures.

In this section, I described how information design theory and research methods were used to develop an infographic to educate parents on booster how booster seats work. The next step in the process is to examine whether the infographic is effective at changing parents’
perceived benefit of booster seats. The next section describes how the effectiveness of the infographic was tested in a randomized control trial.
7 Study 3: Proof-of-Concept Pilot Randomized Control Trial

In previous sections, I used FTT theory to deduce a causal explanation that accounts for low rates of booster seat use, despite high rates of utilization of child restraints for younger children. This causal explanation postulates that people have a tendency to view injuries to vehicle occupants as ejection related. I termed this proposition the ejection stereotype hypothesis. The ejection stereotype hypothesis was successfully tested in a falsification experiment with experts in child passenger safety (see Section 4). Using principles of information design and market research tools, I developed an infographic to defuse the ejection stereotype, increase perceived benefit of booster seats, and, ultimately, encourage parents to use them (see Chapter 6). In this section, I describe a proof-of-concept pilot Randomized Control Trial (RCT) to test if the infographic accomplishes this goal.
I characterized this study as a pilot proof-of-concept RCT, for three reasons: (1) In pharmacological research, a pilot proof-of-concept study is carried out to determine if a treatment is biologically active or inactive (i.e., has effects on living matter). Analogously, the goal of the present study is to determine whether the infographic is “psychologically” active; that is, if it has effects on psychological constructs such as parents’ knowledge or opinions about booster seats. (2) Proof-of-concept studies typically use intermediate measures (e.g., concentration of a biochemical compound) as opposed to end measures such as cure or death. Similarly, the present study does not evaluate actual behaviour (e.g., booster seat use) and instead uses surrogate measures such as perceived benefit of booster seats. (3) Proof-of-concept studies are pilot RCTs conducted to determine whether or not to continue the development of an intervention. In the present study, results will inform whether a more extensive, full-scale trial (e.g., involving direct observation of booster seat use at intersections or parking lots) is justified. To make this determination, I will examine if the infographic increases benefit of booster seats over and above the effects of current education material. In this sense, this is a superiority trial.

7.1 Study goal

The overall goal of the present proof-of-concept pilot RCT is to inform a decision as to whether to continue or discontinue the development of booster seat use interventions based on the ejection stereotype hypothesis.

7.2 Primary objective

- To determine whether the infographic improves parents’ perceived benefit of booster seats.

7.3 Secondary objectives

To determine if the infographic improves parents’
- Intention to use booster seats.
- Subjective estimate of the impact of the intervention on other parents’ intention to use booster seat seats.
- Recall of booster seat information.
- Interest in the booster seat information.

7.4 Methods

7.4.1 Trial design

I used a concurrent two-group parallel randomized controlled design, with allocation ratio of 1:1. A control group is necessary to minimize threats to validity stemming from repeating observations on the same participants. Specifically, learning, sensitization (e.g., gleaning key information from the baseline questions, which later influences responses to follow-up questions) or demand effects (e.g., participants surmise what researchers want in the first questions and answer subsequent questions accordingly).\textsuperscript{97,98} See Figure 7.1 for trial schema.

7.4.2 Participants

Eligible participants were parents of children 4 to 8 years old residing in any Canadian province, who spoke English and drove with their child at least once a month. This cut-off point was chosen, because use of car seats is reported to be lower among families that drive their children less than once a week compared to more than once per week.\textsuperscript{114} Participants were excluded if their child had a physical condition that required special transportation. Parents were invited to participate, irrespective of whether they used booster seats always, occasionally, or never.
Screening & Consent
- Consented to answer questionnaire?
- Parents of a child 4 to 8 years old, residing in Canada, who drive with their child at least once a month?

Assessment
BSASabb subscales
- Perceived benefit
- Benefit gist
- Intent to use
- Intent to learn

Control Arm
n = 367
Transport Canada booster seat information online: When it is safe for children to use booster seats and when it is safe to transition them to adult seatbelts; how to install them and how to correctly use them.

Intervention Arm
n = 364
Infographic + Transport Canada booster seat information: How booster seats prevent injuries; why they are important; when it is safe for children to use booster seats and when it is safe to transition them to adult seatbelts; how to install them and how to correctly use them.

Follow up assessment
BSASabb subscales
- Perceived benefit
- Benefit gist
- Intent to use
- Intent to learn

Projected intent
- Projected intent to use
- Projected intent to learn

Knowledge of booster seats
- Gist knowledge
- Applied knowledge

Interest in the material
- Time spent reading the material

Figure 7.1 Trial schema
Data were collected using an online survey platform hosted by Qualtrics Inc. and administered from the BC Children’s Hospital Research Institute in Vancouver, Canada. Qualtrics is an online survey platform that conforms to Canadian standards of privacy of information. The study protocol was approved by The University of British Columbia / BC Children’s and Women’s Hospital Research Ethics Board (certificate number H14-01569).

Participants were recruited through a market research service, Maru Blue, which keeps a database of 130,000 individuals who have consented to receive invitations to online surveys. Individuals registered in the database were sent an email invitation, which included a link to my online survey. Interested participants would click a link, read a description of the study on the landing page, consent to participate, and answer eligibility questions. See Appendix 5 for printed version of the questionnaire. Respondents who met inclusion criteria would continue with the rest of the survey and respondents who did not meet inclusion criteria were redirected to a webpage that explained that they were not eligible and thank them for their interest in the study. Maru Blue uses a point system to incentivize responses. The number of points awarded for completing a given survey is determined based on the estimated length. Participants were awarded 100 points, which is equivalent to $1.

Quotas by sex and education level were set up to ensure representation of all socioeconomic levels. It was important to achieve a balanced sample in these two variables, because mothers are more likely to know more about car seat safety than fathers, and because socioeconomic status is associated with booster seat use.\textsuperscript{115} Table 7.1 shows the recruitment targets for mothers and fathers of each education level (based on Statistics Canada surveys). The online survey was initially set up in such a way that once a quota for a group was completed, the survey would not be available to that group. For example, once 38 fathers with a bachelor’s degree completed the survey, the platform would close access to the survey for this
particular group. As shown in Table 7.1, I initially aimed to recruit approximately equal numbers of participants with doctoral, college, or high school degrees. This proved to be difficult. Consequently, after trial commencement, I had to relax the quota system, so it would allow participants to access the survey even after the initial quota had been reached. For example, fathers with a bachelor’s degree were allowed to complete the survey, even after the 38-participant quota for that group had been met. By the time these changes were implemented, I already had 454 surveys completed, corresponding to 74% of the total target sample.

Table 7.1 Participant recruitment quotas by education level and sex, at trial commencement

<table>
<thead>
<tr>
<th>Education Level</th>
<th>Fathers</th>
<th>Mothers</th>
</tr>
</thead>
<tbody>
<tr>
<td>No certificate, diploma or degree</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td>High school certificate or equivalent</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td>Apprenticeship or trades certificate</td>
<td>39</td>
<td>39</td>
</tr>
<tr>
<td>College, CEGEP, non-university certificate or diploma</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td>University certificate</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td>Bachelor’s degree</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td>Master’s degree</td>
<td>37</td>
<td>37</td>
</tr>
<tr>
<td>Doctorate</td>
<td>37</td>
<td>37</td>
</tr>
<tr>
<td><strong>Sub totals</strong></td>
<td><strong>304</strong></td>
<td><strong>304</strong></td>
</tr>
</tbody>
</table>

7.4.3 Interventions

Participants in the intervention arm of the trial were shown two webpages: the first page was the infographic described in Chapter 6, which explains three key ideas: (1) seat belts redirect crash forces to the child’s thorax and pelvis; (2) booster seats ensure that children wear the seat belt correctly across the hips and chest; and (3) booster seats, used in combination with seat belts, prevent injuries to head, neck, spine, abdomen, internal organs, as well as injuries resulting from ejection. See Appendix 5 for a copy of the infographic. The infographic was based on principles of information design. Specifically, the main idea was represented graphically and was reinforced with labels and text. Scaled images facilitated comparison of the sizes of children versus adults; seat belt fit on children versus adults, seat belt fit on a child using a booster seat versus a child not using one. Additionally, motion and impact lines, typically
used in comic books to convey momentum and force, depicted where crash forces would be diverted in different restraint conditions: adult, a child on a booster seat, and a child with an adult seat belt across the neck, under the arm, or behind the back. See Chapter 6 for more details about the infographic. The second webpage was a replica of Transport Canada booster seat information available online at the time of the trial. The material was stripped of logos and references to the governmental agency, but Transport Canada was properly cited. This webpage describes, in plain language, the minimum weight to determine when a child should use a booster seat and described when it is safe for a child to use an adult seatbelt only. The material also provides instructions and pictures showing how to check the fit of the booster seat on the child and the vehicle, and how to buckle up the child. When explaining the rationale for the guidelines, fit, comfort, and protection from injuries are cited. This material, however, does not specify the types of injuries that could occur without a booster seat, nor does it describe how booster seats reduce injury risk (i.e., redirecting crash forces to the ribcage and pelvis). Full version of the original webpage is currently available at: http://www.tc.gc.ca/en/services/road/child-car-seat-safety/installingchild-car-seat-booster-seat/stage-3-booster-seats.html.

Participants in the control arm of the trial were shown only one webpage: the replica of Transport Canada booster seat education material. See Table 7.2

<table>
<thead>
<tr>
<th>Arm</th>
<th>Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control arm</td>
<td>Replica of Transport Canada booster seat webpage</td>
</tr>
<tr>
<td>Intervention arm</td>
<td>Infographic</td>
</tr>
<tr>
<td></td>
<td>Replica of Transport Canada booster seat webpage</td>
</tr>
</tbody>
</table>

Adherence to the intervention was enhanced by asking participants to carefully review the material and advising them beforehand that they would later be asked questions about the
content. Although participants were allowed to skip any page of the online survey, the “Next” button was placed at the bottom of each page to reduce the likelihood that respondents skipped the intervention material without reading it. Adherence to the intervention was assessed by tracking whether participants viewed the webpages containing infographic and/or the Transport Canada material.

7.4.4 **Primary outcome: Increase in perceived safety benefit of booster seats**

*Perceived safety benefit of booster seats* was assessed twice (immediately before and immediately after intervention), using the Benefit subscale of the abbreviated version of the Booster Seat Attitudes Scale (BSASabb), henceforth called BSASabb. The BSASabb reported good fit in confirmatory factor analysis using baseline data from the present study: Root Mean Square Error of Approximation (RMSEA) = 0.052, 90% confidence interval (CI): 0.037 - 0.067; Comparative Fit Index (CFI) = 0.981; Standardized Root Mean Square Residual (SRMR) = 0.035. Questionnaire items and more details of Confirmatory Factor Analysis (CFA) are described in Appendix 7.

Participants were administered the BSASabb through the online survey platform, without the participation of outcome assessors or researchers. The benefit subscale of the BSASabb has two factors, which I named: *Perceived Benefit* (i.e., understanding that booster seats prevent injuries) and *Key Benefit* (i.e., understanding that booster seats prevent life threatening injuries to the spine and abdomen).

7.4.5 **Secondary outcomes**

*Intention to use booster seat* was assessed twice (immediately before and immediately after intervention), using the Intent subscale of the BSASabb. Participants were administered the BSASabb through the online survey platform, without the participation of outcome assessors
or researchers. The Intent subscale of the BSASabb has two factors: Intent to Use and Intent to Learn (i.e., intention to attend a car seat clinic or workshop). Questionnaire items are described in Appendix 7.

Subjective estimate of the impact of the intervention on their peers was assessed once (immediately after intervention). This outcome was introduced as an alternative measure of intention to use, in case of ceiling effects resulting from social desirability. To this end, I developed the Projected Intent scale, which consists of five items asking participants to conjecture whether the intervention would encourage other parents to use booster seats or to attend a clinic or workshop. This is based on previous research indicating that individuals’ judgments of other people’s values and choices are infused with their own attitudes and preferences; a psychological phenomenon known as projection bias. In other words, one’s judgments about what others feel, think, or would do are projections of what one feels, thinks, or would do. Hence, the Projected Intent scale offers insight into participants’ intention to use without the pitfalls of social desirability. The Projected Intent scale questionnaire was administered by the online survey platform, without the participation of outcome assessors or researchers. The Projected Intent scale reported good fit in confirmatory factor analysis using baseline data from the present study: RMSEA = 0.077, 90% CI:0.046 - 0.110; CFI = 0.990; SRMR = 0.026. Appendix 8 lists questionnaire items and describes the psychometric properties of the Projected Intent scale.

Parents’ recall of booster seat information following the intervention was assessed once (immediately after). Information recall was evaluated with a booster seat knowledge questionnaire that I developed. This questionnaire evaluates gist-based knowledge in two forms: knowledge of the purpose and principle of operation of booster seats, Gist Knowledge, and ability to detect booster seat use errors by looking at a picture, Applied Gist. The
information recall questionnaire was administered by the online survey platform, without the participation of outcome assessors or researchers. The knowledge questionnaire reported good fit in confirmatory factor analysis using baseline data from the present study: RMSEA = 0.000, 90%, CI: 0.000 - 0.039; CFI = 1.000; SRMR = 0.025. Questionnaire items and more details of CFA are described in Appendix 9.

*Interest in booster seat information* was assessed in two ways. *Time spent reviewing the material* was assessed once (during intervention). The online survey platform was programmed to count the number of seconds respondents spent reviewing the Transport Canada Material, which is the component that was common to both the intervention and control arms. I also planned to assess *Interest in additional information* by placing hyperlinks to external websites (e.g., booster seat recalls, legislation by province, car seat clinics) and counting the number of clicks. However, after trial commencement, this measure was dropped as outcome measure, due to technical difficulties.

Table 7.3 describes all study measures used, how they were assessed, and when they were assessed in the relation to the experiment.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Instrument</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived benefit</td>
<td>BSASabb</td>
<td>Before and after intervention</td>
</tr>
<tr>
<td>Intention to use</td>
<td>BSASabb</td>
<td>Before and after intervention</td>
</tr>
<tr>
<td>Estimate of the impact of the intervention on other parents</td>
<td>Projected intent scale</td>
<td>After intervention</td>
</tr>
<tr>
<td>Recall of booster seat information</td>
<td><em>Gist Knowledge, Applied Gist scales</em></td>
<td>After intervention</td>
</tr>
<tr>
<td>Interest in booster seat information</td>
<td><em>Time spend reading the material Interest in additional information</em></td>
<td>After intervention</td>
</tr>
</tbody>
</table>

BSASabb = Abbreviated version of the Booster Seat Attitudes Scale
7.4.6 Pre-specified criteria to judge whether a future definitive trial is justified.

The present study is a proof-of-concept trial pilot trial. A future, larger scale intervention study will be justified if the infographic is found to be “psychologically” active. That is, if it is associated with at least the primary outcome perceived benefit of booster seats. The reason the primary outcome is given so much importance in this study is that the intervention is expected to primarily influence parents’ appreciation of the injury risk reduction afforded by booster seats. If the intervention is found to have effects on secondary outcomes (e.g., increased intent to use, better knowledge recall) but not on perceived benefit, then a future, a large scale intervention would not be justified. Such a result would imply that the intervention did not act as intended. Instead, hypotheses should be generated and subsequently tested in future small, scale studies. If the intervention is not associated with any outcome, then further research would not be justified.

7.4.7 Sample size

I estimated that a sample of 606 participants would provide 90% power to detect a mean difference of 0.4 points in the Benefit subscale of the BSAS, at a significance level of 0.05 (two-tailed). This difference in benefit scores has been found to distinguish those parents who consistently restrain their child in booster seats from those who do not. Sample size was estimated with the TwoSampleMean function for trials that tests superiority of interventions (TrialSize package for R).117

7.4.8 Randomization and blinding

Participants were randomized with the randomization tool included in the survey platform, Qualtrics, which automatically generates and implements the allocation sequence, and assigns participants to interventions, without the need of human intervention. This has the advantage that participants and researchers are automatically blinded to the allocation and
allocation sequence. The platform was also programmed to produce a simple randomization sequence. No stratification was specified. The randomization tool incorporated in Qualtrics uses the Mersenne twister algorithm,\textsuperscript{118} which has passed most tests of statistical randomness, and is used in SPSS, Python, R, Stata, and many other statistical applications.\textsuperscript{118}

Participant allocation was also blinded in statistical analysis, by randomly assigning “Arm 1” and “Arm 2” labels, before analysis. This random assignment of labels was programmed and implemented in R by the data analyst during data cleaning.\textsuperscript{119}

7.4.9 Per-protocol analysis

Increase in perceived safety benefit of booster seats (primary outcome) and increase in intention to use booster seat (a secondary outcome) was evaluated by, first calculating the difference between the post-intervention score and the pre-intervention score for each participant. This difference was then compared with \( t \) tests (two-tailed).

Parents’ judgments of the impact of the intervention on their peers (a secondary outcome), which was assessed post-intervention only, was compared across study arms with the \( t \) tests (two-tailed). The same statistical analysis was used to evaluate the other secondary outcomes (parents’ recall of booster seat information, Interest in booster seat information).

No subgroup analyses or multiple comparisons were pre-specified in this proof-of-concept pilot RCT, as it was only powered to detect differences in perceived benefit between the two arms.
7.4.10 Intent-to-treat analysis

Intent to treat analysis was conducted by examining the sensitivity of the study to extreme values. Two additional statistical analyses were conducted for each outcome measure; one where missing values resulting from participant dropouts were imputed the highest possible score, and one where missing values were imputed the lowest possible scores.

7.5 Results

Figure 7.2 CONSORT 2010 Flow Diagram
7.5.1 Participant selection, exclusion, dropouts, and final sample

A total of 10,282 individuals received the email invitation to participate in the study. Of these, 2,921 clicked the link to the online survey, and 62 of these declined after reading the consent information. The total response rate (those who clicked the link AND consented / total invited) was 29%. Out of those who consented, 242 did not meet inclusion criteria, 72 did not answer eligibility questions, and 14 dropped out before randomization. 1,800 were excluded, because quotas for their sex or education level had already been filled. A total of 731 participants were randomized; 367 were allocated into the intervention arm and 364 were allocated in the control arm. A total of 11 participants were lost to follow up in the intervention arm, 4 were lost in the control arm. 716 participants were included in main analyses. Recruitment and follow up (which as conducted immediately after intervention) took place between the 10th and the 27th of December 2018.

Tables 7.4 and 7.5 describe demographic characteristics of the sample by study arm. No significant differences were found between the two groups.

Table 7.4 Demographic characteristics of the sample by study arm (part 1)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Intervention (n=367)</th>
<th>Control (n=364)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n (%)/M(SD)/Mdn [IQR]</td>
<td>n (%)/M(SD)/Mdn [IQR]</td>
</tr>
<tr>
<td>Sex= Female</td>
<td>199 (54.2)</td>
<td>191 (52.5)</td>
</tr>
<tr>
<td>Age</td>
<td>39.16 (7.10)</td>
<td>38.40 (6.98)</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No certificate, diploma or degree</td>
<td>18 (4.9)</td>
<td>14 (3.8)</td>
</tr>
<tr>
<td>High school certificate or equivalent</td>
<td>36 (9.8)</td>
<td>40 (11.0)</td>
</tr>
<tr>
<td>Apprenticeship or trades</td>
<td>52 (14.2)</td>
<td>55 (15.1)</td>
</tr>
<tr>
<td>University certificate or diploma</td>
<td>38 (10.4)</td>
<td>38 (10.4)</td>
</tr>
<tr>
<td>College, CEGEP or other</td>
<td>68 (18.5)</td>
<td>84 (23.1)</td>
</tr>
<tr>
<td>Bachelor's degree</td>
<td>89 (24.3)</td>
<td>62 (17.0)</td>
</tr>
<tr>
<td>Master's degree</td>
<td>54 (14.7)</td>
<td>59 (16.2)</td>
</tr>
<tr>
<td>PhD, MD, Dentist, or equivalent</td>
<td>12 (3.3)</td>
<td>12 (3.3)</td>
</tr>
</tbody>
</table>

M = Mean; SD = Standard deviation; Mdn = Median; IQR = Interquartile Range.
Table 7.5 Demographic characteristics of the sample by study arm (part 2)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Enhanced (n=367)</th>
<th>Standard (n=364)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n (%)/M(SD)/Mdn [IQR]</td>
<td>n (%)/M(SD)/Mdn [IQR]</td>
</tr>
<tr>
<td>Income</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$103,300 or more</td>
<td>127 (41.0)</td>
<td>114 (35.4)</td>
</tr>
<tr>
<td>$43,300-$63,299</td>
<td>43 (13.9)</td>
<td>44 (13.7)</td>
</tr>
<tr>
<td>$63,300-$83,299</td>
<td>39 (12.6)</td>
<td>50 (15.5)</td>
</tr>
<tr>
<td>$83,300-$103,299</td>
<td>56 (18.1)</td>
<td>71 (22.0)</td>
</tr>
<tr>
<td>Under $43,299</td>
<td>45 (14.5)</td>
<td>43 (13.4)</td>
</tr>
<tr>
<td>Employment status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A homemaker</td>
<td>49 (14.1)</td>
<td>51 (14.5)</td>
</tr>
<tr>
<td>Employed/self-employed</td>
<td>270 (77.8)</td>
<td>275 (78.1)</td>
</tr>
<tr>
<td>Not working</td>
<td>28 (8.1)</td>
<td>26 (7.4)</td>
</tr>
<tr>
<td>Born in Canada = Outside Canada</td>
<td>66 (18.9)</td>
<td>58 (16.3)</td>
</tr>
<tr>
<td>Language spoken at home = English</td>
<td>339 (93.1)</td>
<td>343 (93.5)</td>
</tr>
<tr>
<td>Marital status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married/Common-law</td>
<td>308 (89.5)</td>
<td>308 (87.3)</td>
</tr>
<tr>
<td>Separated/Divorced/Widowed</td>
<td>22 (6.4)</td>
<td>23 (6.5)</td>
</tr>
<tr>
<td>Single/Never married</td>
<td>14 (4.1)</td>
<td>22 (6.2)</td>
</tr>
<tr>
<td>Number of children</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 child</td>
<td>81 (22.1)</td>
<td>74 (20.3)</td>
</tr>
<tr>
<td>2 children</td>
<td>166 (45.2)</td>
<td>186 (51.1)</td>
</tr>
<tr>
<td>3 children</td>
<td>83 (22.6)</td>
<td>62 (17.0)</td>
</tr>
<tr>
<td>4 or more</td>
<td>37 (10.1)</td>
<td>42 (11.5)</td>
</tr>
<tr>
<td>Province (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alberta</td>
<td>58 (16.5)</td>
<td>64 (18.0)</td>
</tr>
<tr>
<td>Atlantic Canada</td>
<td>25 (7.1)</td>
<td>34 (9.6)</td>
</tr>
<tr>
<td>British Columbia</td>
<td>52 (14.8)</td>
<td>45 (12.6)</td>
</tr>
<tr>
<td>Manitoba and Nunavut</td>
<td>20 (5.7)</td>
<td>14 (3.9)</td>
</tr>
<tr>
<td>Ontario</td>
<td>161 (45.7)</td>
<td>168 (47.2)</td>
</tr>
<tr>
<td>Quebec</td>
<td>19 (5.4)</td>
<td>15 (4.2)</td>
</tr>
<tr>
<td>Saskatchewan</td>
<td>17 (4.8)</td>
<td>16 (4.5)</td>
</tr>
</tbody>
</table>

M = Mean; SD = Standard deviation; Mdn = Median; IQR = Interquartile Range.
Table 7.6 describes the outcome variables measured at baseline by study arm. No differences between the two groups were found at baseline.

Table 7.6 Outcome variables that were measured at baseline by study arm

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Intervention Arm (n=367) Mean (SD)</th>
<th>Control Arm (n=364) Mean (SD)</th>
<th>Difference (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived Benefit</td>
<td>4.31 (0.70)</td>
<td>4.31 (0.70)</td>
<td>0.01 (-0.10-0.10)</td>
</tr>
<tr>
<td>Key Benefit</td>
<td>4.45 (0.64)</td>
<td>4.45 (0.68)</td>
<td>-0.00 (-0.10-0.10)</td>
</tr>
<tr>
<td>Intent to Use</td>
<td>4.69 (0.52)</td>
<td>4.73 (0.50)</td>
<td>-0.04 (0.03-0.12)</td>
</tr>
<tr>
<td>Intent to Learn</td>
<td>3.65 (1.02)</td>
<td>3.63 (1.09)</td>
<td>0.02 (0.17-0.13)</td>
</tr>
</tbody>
</table>

M = Mean; SD = Standard deviation; CI = Confidence Interval

7.5.2 Adherence to treatment

Participants in the control arm were assigned to review one webpage: a replica of the Transport Canada information on booster seats. All participants in this arm completed their assigned treatment: they viewed the one page assigned to them and spent, on average, 161 seconds on it. Participants in the intervention arm were assigned to review two webpages: the infographic explaining how booster seats work and the replica of Transport Canada information on booster seats. Seven participants in the intervention arm did not complete their assigned intervention and dropped out of the study immediately after. Participants in the intervention arm who completed their assigned intervention spent, on average, 58 seconds reviewing the infographic, and 128 seconds reviewing the Transport Canada replica.

7.5.3 Per-protocol analysis

The primary outcome, increase in perceived safety benefit from baseline to follow up is presented in Table 7.7. As expected, Perceived Benefit and Key Benefit, the two factors comprising the Intent subscale of the BSASabb, reported larger increases in the intervention arm compared with the control arm. This was confirmed by independent samples t-tests.
Table 7.7 Changes in Perceived benefit and Intent following intervention by study arm

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Intervention Arm Mean (SD)</th>
<th>Control Arm Mean (SD)</th>
<th>Difference (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in Perceived Benefit(^a)</td>
<td>0.27 (0.53) n=357</td>
<td>0.15 (0.53) n=360</td>
<td>0.12 (0.04-0.20)</td>
</tr>
<tr>
<td>Increase in Key Benefit(^a)</td>
<td>0.29 (0.54) n=356</td>
<td>0.15 (0.50) n=360</td>
<td>0.15 (0.07-0.22)</td>
</tr>
<tr>
<td>Increase in Intent to Use(^a)</td>
<td>0.03 (0.38) n=360</td>
<td>0.01 (0.32) n=360</td>
<td>0.02 (-0.03 - 0.07)</td>
</tr>
<tr>
<td>Increase in Intent to Learn(^a)</td>
<td>0.15 (0.65) n=359</td>
<td>0.07 (0.61) n=360</td>
<td>0.08 (0.01-0.17)</td>
</tr>
</tbody>
</table>

M = Mean; SD = Standard deviation; CI= Confidence Interval; a. Post minus pre intervention measures.

*Increase in intent to use booster seats* from baseline to follow up in the intervention arm compared with the control arm is presented in Table 7.7. *Intent to Use* and *Intent to Learn*, the two factors comprising the Intent subscale of the BSASabb, reported no greater increase in the intervention arm compared with the control arm.

Table 7.8 describes secondary outcome measures that were assessed after intervention only. *Projected Intent to Use*, *Projected Intent to Learn*, as well as *Applied gist* and *Gist knowledge* scores were higher in the intervention arm than in the control arm. This is confirmed by *t* tests. Interest in booster seat information, as measured by *Time spend reviewing the Transport Canada webpage* was lower in the intervention arm compared with the control arm.

Table 7.8 Comparison of outcome measures by study arm

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Intervention Arm Mean (SD)</th>
<th>Control Arm Mean (SD)</th>
<th>Difference (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Projected Intent to Use(^a)</td>
<td>4.62 (0.53) n=360</td>
<td>4.49 (0.62) n=360</td>
<td>0.13 (0.05-0.22)</td>
</tr>
<tr>
<td>Projected Intent to Learn(^a)</td>
<td>3.95 (0.89) n=360</td>
<td>3.81 (0.91) n=360</td>
<td>0.14 (0.01-0.28)</td>
</tr>
<tr>
<td>Gist knowledge(^a)</td>
<td>1.29 (0.74) n=352</td>
<td>0.83 (0.7) n=360</td>
<td>0.45 (0.34-0.56)</td>
</tr>
<tr>
<td>Applied gist(^a)</td>
<td>2.70 (0.64) n=352</td>
<td>2.60 (0.68) n=359</td>
<td>0.10 (0.00-0.19)</td>
</tr>
<tr>
<td>Interest(^b)</td>
<td>128.00 (218.00) n=360</td>
<td>161.00 (190.00) n=360</td>
<td>32.56 (2.65-62.46)</td>
</tr>
</tbody>
</table>

M = Mean; SD = Standard deviation; CI= Confidence Interval; a. Measured only after intervention; b. Measured as time spent reviewing Transport Canada information.
7.5.4 Intent-to-treat analyses

Table 7.9 presents results from intent-to-treat analysis, where missing values at follow up were imputed the lowest possible value. Increase in *Perceived Benefit*, *Key Benefit*, *Projected Intent to use*, *Projected Intent to Learn*, and Interest in booster seat information (as measured by *Time spend reviewing the Transport Canada webpage*) were not sensitive to imputation of lowest values.

Table 7.9 Intent-to-treat analysis imputing lowest possible value to missing observations

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Intervention Arm Mean (SD)</th>
<th>Control Arm Mean (SD)</th>
<th>Difference (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in Perceived Benefit&lt;sup&gt;a&lt;/sup&gt; (-3.00 to 3.00)</td>
<td>0.22 (0.62)</td>
<td>0.11 (0.62)</td>
<td>0.10 (0.01-0.19)</td>
</tr>
<tr>
<td>Increase in Key Benefit&lt;sup&gt;a&lt;/sup&gt; (-3.00 to 2.00)</td>
<td>0.22 (0.69)</td>
<td>0.11 (0.58)</td>
<td>0.10 (0.01-0.19)</td>
</tr>
<tr>
<td>Increase in Intent to Use&lt;sup&gt;a&lt;/sup&gt; (-2.00 to 2.33)</td>
<td>-0.02 (0.52)</td>
<td>-0.02 (0.52)</td>
<td>0.01 (0.06-0.07)</td>
</tr>
<tr>
<td>Increase in Intent to Learn&lt;sup&gt;a&lt;/sup&gt; (-2.00 to 2.33)</td>
<td>0.12 (0.69)</td>
<td>0.05 (0.66)</td>
<td>0.08 (0.02-0.17)</td>
</tr>
<tr>
<td>Projected Intent to Use&lt;sup&gt;b&lt;/sup&gt; (2 to 5)</td>
<td>4.57 (0.63)</td>
<td>4.49 (0.62)</td>
<td>0.08 (0.01-0.17)</td>
</tr>
<tr>
<td>Projected Intent to Learn&lt;sup&gt;b&lt;/sup&gt; (2 to 5)</td>
<td>3.92 (0.92)</td>
<td>3.81 (0.91)</td>
<td>0.11 (0.02-0.24)</td>
</tr>
<tr>
<td>Gist knowledge&lt;sup&gt;a&lt;/sup&gt; (0 to 2)</td>
<td>1.23 (0.80)</td>
<td>0.82 (0.70)</td>
<td>0.41 (0.3-0.52)</td>
</tr>
<tr>
<td>Applied gist&lt;sup&gt;a&lt;/sup&gt; (0 to 3)</td>
<td>2.59 (0.82)</td>
<td>2.57 (0.74)</td>
<td>0.02 (-0.10-0.13)</td>
</tr>
<tr>
<td>Interest&lt;sup&gt;c&lt;/sup&gt; (1.90 to 2741.67)</td>
<td>126.00 (217.00)</td>
<td>160.00 (190.00)</td>
<td>34.53 (4.92-64.14)</td>
</tr>
</tbody>
</table>

M = Mean; SD = Standard deviation; CI= Confidence Interval; a. Post minus pre intervention measures; b. Measured only after intervention; c. Measured as time spent reviewing Transport Canada information.

Table 7.10 presents results from intent-to-treat analysis, where missing values at follow up were imputed the highest possible value. Increase in *Perceived Benefit*, *Key Benefit*, *Projected Intent to Use*, and *Projected Intent to Learn* were not sensitive to imputation of highest values. In contrast, Interest in booster seat information, as measured by *Time spend reviewing the Transport Canada webpage* was.
Table 7.10 Intent-to-treat analysis imputing highest possible value to missing observations

<table>
<thead>
<tr>
<th>Outcome (follow-up minus baseline)</th>
<th>Intervention Arm Mean (SD) n=367</th>
<th>Control Arm Mean (SD) n=364</th>
<th>Difference (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in Perceived Benefit&lt;sup&gt;a&lt;/sup&gt; (-2.00 to 3.00)</td>
<td>0.300 (0.563)</td>
<td>0.148 (0.530)</td>
<td>0.15 (0.07-0.23)</td>
</tr>
<tr>
<td>Increase in Key Benefit&lt;sup&gt;a&lt;/sup&gt; (-2.00 to 2.00)</td>
<td>0.31 (0.57)</td>
<td>0.15 (0.49)</td>
<td>0.16 (0.08-0.23)</td>
</tr>
<tr>
<td>Increase in Intent to Use&lt;sup&gt;a&lt;/sup&gt; (-2.50 to 2.33)</td>
<td>0.04 (0.38)</td>
<td>0.01 (0.31)</td>
<td>0.03 (0.02-0.08)</td>
</tr>
<tr>
<td>Increase in Intent to Learn&lt;sup&gt;a&lt;/sup&gt; (-2.50 to 2.33)</td>
<td>0.19 (0.70)</td>
<td>0.081 (0.62)</td>
<td>0.11 (0.01-0.20)</td>
</tr>
<tr>
<td>Projected Intent to Use&lt;sup&gt;b&lt;/sup&gt; (2 to 5)</td>
<td>4.63 (0.52)</td>
<td>4.49 (0.62)</td>
<td>0.14 (0.06-0.23)</td>
</tr>
<tr>
<td>Projected Intent to Learn&lt;sup&gt;b&lt;/sup&gt; (2 to 5)</td>
<td>3.97 (0.89)</td>
<td>3.81 (0.91)</td>
<td>0.16 (0.03-0.30)</td>
</tr>
<tr>
<td>Gist knowledge&lt;sup&gt;a&lt;/sup&gt; (0 to 2)</td>
<td>1.32 (0.7)</td>
<td>0.86 (0.72)</td>
<td>0.49 (0.35-2.56)</td>
</tr>
<tr>
<td>Applied gist&lt;sup&gt;a&lt;/sup&gt; (0 to 3)</td>
<td>2.71 (0.63)</td>
<td>2.61 (0.68)</td>
<td>0.10 (0.01-0.19)</td>
</tr>
<tr>
<td>Interest&lt;sup&gt;c&lt;/sup&gt; (1.90 to 2741.67)</td>
<td>178.00 (418.00)</td>
<td>168.00 (233.00)</td>
<td>10.20 (38.93-59.34)</td>
</tr>
</tbody>
</table>

SD = Standard deviation; CI= Confidence Interval; a. Post minus pre intervention measures; b. Measured only after intervention. C. Measured as time spent reviewing Transport Canada information.

7.5.5 Ancillary analysis

The projected Intent to use and projected intent to learn scales (i.e., parents’ subjective estimate of the impact of the intervention on their peers) were introduced as alternative measures of intent to use booster seats, in case of ceiling effects caused by social desirability. The rationale for this measure was based on the projection bias (i.e., people’s judgements about what others would do reflect, in part, what they would do). As predicted, Intent to Use was significantly correlated with Projected Intent to Use (Kendall’s tau =0.46, p < 0.000) and Intent to Learn was significantly correlated with Projected Intent to Learn (Kendall’s tau = 0.60, p < 0.000). In other words, Projected Intent to Use and Projected Intent to Learn scales can be used as measures of parents’ own intent to use and to learn about booster seats.

7.5.6 Harms

No harms were detected. However, the follow-up questionnaire included one item asking respondents to respond if the following statement was true or false: “It is safer for children not to
use seat belts at all.” This item was introduced, because of anecdotal report of a family who, for unknown reasons, came to believe that seat belts were unsafe for children and, thus, should not be used at all. A total of six parents answered this question incorrectly and six more indicated that they did not remember the correct answer. In both cases, the survey immediately and automatically displayed a warning reiterating the importance of seat belts and reminding participants that they are mandatory across Canada.

7.6 Discussion

The present study tested an intervention to increase parents’ perceived benefit of booster seats. The hypothesis underlying the intervention is that parents’ perceived safety benefits of booster seats and their intention to use them will increase if they understand that booster seats ensure seat belts redirect crash forces to stronger parts of the body. Accordingly, I predicted that an infographic that communicates this notion will increase parents’ perceived benefit. Additionally, I expected the intervention to increase intent to use, booster seats information recall, and interest in learning more about booster seats. To my knowledge, this is the first time such a hypothesis has been tested. Previous studies on educational interventions to promote booster seat use have not explored this idea. Rather, they have examined if booster seat use can be encouraged by: (1) listing the potential injuries resulting from lack of booster seat use,\textsuperscript{71} (2) emphasizing fit and comfort,\textsuperscript{74} (3) showing crash test footage of a child-size dummy restrained only in an adult seat belt,\textsuperscript{79,82} or injury statistics.\textsuperscript{80}

Results confirmed my prediction that the intervention would increase parents’ perceived benefit of booster seats, as measured by the BSAS\textsubscript{abb}. In the intervention arm, the mean \textit{Perceived Benefit} and the mean \textit{Key Benefit}, increased by 0.27 and 0.29 points, respectively. A survey study conducted by Cunningham et al. with sample of 1,714 parents found that a mean difference of 0.4 in the \textit{Perceived Benefit} subscale of the BSAS distinguishes parents who
consistently restrain their child in booster seats from those who do not. Using this result as a standard to interpret findings in the present study, I conclude that the effect found in the present study could be too small to produce an effect in parents’ behaviour. This could explain why I found a difference in *Perceived Benefit* and *Key Benefit*, but not in *Intent to Use* and *Intent to learn* Scores (perceived benefit is the strongest individual-level predictor of booster seat use). Nevertheless, the comparison of my results with those obtained by Cunningham et al. is limited by the fact that the BSAS (the original) and the BSASabb (used in the present study) are different. See Appendix 7 for more details about these differences.

There is an alternative explanation as to why the present study found differences in *Perceived Benefit* and *Key Benefit*, but not in *Intent to Use* and *Intent to learn*: ceiling effect. Indeed, baseline scores in both *Perceived Benefit, Key benefit, Intent to Use, and Intent to Learn* were very high at baseline, which did not allow for much improvement. This explanation is supported by a significant effect of the intervention on *Projected Intent scale* (respondents’ ratings of other parents’ intent to use booster seat). As predicted, parents’ own *Intent to Use* and *Intent to Learn* were correlated with their *Projected Intent to Use* and *Projected Intent to Learn*. This indicates that respondents’ views of other parents’ behavioural intentions represent, at least partially, their own intentions. Therefore, I conclude that the intervention had an effect on parents’ own behavioural intentions. Overall, results indicate that the intervention improved parents’ perceived benefit of booster seats and suggest that it increased their intent to use them.

I also found that participants in the intervention arm remembered and understood the information provided better than those in the control arm. Indeed, participants in the intervention arm had better *Gist knowledge* (understanding the bottom-line meaning of the information) and *Applied Gist knowledge* (applying booster seat guidelines to a particular situation) compared to
those in the control arm. Importantly, *Applied Gist*, as measured by my survey, refers to parents’ ability to identify specific restraint errors: lap belt on the belly and shoulder belt across the neck. This suggests that the intervention may be used to ameliorate the pervasive problem of incorrect use of booster seats.\(^{45-47,55,59,64,65,95,120}\) This finding also implies a potential novel solution to misuse of booster seats: if parents understand that booster seats help prevent injuries by redirecting crash forces to stronger anatomical structures, they may be less likely to restrain their child in a booster seat with the shoulder belt behind the back.

Participants in the intervention arm spent less time reading the Transport Canada information than their counterparts in the control arm. This was a pre-specified measure of participants’ interest in the material and, thus, could mean that the infographic made participants less interested in the Transport Canada information. However, results also indicate that respondents in the intervention arm had higher information recall scores. In other words, participants in the intervention arm learned significantly more content at a significantly faster pace. Hence, it is possible that the infographic made the Transport Canada information easier to understand and learn, which would explain shorter times. This explanation is consistent with FTT. Adults are more likely to pay attention to meaningful information and tend to make inferences that go beyond the literal expression of what they are reading, hearing, or experiencing.\(^{86}\). Therefore, by prefacing Transport Canada information with an infographic that conveys the bottom-line meaning, parents were given the tools to understand, for example, why it is wrong (and dangerous) for the child to have the lap belt on his or her belly. This is a key characteristic that distinguishes the present approach from previous booster seat education interventions.\(^{71,74,77,79,80,82,110,111,121-123}\)

Data on adherence to treatment suggest that the intervention may have negatively affected adherence to treatment. While seven participants in the intervention arm dropped out
after reading the infographic, all participants in the control arm completed their assigned
treatment. This may have occurred, because the treatment in the intervention arm was longer
than in the control arm. A future definitive trial should ensure that the length of the material (e.g.,
number of print pages or webpages) is the same for both the intervention and control arms.

The present Proof-of-Concept Pilot RCT has the following limitations: first, the
instrument used to measure perceived benefit (BSASabb) is a new version of BSAS. As a
result, the interpretation of the results based on studies that used the original BSAS may not be
adequate. Future studies using the BSASabb are needed to define cut off points that facilitate
interpretation; for example: “an increase of X points in the Key Benefit subscale differentiate
between parents who use booster seats some of the time and parents who use it all the time.”
Second, the presence of ceiling effects in Perceived Benefit, Key Benefit, Intent to Use, Intent to
Learn and Projected Intent suggest that most participants were already aware of the benefit of
booster seats and were likely to use them. Thus, future studies, should target participants
known to be less likely to restraint their children in booster seats (e.g., fathers, parents of
children 6 to 8 years of age). Third, randomization was implemented in a software that does
not enable full control of the process (e.g., specifying a blocked randomization). Efforts should
be made in a future definitive trial to use more standard methods of randomization.

In this Proof-of-Concept Pilot RCT key sources of bias were mitigated: selection bias
was mitigated by automating the randomization using the online survey platform. Neither the
investigator, nor participants had control over, or were aware of, the allocation sequence or
allocation process. Furthermore, the online survey was programmed to automatically accept or
reject participants, based on participants’ responses to screening questions. Consequently, the
decision to recruit a participant was not influenced by investigators knowledge of which
intervention a person would receive. Confounding was mitigated through random allocation of
participants. As shown in Tables 7.4 and 7.5, intervention and control arms were similar at baseline. Importantly, study arms were not different in term of characteristics associated with the main outcome measure, perceived benefit of booster seats: parent age, income, education, Canadian province of residence. Information of measurement bias was attenuated by using and validating a previously published scale the BSAS. Unfortunately, as previously discussed, factor analysis using baseline data from this study produced different factors, which adds uncertainty in the interpretation of the meaning of results. Furthermore, sample characteristics from the present study may limit generalizability of results. Non-respondents were predominantly women, individuals with middle and low education levels and families comprising two or more children. Although all education levels were represented, the final sample had sizable proportion of parents reporting high income levels. Methods used in this Proof-of-Concept Pilot RCT can be applied in a larger online RCT, after improving interpretability of questionnaire-based measures (BSASabb, projected intent to use, and recall of booster seat information). For example, a future study can examine whether the Applied Gist subscale of the information recall questionnaire is associated with actual improvement in parents correct use of booster seats. A different survey platform should be used to allocate participants to study arms, in order to ensure more control over the randomization method. Use of a participant recruitment service can also be applied in a future larger scale RCT. These services are fast and inexpensive and can give researchers access to very specific population groups, provided that inclusion criteria are well defined. Finally, internet-based surveys can be used in a number of studies, but perhaps are not suitable for a larger scale RCT on booster seat education. While the Internet is a suitable medium to distribute and evaluate people’s reactions to information, online surveys can only provide self-reported outcomes (e.g., behavioural intention) or, at best, behaviour online (e.g., Facebook shares, online purchases). These outcomes measures do not necessarily imply actual behaviour.
7.7 Is a future definitive trial justified?

In this proof-of-concept trial, the pre-specified criteria to determine if a larger, future trial is justified was: the infographic is found to increase perceived benefit of booster seats. Results indicate this was the case. Moreover, results are also promising regarding secondary outcomes such as increase knowledge and intention to use booster seats. Consequently, a future, definitive trial is justified.

7.8 Other information

The study protocol was registered prospectively in ClinicalTrials.gov, identifier: NCT03573830, and can be accessed in https://clinicaltrials.gov. The research protocol was approved by The University of British Columbia / BC Children’s and Women’s Hospital Research Ethics Board, certificate number H14-01569. This proof-of-concept pilot RCT was funded by the BC Children’s Hospital Research Institute, through the Evidence to Innovation Seed Grant and the University of British Columbia Public Scholars Program, and the AUTO21 Network of Centres of Excellence, Canada’s automotive research program.


8 General Discussion

This dissertation illustrates how the Popperian,\textsuperscript{1} Kuhnian,\textsuperscript{2} Lakatosian,\textsuperscript{4} and Elserian\textsuperscript{6,8} views of scientific progress, collectively named the \textit{Lakatos-Elster scientific paradigm}, can be applied to a public health problem: how to increase booster seat use. I began by summarizing the philosophical ideas that comprise the \textit{Lakatos-Elster scientific paradigm}. To the extent of my knowledge, this is the first time this scientific paradigm has been used in the context of child passenger safety, or even injury prevention. More specifically, this is use of the \textit{Lakatos-Elster scientific paradigm} to understand why research on booster seat effectiveness has experienced limited progress and what can be done to overcome the problem of inconclusive results, despite limitations in the quality of data. Studies on booster seat effectiveness have produced inconsistent results\textsuperscript{20,41,48–52} and a recent attempt at reconciling these findings through a systematic review of evidence was inconclusive. Although the systematic review conducted by Asbridge and collaborators,\textsuperscript{40} met standards of scientific rigour, their conclusions were limited by
the quality of available studies and, thus, they were forced to conclude their review with a call for more studies with better quality. Such a call is, to some extent futile, as Asbridge and collaborators recognized that the quality of studies is limited by the quality of available crash data.\textsuperscript{40} By conducting a review of the same evidence from the \textit{Lakatos-Elster scientist paradigm}, I showed that researchers can go beyond inconclusive results and even overcome some of data quality limitations, by refining and improving the theory that “booster seat reduce injury risk.” For example, the hypothesis that booster seats primarily reduce the risk of abdominal injuries, could be tested using data from published studies.\textsuperscript{20,41} Furthermore, this is the first time \textit{Lakatos-Elster scientific paradigm} was used to show limitations and knowledge gaps even when the body of research produced consistent results. Most notably, I showed how the public health paradigm has produced, in the span of 15 years, three studies with almost identical interventions, and similar rates of booster seat use at their end points: 26%, 36%, and 26%; a fact that indicates how little progress was achieved in those years.

This is also the first time FTT theory has been applied in child passenger safety. As I demonstrated in the literature review, the use of theory to understand or develop interventions to increase booster seat use is limited. Only three of eight studies on interventions to increase booster seats\textsuperscript{71,74,76,77,79,80,82} used a behaviour change theory to inform the intervention,\textsuperscript{74,79,81} specifically the PRECEDE-PROCEED model of behavioural interventions\textsuperscript{75} and the Precaution Adoption Process Model.\textsuperscript{124}

Before this dissertation, the distinction between verbatim and gist memories had not been considered in the study of booster seat use. Previous studies either focused only on verbatim knowledge (i.e., age, height, and weight to transition children to booster seats and off booster seats),\textsuperscript{35,36,38,67} or conflate the two.\textsuperscript{39,60,121--123,71,74,76,77,79,82,110,111} As the study reported in Chapter 5 indicated, this distinction was critical to understand how to increase perceived benefit
of booster seats; verbatim knowledge of booster seats was not sufficient to fully understand the perceived benefits of booster seats; gist knowledge, the substantive understanding of why booster seats are important was also necessary.

The Proof-of-Concept Pilot RCT tested an aspect of an intervention that had not been studied to date. Before the present dissertation, no other behavioural intervention study had attempted to increase parents' perceived benefit of booster seat by explaining that they redirect crash forces to stronger parts of the body. This is a key characteristic of the infographic, and logically derives from the ejection stereotype hypothesis and FTT. Furthermore it is a characteristic that distinguishes the infographic intervention from previous ones. Typically, interventions have emphasized the importance of booster seats in terms of fit and comfort, or the potential injuries that can occur if booster seats are not used (including those caused by ejection). In some cases parents were simply shown crash test footage without additional information to provide context.

The ejection stereotype hypothesis, which is derived from, and thus, supported by FTT, was also supported by empirical evidence. Indeed, a Popperian falsification test showed that a sample of experts exhibited the ejection stereotype, despite their high levels of knowledge. Admittedly, there are alternatives to the ejection stereotype also derived from FTT. An “underestimation of velocity gist” could account for low rates of booster seat use: parents could perceive that the typical speed they drive (e.g., 50 KPH) is too low to cause serious injuries in case of a crash. This is unlikely, as a recent study on booster seat use, which included rural and urban population, found that the maximum speed on commute was not associated with booster seat use. Another alternative explanation as to why parents do not use booster seats or use them incorrectly (e.g., with the shoulder belt behind the back), is child opposition: parents allow their child to use only the seatbelt or a booster seat with the shoulder belt behind the back, not
because they focus on ejection, but as a compromise between child opposition and the need for safety. In a study using conjoint analysis and a sample of 1,714 parents across Canada, researchers found that child opposition influences booster seat use.\textsuperscript{60} However, the same study found that perceived safety benefit is a more important reason for using a booster seat among parents. Since, it is conceivable that the ejection stereotype interacts with child opposition to result in a compromise, a future study should examine these competing explanations.

What place does the ejection stereotype occupy in the landscape of research on booster seat use and in preventive medicine more generally? To begin, the research presented here does not necessarily refute or replace previous findings on factors that influence booster seat use or how to encourage it. Legislation, social norms, multifaceted interventions, community-based programs, labels, threat appeals, all contribute to increase booster seat use. The ejection stereotype hypothesis stands out, because it offers a different account of how knowledge and perceived benefit of booster seats come to be, and it offers a strategy to communicate this information, so more parents understand their benefit, and use them correctly and more often. Importantly, the infographic or any other communication device to convey the main purpose of booster seats can be incorporated into any type of interventions (multifaceted, community-based, and mass-media).

With respect to preventive medicine in general, the research presented here adds to the body of knowledge on health behaviour. Indeed, the evidence for the ejection stereotype supports the postulate that people’s judgments are influenced by representational biases that occur despite knowledge. When put together, research on representational biases related to condoms and booster seats form a new more general idea: \textit{health stereotypes}. The notion that individuals’ choices regarding health and safety can be biased by incorrect generalizations and misconceptions about health conditions or the means to prevent them. For example, the
concept of health stereotypes could be applied concussions. Concussions occur as a result of low-velocity forces that can cause the brain to “shake” inside the cranium. If individuals were found to have a tendency believe that concussions are only caused by direct blows to the head, then they could overestimate the safety afforded by helmets. Indeed, concussion may be caused by direct blows to the neck or elsewhere on the body.

All in all, the present dissertation demonstrates that theory has further utility in preventive medicine beyond informing an intervention. Theory, specifically a theory within a progressive research program, can drive the development of novel hypotheses and approaches to interventions. As I have demonstrated in the preceding pages, theory is useful to drive progress in preventive medicine by supporting new causal explanations that are falsifiable, that imply counterintuitive predictions, and lead to development of novel approaches to solve health behaviour problems. Ultimately, this dissertation exemplifies Kurt Lewin’s view that there is nothing more practical than a good theory.
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Appendices

Appendix 1. Knowledge scale for professionals

Knowledge questionnaire for professionals was validated in a sample of 312 individuals who work or volunteer in activities related to child passenger safety. A Confirmatory Factor Analysis (CFA) was using the lavaan package version 0.6-2\textsuperscript{126} for R, version 3.4.4\textsuperscript{119} and RStudio version 1.1.423.\textsuperscript{127} Six models were specified and tested based primarily the content of the items and informed by model residuals and covariance tables.

<table>
<thead>
<tr>
<th>Iteration</th>
<th>$\chi^2$</th>
<th>df</th>
<th>P</th>
<th>RMSEA (90% CI)</th>
<th>CFI</th>
<th>SRMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1</td>
<td>66.05</td>
<td>27</td>
<td>0.000</td>
<td>0.068 (0.048 - 0.089)</td>
<td>0.824</td>
<td>0.160</td>
</tr>
<tr>
<td>Model 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 3</td>
<td>36.024</td>
<td>14</td>
<td>0.002</td>
<td>0.071 (0.043-0.100)</td>
<td>0.867</td>
<td>0.167</td>
</tr>
<tr>
<td>Model 6</td>
<td>21.219</td>
<td>9</td>
<td>0.012</td>
<td>0.066 (0.029 -0.103)</td>
<td>0.922</td>
<td>0.151</td>
</tr>
</tbody>
</table>

$\chi^2$ = Chi square; df = degrees of freedom; p = p value of the Chi square test; CFI=Comparative Fit Index; RMSEA= Root Mean Square Error of Approximation; CI = 90% confidence interval; SRMR=Standardized Root Mean Square Residual.

Model 6 statistics indicate good fit.\textsuperscript{128} In principle the $\chi^2$ Chi Square test of goodness of fit should be non-significant. However, this result is typically ignored, because it is sensitive to sample size. Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean Square Residual (SRMR), are within acceptable values.\textsuperscript{128}

The scale had one dimension, and included six items:

Please, indicate if each of following recommendations for child passenger safety is correct or incorrect:

- Knowledge 1: As they grow, children are to be secured in one of four different types of restraints: rear-facing seats, forward-facing seats, booster seats and seat belts.
• Knowledge 3: Parents should restrain their children in rear-facing safety seats as long as the child is within the height and weight limits of the seat.

• Knowledge 4: Booster seats are specifically designed for children three years old or younger.

• Knowledge 5: Children should start using seat belts as soon as they turn eight years old.

Knowledge 6: How do seat belts work? Choose the best answer. Seat belts prevent injuries to vehicle occupants, by:

○ Absorbing the forces of a crash.
○ Encouraging healthy back posture during a crash.
○ Redirecting crash forces towards the hips and chest.
○ Preventing ejection.
○ I don't know

Knowledge 14: How do booster seats work? Please choose the best answer. Booster seats prevent injuries to child passengers, by:

○ Cushioning the child during a crash.
○ Encouraging a child’s healthy back posture during the crash.
○ Ensuring the seat belt redirects crash forces towards the hips and chest.
○ Preventing ejection better than seat belts.
○ I don't know
Appendix 2. Ejection stereotype questionnaire for professionals

(Question 1.)

The girl in the picture meets the criteria for using a booster seat, and is riding on the back seat of a car. When used as shown in the picture, the seat belt is _______% effective in reducing the girl's risk of injury.

Please, indicate your personal estimate by moving the slider along the bar, which ranges from 0% (not effective at all) to 100% (completely effective):

0% - Not effective at all---------------------------------100%-Completely effective

(Question 2.)

The girl in the picture meets the criteria for using a booster seat, and is riding on the back seat of a car. Compared to seat belts alone, the combination of seat belt and booster seats, used as shown in the picture, is _______% effective, in reducing the girl's risk of injury.

Please, indicate your personal estimate by moving the slider along the bar, which ranges from 0% (not effective at all) to 100% (completely effective):

0% - Not effective at all---------------------------------100%-Completely effective

(Question 3.)

Please, indicate if each of following recommendations for child passenger safety is correct or incorrect:

- As they grow, children are to be secured in one of four different types of restraints: rear-facing seats, forward-facing seats, booster seats, and seat belts.
- Parents should restrain their children in rear-facing safety seats as long as the child is within the height and weight limits of the seat.

ix Images used with permission. Original illustrations: Centre for Injury Research and Prevention, The Children’s Hospital of Philadelphia® Changes made to original images: green colour added to all images and shoulder belt in figure d) was moved away from the neck. Use and changes with permission. Adapted by: Bronwen Barnett, BC Injury Research and Prevention Unit.
Parents should start restraining their children in forward-facing seats when they are one year old.

- Booster seats are specifically designed for children three years old or younger.
- Children should start using seat belts as soon as they turn eight years old.

**Question 4.**
The children depicted in the 5 pictures below meet the criteria for using booster seats. Assume the car type, make and model, weather conditions, child’s weight and height are the same. In case of a frontal crash at 50kph, how protected is the child in each of the five scenarios depicted in the pictures?

- Optimally protected
- Fairly protected
- Unsafe
- I don’t know

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(Question 5.)

The children depicted in the 5 pictures below meet the criteria for using booster seats. Assume the car type, make and model, weather conditions, child’s weight and height are the same.

*Please rank the 5 children from most protected to least protected in case of a frontal crash at 50kph.*

(Question 6.)

How do seat belts work? Choose the best answer. Seat belts prevent injuries to vehicle occupants, by:

- Absorbing the forces of a crash.
- Encouraging healthy back posture during a crash.
- Redirecting crash forces towards the hips and chest.
- Preventing ejection.
- I don’t know

---

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(Question 7.)
Please select the terms that describe injury mechanisms associated with premature use of seat belt. You can select more than one answer.

- Jackknifing
- Submarining
- Ejecting
- Silencing
- Canning
- Spelling
- I don't know

(Question 8.)
How do booster seats work? Please choose the best answer. Booster seats prevent injuries to child passengers, by:

- Cushioning the child during a crash.
- Encouraging a child’s healthy back posture during the crash.
- Ensuring the seat belt redirects crash forces towards the hips and chest.
- Preventing ejection better than seat belts.
- I don't know

(Question 9.)
While riding in a car, children need to be protected from injuries to the head, neck, spine, abdomen and internal organs, as well as other injuries resulting from ejection. The girl in the picture meets the criteria for using a booster seat, and is riding on the back seat of a car. When used as shown in the picture, the seat belt is _____ % effective in reducing the girl’s risk of injury to the head, neck, spine, abdomen, internal organs, as well as injuries resulting from ejection. Please, indicate your personal estimate by moving the slider along the bar, which ranges from 0% (not effective at all) to 100% (completely effective):

0% - Not effective at all-----------------------------100%-Completely effective

---

xii Image used with permission. Original illustrations: Centre for Injury Research and Prevention, The Children’s Hospital of Philadelphia® Changes made to original images: green colour added to all images and shoulder belt in figure d) was moved away from the neck. Use and changes with permission. Adapted by: Bronwen Barnett, BC Injury Research and Prevention Unit.
While riding in a car, children need to be protected from injuries to the head, neck, spine, abdomen and internal organs, as well as other injuries resulting from ejection. The girl in the picture meets the criteria for using a booster seat, and is riding on the back seat of a car. Compared to seat belts alone, the combination of seat belt and booster seats, used as shown in the picture, is _____% effective, in reducing the girl's risk of injury to her head, neck, spine, abdomen, internal organs, as well as injuries resulting from ejection. Please, indicate your personal estimate by moving the slider along the bar, which ranges from 0% (not effective at all) to 100% (completely effective):

0% - Not effective at all------------------------------------------100%-Completely effective

Demographics
Month and year of birth
____/____/____ (YYYY/MM/DD)
Do you describe yourself as:
- Female
- Male
- Other:

Which of the following best describes your involvement in child passenger safety activities?
- I work or volunteer in child passenger safety promotion in addition to other UNRELATED public health responsibilities (e.g., disease prevention, Aboriginal Health).
- I work or volunteer in child passenger safety promotion in addition to other RELATED public health responsibilities (e.g., falls prevention, impaired driving).
- I work exclusively in child passenger safety.
- Other: ______________________

For how many years have you worked or volunteered in child passenger safety related activities?

Are you a Certified Child Seat Technician?
- Yes
- No

Where did you obtain your certificate?
- Justice Institute of British Columbia
- St. John Ambulance
- The Child Passenger Safety Association of Canada
- Other: ______________________

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In which year did you obtain your certificate?

What is your highest level of education completed?
- Doctorate or degree in medicine, dentistry, veterinary medicine or optometry
- Master's degree
- Bachelor's degree
- University certificate or diploma (e.g., accounting, banking, insurance, public administration)
- College, CEGEP or other non-university certificate or diploma
- Apprenticeship or trades certificate or diploma (e.g., Secondary School Vocational Diploma, Diplôme d'études professionnelles)
- High school certificate or equivalent
- No certificate, diploma or degree

Today's date
     _____/__/____ (YYYY/MM/DD)
Appendix 3. Focus group guide

INTERVIEWER: Thank everyone for coming to the focus group. Introduce yourself, tell people that we are interested in hearing everyone’s opinions, and remind them to respect others’ points of view.

Warm-up
1. Please, think of something funny your child or one of your children said or did that you wished you had recorded or captured in some way.
2. Introduce yourself using your nickname or pseudo name, and share the moment with us, if you want to. I will start: one day, my six-year-old nephew asked the name of a song I used to sing to him when he was a baby and I said: “I can’t think of it off the top my head.” And my nephew, replied “well, use the bottom of your head then!”

General
Now, I want to talk about a more specific subject: safety for kids riding inside cars.
1. How often do you think about it?
2. What recommendations have you heard or know of?
3. In your opinion, how often parents follow those recommendations?
   • Why do you think that is?
4. What about children between the ages of 4 and 8 approximately?
5. What is a booster seat?
6. What do you know about booster seats?
7. Researchers from University of Windsor found that, in Canada, a large proportion of parents don’t use booster seats even if the child needs one. Why do you think that is?

INTERVIEWER: explore beliefs around crashes and injuries to child passengers, and explore when they should be used.

Test of execution
INTERVIEWER: Hand out mock-ups of the online material and give participants time to read it. Clarify that this it is a mock up, that the final design will incorporate their feedback etc.
8. How would you describe this website page?
9. What ideas come to your mind when you read it
10. Did you find this webpage engaging?
11. Why do you think it is engaging or not engaging?
   INTERVIEWER: Explore wording, changes to the illustration.
12. What part did you find the most engaging?
13. What did you find least engaging?
14. Were there any key parts that left a big impact on you?
15. Is the content easy to understand?
16. How easy is it to understand the content of the webpage?
17. What would you change to make the material understandable?

Test of concept
18. What do you think the bottom-line message is?
19. How relevant is this message for you? Why?
INTERVIEWER: If participants do not mention it, explain: “The purpose of the seat belt is to redirect crash forces to stronger parts of the body: the hips and chest. If a child is not big enough, he or she will wear the seat belts in incorrect places, like across the belly or the neck. This is dangerous because it directs of crash forces to the neck, internal organs, and the spine. This is why booster seats are so important: purpose of booster seat is to raise the child and ensure that the seat belt is placed across the hips and chest and, thus, redirects crash forces to these body parts.”

20. Is this information useful?
21. Is this information different from what you have previously heard or read?
22. Does this impact your beliefs about your car safety for children riding in cars?
   • Why?
23. In what way does this information change your beliefs about seat belts?
24. In what way does this information change your beliefs about booster seats?
25. Do you think that information would motivate parents who do not use booster seat to start using them?
   • Why?
26. Does this information make you want to take action or change your behavior in any way?

Test of misunderstanding
27. Could each of you please express, in your own words, the information we have discussed and how it applies in your life?

INTERVIEWER: If any parent expressed views that are contrary to current guidelines, correct the information after everyone has spoken.

Wrap-up
INTERVIEWER:
Clarify that the material is in development and explain that the information provided is very general. If they need specific advice, they should visit BCAA and ICBC websites.
Appendix 4. Cognitive interview guide

Cognitive interview

INTERVIEWER:
1. Ask the participant to go through the online trial and speak out loud as he or she goes through the material and answers the questions.
2. Stop the participant and ask questions, every time the participant:
   a) Understand the question in an unintended way.
   b) Is confused about what he or she is supposed to do.
   c) Moves the mouse erratically.
   d) Expresses frustration and/or confusion.
   e) Was expecting something different.

Debriefing
1) What do you think about the format of this survey?
2) How easy was it to navigate through the survey?
3) What part was most engaging?
4) What part was least engaging?
5) Is the language understandable? If not, what could be improved?
6) Was the information provided as part of the survey useful?
7) Do you have any suggestions on modifying the appearance or the content?

Test of misunderstanding
8) Could you please express, in your own words, the information we have discussed and how it applies in your life?

INTERVIEWER: If the participant expresses views that are contrary to current guidelines, correct the information after everyone has spoken.

Wrap-up
INTERVIEWER: Clarify that the material is in development and explain that the information provided is very general. If they need specific advice, they should visit BCAA and ICBC websites.
Appendix 5. Proof of Concept RCT online questionnaire

(Inclusion criteria)
How many children do you have?

- [ ] None
- [ ] 1
- [ ] 2
- [ ] 3
- [ ] 4 or more

How many of your children are between 4 and 8 years of age?

- [ ] None
- [ ] 1
- [ ] 2
- [ ] 3 or more

How often do you drive with your child/children 4 to 8 years old?

- [ ] Every day
- [ ] At least once a week
- [ ] At least once a month
- [ ] Never

Do you have a child 4 to 8 years old who needs special transportation? (e.g., a ramp for a wheelchair).

- [ ] Yes
- [ ] No
Which of the following options best describes you?

- Father
- Mother
- Provide your own answer:
- Prefer not to answer

Which of the following best describes your education?

- No certificate, diploma or degree
- High school certificate or equivalent
- Apprenticeship or trades certificate or diploma (e.g., Secondary School Vocational Diploma, Diplôme d’études professionnelles)
- College, CEGEP or other non-university certificate or diploma
- University certificate or diploma (e.g., accounting, banking, insurance, public administration)
- Bachelor’s degree
- Master’s degree
- Doctorate or degree in medicine, dentistry, veterinary medicine or optometry
- Prefer not to answer

Unspecified
How protected from injuries is each child in the following pictures? xiv

xiv Images used with permission. Original illustrations: Centre for Injury Research and Prevention, The Children’s Hospital of Philadelphia® Changes made to original images: green colour added to all images
BSASP0_1: I would purchase a booster seat for my child.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

BSASP0_2: I would drop in at a car seat inspection clinic (local police station/fire department) to ensure the booster seat was installed correctly.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

BSASP0_3: I would attend a workshop to learn how to use a booster seat correctly.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

BSASP0_4: I would make sure my child always rides in a booster seat.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

and shoulder belt in figure d) was moved away from the neck. Use and changes with permission. Adapted by: Bronwen Barnett, BC Injury Research and Prevention Unit.
BSASP0_5: I would prevent my child from riding in any car without a booster seat.
- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

BSASP0_6: Booster seats prevent children from getting injured during normal driving
- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

BSASP0_7: When cars are in a crash, booster seats prevent life-threatening (head and spinal cord) injuries
- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

BSASP0_8: In the event of a crash, booster seats save lives.
- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree
BSASP0_9: I would feel more comfortable if my child was in a booster seat.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

BSASP0_10: When cars are in a crash, booster seats prevent children from injuring others in the car.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Following, you will see education material about booster seats. Please, read it carefully. We want to check if the material is easy to learn and understand. We will ask you questions about the content afterwards.

[INFOGRAPHIC]

The following information and pictures were taken from Transport Canada, and are being used exclusively for the purpose of this study, under fair use. Some minor changes were made: Transport Canada contact information (phone, email) was removed and hyperlinks were replaced with text

[TRANSPOR CANADA INFORMATION]

Otherparents_1: This information would encourage parents to purchase a booster seat for their child.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree
Otherparents_2: This information would encourage parents to drop in at a car seat inspection clinic (local police station/fire department) to ensure the booster seat was installed correctly.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Otherparents_3: This information would encourage parents to attend a workshop to learn how to use a booster seat correctly.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Otherparents_4: This information would encourage parents to make sure their child always rides in a booster seat.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Otherparents_5: This information would encourage parents to prevent their child from riding in any car without a booster seat.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree
BSAS_1_1: I would purchase a booster seat for my child.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

BSAS_1_2: I would drop in at a car seat inspection clinic (local police station/fire department) to ensure the booster seat was installed correctly.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

BSAS_1_3: I would attend a workshop to learn how to use a booster seat correctly.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

BSAS_1_4: I would make sure my child always rides in a booster seat.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree
BSAS_1_5: I would prevent my child from riding in any car without a booster seat.
- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

BSAS_1_6: Booster seats prevent children from getting injured during normal driving
- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

BSAS_1_7: When cars are in a crash, booster seats prevent life-threatening (head and spinal cord) injuries.
- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

BSAS_1_8: In the event of a crash, booster seats save lives.
- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree
BSAS_1_9: I would feel more comfortable if my child was in a booster seat.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

BSAS_1_10: When cars are in a crash, booster seats prevent children from injuring others in the car.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

unspecified1: How protected from injuries is each child in the following pictures? xv

Gist_1: Answer TRUE or FALSE.
The safest place in the car for children is always in the back seat.

- True
- False
- Don’t know or don’t recall

---

xv Images used with permission. Original illustrations: Centre for Injury Research and Prevention, The Children’s Hospital of Philadelphia® Changes made to original images: green colour added to all images and shoulder belt in figure d) was moved away from the neck. Use and changes with permission. Adapted by: Bronwen Barnett, BC Injury Research and Prevention Unit.
Adverse_intervention Answer TRUE or FALSE.

It is safer for children not to use seat belt at all.

- True (1)
- False
- Don’t know or don’t recall (3)

Display This Question:
- If Adverse_intervention = 1
- Or Adverse_intervention = 3

adverse_gist

Thank you for your answer.

Please, note that it is not safer for a child to ride in a car unrestrained. Seat belt use is mandatory across Canada, and booster seat is mandatory in most Canadian provinces and territories. For more information, visit: http://www.tc.gc.ca/en/services/road/child-car-seat-safety/installing-child-car-seat-booster-seat/stage-4-seat-belts.html

Gist_2: SEAT BELTS prevent injuries to people riding in cars, by:

- Absorbing crash forces
- Encouraging healthy back posture during a crash
- Diverting crash forces to the hips and chest
- Preventing people from being thrown out of the car
- Don’t know or don’t recall


Please, select all the mistakes YOU SEE in the picture:

- Child is not using a booster seat
- Child is sitting in the back seat of a car
- Child has the shoulder belt on the neck
- Child has the lap belt on the belly
- Child’s legs are bent at the edge of the seat
- The headrest is too high
- Don’t know or don’t recall
Gist 4: The **most important** purpose of the BOOSTER SEATS is to:

- Help the child look outside the window
- Divert crash forces to the hips and chest
- Prevent the child from being thrown out of the car
- Help the child sit more comfortably
- Don’t know or don’t recall

Gist 5 BOOSTER SEATS **mainly** protect the child's:

- Entire body
- Spine, neck, guts, spleen
- Hips, rib cage, and legs
- Brain
- Don’t know or don’t recall
manip1: In each picture, how protected is the child from being thrown out of the car? 

manip2: In each picture, how protected is the child from injuries to the stomach, guts, or spleen?

manip3: In each picture, how protected is the child from injuries to the head?

---

 Images used with permission. Original illustrations: Centre for Injury Research and Prevention, The Children’s Hospital of Philadelphia® Changes made to original images: green colour added to all images and shoulder belt in figure d) was moved away from the neck. Use and changes with permission. Adapted by: Bronwen Barnett, BC Injury Research and Prevention Unit.
In which province or territory do you live?

- Alberta
- British Columbia
- Manitoba
- New Brunswick
- Newfoundland and Labrador
- Northwest Territories
- Nova Scotia
- Nunavut
- Ontario
- Prince Edward Island
- Quebec
- Saskatchewan
- Yukon
- Prefer not to answer

What is your age?

- Type your age: ________________________________
- Prefer not to answer

Where were you born?

- Canada
- Outside Canada
- Prefer not to answer

How long have you been in Canada?

- I have been in Canada for: ________________________________
- Prefer not to answer
What language do you speak at home?

- We speak: ________________________________
- Prefer not to answer

Which of the following options best describes your relationship status?

- Single/Never-married
- Married/Common-law
- Separated/Divorced
- Widowed
- Prefer not to answer

How many of your children are:

- Less than 4 years old: ________________________________
- Between 4 and 5 years old: ________________________________
- Older than 5 years, younger than 7: ________________________________
- Between 7 and 8 years: ________________________________
- 9 years or older: ________________________________

Employment status at the moment: (Please check the most appropriate answer)

- Employed for wages / self-employed
- Unemployed
- A homemaker
- A student
- Retired
- Unable to work
- Other: ________________________________
- Prefer not to answer
Household income: (Please check the category that best describes your total household income before taxes)

○ Under $43,299
○ $43,300-$63,299
○ $63,300-$83,299
○ $83,300-$103,299
○ $103,300 or more
○ Prefer not to answer

Display This Question if participant was shown the infographic

You were randomly assigned to see all the information we are evaluating. There is no more information for you to review.

Thank you!

Display This Question if participant was not shown the infographic

If controls1: You were randomly assigned to review half of the information. Would you like to see the information other people saw?

○ Yes
○ No

Display This Question: If If controls1 = 4

If controls2
In this survey, you were randomly assigned to review one of two different information materials. In case you are curious, here is the information material you did not get to see.
This graphic was based on the research by: Kristy B. Arbogast and collaborators. (2007) The Journal of Trauma Justin J. Ernat and collaborators. (2013) Spine Journal

Display This Question: If If controls2 Is Displayed

If control_3

Answer TRUE or FALSE.
It is safer for children not to use seat belt at all.

- True (1)
- False (2)
- Don't know or don't recall (3)

If control_3 = 1

Thank you for your answer.

Please, note that it is not safer for a child to ride in a car unrestrained. Seat belt use is mandatory across Canada, and booster seat is mandatory in most Canadian provinces and territories. For more information, visit: http://www.tc.gc.ca/en/services/road/child-car-seat-safety/installing-child-car-seat-booster-seat/stage-4-seat-belts.html

End of Block: If controls

Start of Block: Additional information

Would you like to see additional information on booster seats?
The links will open in a new window or tab so you need to come back to complete this survey.

Summary of provincial and territorial laws
Product recalls
Who offers car seat clinics or installation check-ups
Original Transport Canada information about booster seats
Transport Canada Information about seat belts
Appendix 6. Final infographic version 1.2

4 Dangerous ways to put the seat belt on your child

1. Shoulder belt across neck
2. Lap belt on neck
3. Shoulder belt on back
4. Child can be thrown out of the car or hit other people inside

So what is the safe way? Use a booster seat

Use a booster seat
- Top of shoulder belt across chest
- Lap belt on lap
- Booster seat 45% safer

Booster seats are 45% Safer
- Lap belt on lap
- Shoulder belt across chest
- Booster seat in strong and can handle the force
Appendix 7. Validation of the Abbreviated Booster Seat Attitudes Scale (BSASabb)

An abbreviated version of the Booster Seat Attitudes Scale (BSAS),\textsuperscript{39} the BSASabb, was validated in a sample of 745 parents who completed the BSASabb at baseline. A Confirmatory Factor Analysis (CFA) was conducted in RStudio version 1.1.423 and R version 3.2.5, using the lavaan package version 0.6-2. The BSASabb includes only the Intent to Use and the Perceived Benefit subscales of the full version. The table below details items included in the BSASabb.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item number</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intent to use</td>
<td>BSASabb 1</td>
<td>I would purchase a booster seat for my child.</td>
</tr>
<tr>
<td></td>
<td>BSASabb 2</td>
<td>I would drop in at a car seat inspection clinic (local police station/fire department) to ensure the booster seat was installed correctly.</td>
</tr>
<tr>
<td></td>
<td>BSASabb 3</td>
<td>I would attend a workshop to learn how to use a booster seat correctly.</td>
</tr>
<tr>
<td></td>
<td>BSASabb 4</td>
<td>I would make sure my child always rides in a booster seat.</td>
</tr>
<tr>
<td></td>
<td>BSASabb 5</td>
<td>I would prevent my child from riding in any car without a booster seat.</td>
</tr>
<tr>
<td>Perceived benefit</td>
<td>BSASabb 6</td>
<td>Booster seats prevent children from getting injured during normal driving.</td>
</tr>
<tr>
<td></td>
<td>BSASabb 7</td>
<td>When cars are in a crash, booster seats prevent life-threatening (head and spinal cord) injuries.</td>
</tr>
<tr>
<td></td>
<td>BSASabb 8</td>
<td>In the event of a crash, booster seats save lives.</td>
</tr>
<tr>
<td></td>
<td>BSASabb 9</td>
<td>I would feel more comfortable if my child was in a booster seat.</td>
</tr>
<tr>
<td></td>
<td>BSASabb 10</td>
<td>When cars are in a crash, booster seats prevent children from injuring others in the car.</td>
</tr>
</tbody>
</table>

I first tested a two factor model, emulating the original BSAS.\textsuperscript{39} See table below. Model fit measures indicated poor fit. Three more models were specified based primarily theory or the content of the items and informed by model residuals and covariance tables. In Model 2, I split intent to use into two factors, Intent to Use and Intent to learn, because BSASabb2 (“I would drop in at a car seat inspection clinic…”) and BSASabb3 (“I would attend a workshop…”) are conceptually separated from the rest: they are more about learning and imply specific actions that require scheduling and commuting to a place. In Model 3, I put BSASabb7 (“booster seats prevent life-threatening (head and spinal cord) injuries”) in a separate factor, Key Benefit,
because this is precisely the key feature of booster seats that is neglected when people have
the ejection stereotype. In Model 4, I put BSASabb8 ("booster seats save lives") in the Key
Benefit factor, because these items refer to the lifesaving properties of booster seats. I also
removed BSASabb9 ("...feel more comfortable if my child was in a booster seat."), because this
item does not really describe a safety benefit for the child. Model 4 statistics indicate good fit.128
In principle the $X^2$ Chi Square test of goodness of fit should be non-significant. However, this
result is typically ignored, because it is sensitive to sample size. Comparative Fit Index (CFI),
Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean Square
Residual (SRMR), are within acceptable values.128

Validation of the Abbreviated Booster Seat Attitudes Scales (BSASabb) through
Confirmatory Factor Analysis

<table>
<thead>
<tr>
<th>Iteration</th>
<th>$X^2$</th>
<th>df</th>
<th>p</th>
<th>RMSEA (90% CI)</th>
<th>CFI</th>
<th>SRMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1</td>
<td>891.87</td>
<td>34</td>
<td>0.000</td>
<td>0.185 (0.174 - 0.195)</td>
<td>0.695</td>
<td>0.119</td>
</tr>
<tr>
<td>Model 2</td>
<td>439.80</td>
<td>32</td>
<td>0.000</td>
<td>0.131 (0.121 - 0.142)</td>
<td>0.855</td>
<td>0.088</td>
</tr>
<tr>
<td>Model 3</td>
<td>364.34</td>
<td>30</td>
<td>0.000</td>
<td>0.123 (0.112 - 0.134)</td>
<td>0.881</td>
<td>0.074</td>
</tr>
<tr>
<td>Model 4</td>
<td>62.89</td>
<td>21</td>
<td>0.000</td>
<td>0.052 (0.037 - 0.067)</td>
<td>0.981</td>
<td>0.035</td>
</tr>
</tbody>
</table>

$X^2$ = Chi square; df = degrees of freedom; p = p value of the Chi square test; CFI=Comparative Fit
Index; RMSEA= Root Mean Square Error of Approximation; CI = 90% confidence interval;
SRMR=Standardized Root Mean Square Residual.

The table below details the final version of the Abbreviated Booster Seat Attitudes Scale
(BSASabb).

### Abbreviated Booster Seat Attitudes Scale (BSASabb) – Validated version

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item number</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intent to Use</td>
<td>BSASabb 1</td>
<td>I would purchase a booster seat for my child.</td>
</tr>
<tr>
<td></td>
<td>BSASabb 4</td>
<td>I would make sure my child always rides in a booster seat.</td>
</tr>
<tr>
<td></td>
<td>BSASabb 5</td>
<td>I would prevent my child from riding in any car without a booster seat.</td>
</tr>
<tr>
<td>Intent to Learn</td>
<td>BSASabb 2</td>
<td>I would drop in at a car seat inspection clinic (local police station/fire department) to ensure the booster seat was installed correctly.</td>
</tr>
<tr>
<td></td>
<td>BSASabb 3</td>
<td>I would attend a workshop to learn how to use a booster seat correctly.</td>
</tr>
<tr>
<td>Perceived Benefit</td>
<td>BSASabb 6</td>
<td>Booster seats prevent children from getting injured during normal driving.</td>
</tr>
<tr>
<td></td>
<td>BSASabb 10</td>
<td>When cars are in a crash, booster seats prevent children from injuring others in the car.</td>
</tr>
<tr>
<td>Key Benefit</td>
<td>BSASabb 7</td>
<td>When cars are in a crash, booster seats prevent life-threatening (head and spinal cord) injuries.</td>
</tr>
<tr>
<td></td>
<td>BSASabb 8</td>
<td>In the event of a crash, booster seats save lives.</td>
</tr>
</tbody>
</table>
Appendix 8. Factor Validation of the Projected Intent Scale

An alternative version of the Intent to Use subscale of the Booster Seat Attitudes Scale (BSAS)\(^{39}\) was developed and validated in a sample of 745 parents. The goal of this scale is to circumvent respondents’ tendency to check the socially desirable answer (e.g., I restrain my child in a booster seat all the time) by asking them to conjecture what their peers would do. Research indicates that, when inferring other people’s attitudes, individuals tend to imbue their judgments with their own attitudes\(^{116}\).

*The Projected Intent* scale was validated with Confirmatory Factor Analysis (CFA) was conducted in RStudio version 1.1.423 and R version 3.2.5, using the lavaan package version 0.6-2. The BSASabb includes only the *Intent to Use* and the *Perceived Benefit* subscales of the full version. The table below shows the questionnaire items.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item number</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Projected Intent to Use</td>
<td>Otherparents_1</td>
<td>This information would encourage parents to purchase a booster seat for their child.</td>
</tr>
<tr>
<td>Projected Intent to Use</td>
<td>Otherparents_2</td>
<td>This information would encourage parents to drop in at a car seat inspection clinic (local police station/fire department) to ensure the booster seat was installed correctly.</td>
</tr>
<tr>
<td>Projected Intent to Use</td>
<td>Otherparents_3</td>
<td>This information would encourage parents to attend a workshop to learn how to use a booster seat correctly.</td>
</tr>
<tr>
<td>Projected Intent to Use</td>
<td>Otherparents_4</td>
<td>This information would encourage parents to make sure their child always rides in a booster seat.</td>
</tr>
<tr>
<td>Projected Intent to Use</td>
<td>Otherparents_5</td>
<td>This information would encourage parents to prevent their child from riding in any car without a booster seat.</td>
</tr>
</tbody>
</table>

I first tested a one factor model. Model fit measures indicated poor fit. See table below. Model 2 split *Intent to Use* into two factors intent to use and intent to learn, because Otherparents_2 (“…encourage parents to drop in at a car seat…”) and Otherparents_3 (“…encourage parents to attend a workshop…”) are conceptually separated from the rest: they are more about learning and imply specific actions that require scheduling and commuting to a place. Model 2 statistics indicate good fit.\(^{128}\) Comparative Fit Index (CFI), Root Mean Square
Error of Approximation (RMSEA), and the Standardized Root Mean Square Residual (SRMR), are within acceptable values.  

Validation of the Projected Intent scale

<table>
<thead>
<tr>
<th>Iteration</th>
<th>$\chi^2$</th>
<th>df</th>
<th>p</th>
<th>RMSEA (90% CI)</th>
<th>CFI</th>
<th>SRMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1</td>
<td>448.60</td>
<td>5</td>
<td>0.000</td>
<td>0.351 (0.324 - 0.379)</td>
<td>0.737</td>
<td>0.115</td>
</tr>
<tr>
<td>Model 2</td>
<td>20.89</td>
<td>4</td>
<td>0.000</td>
<td>0.077 (0.046 - 0.110)</td>
<td>0.990</td>
<td>0.026</td>
</tr>
</tbody>
</table>

$\chi^2$ = Chi square; df = degrees of freedom; p = p value of the Chi square test; CFI = Comparative Fit Index; RMSEA = Root Mean Square Error of Approximation; CI = 90% confidence interval; SRMR = Standardized Root Mean Square Residual.

The table below details the final version of the Abbreviated Booster Seat Attitudes Scale (BSASabb).

Abbreviated Booster Seat Attitudes Scale (BSASabb) – Validated version

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item number</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other parents’ intent to use</td>
<td>Otherparents_1</td>
<td>This information would encourage parents to purchase a booster seat for their child.</td>
</tr>
<tr>
<td></td>
<td>Otherparents_2</td>
<td>This information would encourage parents to drop in at a car seat inspection clinic (local police station/fire department) to ensure the booster seat was installed correctly.</td>
</tr>
<tr>
<td></td>
<td>Otherparents_3</td>
<td>This information would encourage parents to attend a workshop to learn how to use a booster seat correctly.</td>
</tr>
<tr>
<td>Other parents’ intent to learn</td>
<td>Otherparents_4</td>
<td>This information would encourage parents to make sure their child always rides in a booster seat.</td>
</tr>
<tr>
<td></td>
<td>Otherparents_5</td>
<td>This information would encourage parents to prevent their child from riding in any car without a booster seat.</td>
</tr>
</tbody>
</table>
Appendix 9. Factor validation booster seat knowledge scale for parents

A booster seat knowledge questionnaire to measure parents' knowledge was developed and factor validated in a sample of 745 parents who completed the knowledge questionnaire at baseline. Because of time constraints, the knowledge questionnaire needed to be short. Thus, the questionnaire had only 10 items: four general and six specific. The general items were multiple choice questions. The specific items refer to guidelines described in the educational material. Participants were shown a picture of a child using restraint and were asked to point out which mistakes had been made when restraining the child. The picture was taken from a previous Transport Canada website (Website is no longer available). See table below.

<table>
<thead>
<tr>
<th>Type</th>
<th>Item number</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Know1</td>
<td>The safest place in the car for children is always in the back seat.</td>
</tr>
<tr>
<td></td>
<td>Know2</td>
<td>SEAT BELTS prevent injuries to people riding in cars, by…</td>
</tr>
<tr>
<td></td>
<td>Know4</td>
<td>The most important purpose of the BOOSTER SEATS is to…</td>
</tr>
<tr>
<td></td>
<td>Know5</td>
<td>BOOSTER SEATS mainly protect the child’s…</td>
</tr>
<tr>
<td>Applied</td>
<td>Know3</td>
<td>Please, select all the mistakes YOU SEE in the picture:</td>
</tr>
<tr>
<td></td>
<td>Know3_1</td>
<td>Child is not using a booster seat.</td>
</tr>
<tr>
<td></td>
<td>Know3_2</td>
<td>Child is sitting in the back seat of a car.</td>
</tr>
<tr>
<td></td>
<td>Know3_3</td>
<td>Child has the shoulder belt on the neck.</td>
</tr>
<tr>
<td></td>
<td>Know3_4</td>
<td>Child has the lap belt on the belly.</td>
</tr>
<tr>
<td></td>
<td>Know3_5</td>
<td>Child’s legs are bent at the edge of the seat.</td>
</tr>
<tr>
<td></td>
<td>Know3_6</td>
<td>The headrest is too high.</td>
</tr>
</tbody>
</table>

Confirmatory Factor Analysis (CFA) was conducted in RStudio version 1.1.423 and R version 3.2.5, using the lavaan package version 0.6-2. The table below summarizes fit measures of CFA models. Five models specified based primarily theory or the content of the items and informed by predicted versus observed frequencies and covariance tables. In Model 1
all items were included in a single factor: booster seat knowledge. In Model 2, three items were removed, because they are not directly related with booster seats: Know2 (“seat belts prevent…”); Know3_6 (“headrest is too high.”); Know3_2 (“sitting in the back seat…”). Residual, modification indices, observed frequencies, detected one problematic item: Know3_5 (“Child's legs are bent at the edge of the seat.”). This item was meant to be another mistake that parents had to detect, as the child is sliding forward to bend the knees over the edge of the seat. However, this is not very clear in the picture. See table below. Models 3 and 4 (not shown in the table) did not converge, likely because of low correlation between items. In Model 5, two factors were specified (gist and verbatim) and two more items were removed. Know1 (“The safest place in the car for children is always in the back seat.”) was too general and applies to all child under 13 years of age. As show in the table below, Model 5’s the X² Chi Square test of goodness is non-significant, indicating good fit. Furthermore, the Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean Square Residual (SRMR), are within acceptable values.¹²⁸

<table>
<thead>
<tr>
<th>Iteration</th>
<th>X²</th>
<th>df</th>
<th>p</th>
<th>RMSEA (90% CI)</th>
<th>CFI</th>
<th>SRMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1</td>
<td>303.537</td>
<td>35</td>
<td>0.000</td>
<td>0.104 (0.094 -0.115)</td>
<td>0.585</td>
<td>0.185</td>
</tr>
<tr>
<td>Model 2</td>
<td>112.179</td>
<td>14</td>
<td>0.000</td>
<td>0.100 (0.083-0.117)</td>
<td>0.813</td>
<td>0.157</td>
</tr>
<tr>
<td>Model 5</td>
<td>1.451</td>
<td>4</td>
<td>0.835</td>
<td>0.000 (0.000-0.033)</td>
<td>1.000</td>
<td>0.022</td>
</tr>
</tbody>
</table>

X² = Chi square; df = degrees of freedom; p = p value of the Chi square test; CFI=Comparative Fit Index; RMSEA= Root Mean Square Error of Approximation; CI = 90% confidence interval; SRMR=Standardized Root Mean Square Residual.

The table below details the final version of the Abbreviated Booster Seat Attitudes Scale (BSASabb).

<table>
<thead>
<tr>
<th>Type</th>
<th>Item number</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gist</td>
<td>Know4</td>
<td>The most important purpose of the BOOSTER SEATS is to…</td>
</tr>
<tr>
<td></td>
<td>Know5</td>
<td>BOOSTER SEATS mainly protect the child's…</td>
</tr>
<tr>
<td>Applied</td>
<td>Know3_1</td>
<td>Child is not using a booster seat.</td>
</tr>
<tr>
<td>Gist</td>
<td>Know3_3</td>
<td>Child has the shoulder belt on the neck.</td>
</tr>
<tr>
<td></td>
<td>Know3_4</td>
<td>Child has the lap belt on the belly.</td>
</tr>
</tbody>
</table>