Child-Resistant Containers: Examining their Efficacy and Children’s Interest

by
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A Thesis
presented to
The University of Guelph

In partial fulfilment of requirements
for the degree of
Master of Arts
in
Psychology

Guelph, Ontario, Canada
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ABSTRACT

CHILD-RESISTANT CONTAINERS: EXAMINING THEIR EFFICACY AND CHILDREN'S INTEREST

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University of Guelph, 2022

The current study included twenty-eight children aged five to eight years. It examined their interest level in and ability to open three types of child-resistant containers (CRC) and determined if inhibitory control (IC) was associated with these performance measures. Participants were randomly assigned to one of three container conditions: twist-open, flip-open, and push-out. Each child was presented with a CRC and a control container. Participants were first given the opportunity to open the containers spontaneously and then asked to open after explicit modelling. Participants were more interested in the control containers than CRCs for the twist- and flip-open conditions, but there was no difference for the push-open condition. Children’s interest levels across CRCs did not differ. Children were more likely to open control containers than CRCs spontaneously. More children opened CRCs after explicit modelling than spontaneously. Children low in IC opened more CRCs spontaneously. Implications for pediatric poisoning prevention are discussed.
ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to my advisor for the invaluable support and patience in navigating this project. I also greatly appreciate my committee member for sharing her knowledge, expertise, and insight. Many thanks to the chair and defense committee for generously providing their knowledge.

Special thanks to the members of my cohort and peers within the program for their moral support and advice throughout this process. I couldn’t have done this without my lab members, who helped with scheduling and recruitment. Many thanks also go to the families who participated in my study and made it all possible.

Finally, I would like to acknowledge the incredible support of my family and friends, who kept my motivation high during this project. I feel so grateful to have such a wonderful group around me, and they inspire me to be better every day.
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1. Introduction

Across age groups, unintentional poisonings are the second leading cause of injury among people in Canada (Government of Canada, 2021). This risk is especially pronounced in young children (Gummin et al., 2020). While pediatric fatalities due to poisoning are typically uncommon (Gummin et al., 2020), the risk of pediatric poisoning exposure still represents a large public health concern and comes at a high cost to the Canadian health care system. Unintentional poisonings account for $2.6 billion annually, and the cost of injury treatment for children under 14 is $996 million per year (Jiang et al., 2020; Parachute, 2015). The current study addresses this pediatric health issue by examining both children’s ability to open different types of ‘child-resistant’ packaging, as well as their interest in these different types of packaging.

1.1 Theoretical Orientations and Unintentional Poisoning Risk Models

There are various theoretical orientations and conceptual frameworks that are relevant to unintentional poisoning risk. The Social-Ecological Model of Health considers the influence of external contextual life factors on injury risk (Green & Kreuter, 2005). For example, researchers guided by this model might examine how factors such as the number of children in a home, or the living situation, influence poisoning risk in children. In a similar vein, the "injury iceberg" model (Hanson et al., 2005) also considers the psychological, sociological, and physical determinants of injury risk from the individual, intrapersonal level to community and societal influences. These theoretical frameworks recognize the multiple interacting factors that can contribute to unintentional poisonings and highlight how all must be considered when investigating the nature of these events.
Recently, Schwebel et al. (2017) proposed a conceptual model of factors that specifically contribute to pediatric unintentional poisoning. In this model, the authors offer four factors that may impact the likelihood of unintentional poisonings: Individual-level factors (e.g., child personality), product factors (e.g., labelling, packaging), societal factors (e.g., education, social class, policy), and locations factors (e.g., storage, modelling of risk behaviors). The current study draws on this model to understand the role of individual and environmental factors in children's ability and interest in opening child-resistant containers.

1.1.1 Individual Factors
Various internal and external factors make young children particularly vulnerable to poisoning exposures. Young children are at an exceptionally high risk of unintentional poisonings due to their increased curiosity and limited understanding of hazards and danger (Agran et al., 2001; Chen et al., 2013; Jirout & Klahr, 2012). Young children also have increased mobility than infants (e.g., climbing skills) and this can lead to increased access to harmful materials, like cleaning supplies, medicine, or cannabis products that may resemble snacks (e.g., juice, candy; Cao et al., 2016; Connoly et al., 2010; Valdez et al., 2014).

A child's temperament also plays a role in determining their risk for unintentional poisoning. Temperament is thought to guide their actions and experiences, leading some children to seek novelty and engage in risky activities while others actively avoid these experiences and situations (Scarr & McCartney, 1983). Past research has identified several behavioural attributes that are precursors to childhood injury risk (Bijur et al., 1988; Pulkkinen, 1995; Schwebel & Plumert, 1999, Schwebel, 2004). Specifically,
two temperament constructs, high temperamental impulsivity and low temperamental inhibitory control (IC), have emerged in the literature as constructs that can increase the likelihood of pediatric injury (Plumert & Schwebel, 1997; Schwebel & Plumert, 1999). Children with increased IC levels have been found to interact with hazards in their environment more conservatively, have restraint when interacting with potential dangers, and are more likely to engage in more relaxed activities (Schwebel, 2004). In contrast, children high in impulsivity and low in IC show opposing behaviors and are at greater risk for experiencing injury (Morrongiello et al., 2006; Schwebel, 2004; Vollrath et al., 2003).

Adult supervision has been identified as playing a significant role in pediatric poisoning risk. Children who ingest poisons were found to be less closely supervised by their guardian (Schmertmann et al., 2013). Previous research also suggests that poisonings in young children can result from them imitating behaviours of adults, such as observing adults consuming oral medications that look like candy (Brayden et al., 1993; Lewis et al., 1966; Rodgers et al., 2012). Extending past research, the current study considers how modelling influences children’s opening of different types of containers.

1.1.1 Environmental Factors: Packaging and Storage

Given children's emerging curiosity and limited recognition of poisonous substances, the use of child-resistant containers (CRC) was developed to try and reduce their access to harmful common household products. Common styles of CRCs include a push-and-twist container, blister packs, and medicine containers with locking devices. Although parents do not often realize this, these containers are designed to delay children’s
access to their contents rather than preventing access altogether. The regulations and standards associated with this packaging have significant implications for children's access to potentially harmful content. The Canadian Government outlines the criteria for a CRC as being (a) "constructed so that it can be opened only by operating, puncturing, or removing one of its functional and necessary parts using a tool that is not supplied with the container" (Consumer Chemicals and Containers Regulations, 2001); or (b) meeting the child test protocol requirements of the Canadian Standards Association (CSA) CSA Z76.1:21 for reclosable CRCs. These regulations and standards require manufacturers to complete performance tests with children to determine their ability to open the containers. However, in these performance tests, the proper way to open the container is not modelled for the children, and there are no observers present (CSA, 2021). Given that imitation of adults or siblings is a common antecedent of unintentional pediatric poisonings (Rodgers et al., 2012), comparing children's ability to open CRCs spontaneously and after the behaviour has been modelled is a novel aspect of this research and is critical to study.

While packaging standards and guidelines may assist in reducing the number of pediatric poisonings, children will inevitably come into contact with potentially harmful products. In fact, these packaging standards could provide parents with a false sense of security when choosing storage locations for said products. Previous findings reveal that parents often do not perceive poisoning from potentially harmful products like medications to be high-risk or that storage precautions are not necessary if they plan to provide close supervision (Morroniello & Kiriakou, 2004; Rosenberg et al., 2011).
How products are packaged and labelled influences children's interest and how children interact with them (Schneider, 1977; Schwebel et al., 2015). Current consumer trends for these products are moving towards more colourful, eye-catching containers with elevated concentrations to provide smaller packaging, potentially inadvertently increasing the product's attractiveness to young eyes (Schwebel et al., 2017; Valdez et al., 2014). For instance, the increase of pediatric poisonings from the often brightly coloured laundry and dishwasher detergent pods has gained significant attention (Gray & West, 2014; Valdez et al., 2014; Wallis, 2015), with some researchers highlighting the pods resemblance to candy (Valdez, 2014). Similarly, the market has seen an increase in the variety of edible cannabis products available, including baked goods, "gummies," and drinks, which can be easily mistaken for ordinary snacks by children (MacCoun & Mello, 2015). Understanding children's interest in different types of containers and potentially hazardous products in an environment is required to inform targeted prevention strategies.

1.2 The Current Study

This study aimed to evaluate children's interest in different types of CRCs and their ability to open CRCs both spontaneously and after the opening has been modelled; the latter has not been studied before but is critical because many children observe parents and older siblings doing things and may subsequently try to imitate these behaviours (Rodgers et al., 2012). In an effort to create an ecologically-valid test situation, it was necessary to develop an environment that simulates what children experience in the home, so distractors (toys) were present when measures of interest (looking) and spontaneous opening attempts were taken. Children were also provided with more
direct, explicit modelling to gauge their true ability to open the container. Participants were assigned to one of three conditions or container type (push, flip, twist). Each child experienced two containers: one type of CRC and the other that mimicked the same movement without the child-resistance mechanism. Additionally, participants completed three behavioral measures of IC to explore if IC was associated with interest level or opening behaviors. Analyses examined the interest level and ability to open containers within (risk vs. non-risk) and across (push, flip, twist) conditions after both covert and explicit modelling, and evaluated the relationship between interest level (looking), spontaneous opening behaviours, and IC.

2. Methods

2.1 Participants

Participants comprised 28 children aged five to eight years including 17 girls ($M = 5.94$ years-old, $SD = 1.01$ years) and 11 boys ($M = 6.09$ years-old, $SD = 0.83$ years). Participants were randomly selected from an existing database of families interested in research on child development. Only children without allergies to the candies provided were selected for participation. All parents and children were English speaking. The majority of participating children had parents who were Caucasian (91.3%), married (91.3%), had an annual income of above $80,000 (91.3%), and had attended post-secondary education (95.5%). The study protocol was approved by the Research Ethics Board at the University of Guelph (REB #19-06-025). All parents gave written consent prior to participating, and all children provided verbal or written assent, depending on their age.
2. 2 Materials

The child's parent completed a demographic sheet to provide information about their ethnicity, education level, and family income information. Participants were introduced to a 'risk' container and a 'non-risk' control container within their assigned condition to evaluate their interest in such objects and their ability to access the contents. See the Appendix for descriptions of the study containers and conditions.

2. 2. 1 Risk Containers

Risk containers are defined as containers that are commonly found in most homes that contain potentially harmful ingredients. Each participant was randomized to one type of risk container. The contents of each container were emptied and filled with candy that looked like medicine. The risk containers include a multivitamin container (requiring a push “twist” motion), a Tylenol bottle (requiring a “flip” motion after aligning arrows), and a blister pack for lozenges (requiring a "push" motion). These three containers were chosen based on consultation with three experts in Child Injury Prevention research and because the mechanisms used on these containers are most common for over-the-counter medicine. The containers were all approximately the same size as the control containers and all could be easily held in a small child’s hand.

2. 2. 2 Control Containers

Control or “non-risk” containers are defined as containers that require similar movements to the “risk” container (i.e., twist, flip, and push) but that do not have a child-resistance mechanism. The "twist" non-risk container was clear and held candy that had a twist-off lid, the “flip” non-risk container was a Mini M&M, and the “push” non-risk container was a package of gum.
2. 2. 3. Toys

Distractor toys were used (e.g., Rubix cube, pinwheel, peg puzzle, children’s animal book) during testing. The RA brought two distractor toys (randomly picked) into the testing room each time the child was to be exposed to a risk container and left alone with it; two different toys were left with each container. These toys were meant to serve as potential distractors for the child while they were left alone in the testing room with the container and to reflect a more natural situation to that the child would experience in the home (i.e., there are likely to be child-appropriate toys in the same context as poison-containing containers).

2. 3 Measures

To explore if temperament influences attention and/or opening behaviours, participants completed three behavioural measures of IC (Schwebel, 2004).

2. 3. 1 Walk-a-Line Task

Adapted from Maccoby et al. (1965) and Kochanska et al. (1997), participants were asked to walk down a pretend path made of 1.88-inch x 12-feet of green tape on the carpeted floor. There was an initial baseline trial, one trial where they were asked to walk as slowly as they could, and one trial when they were asked to walk as quickly as they could. Each trial was timed in seconds and their times were recorded. The difference between time walking during baseline and the slow trial was calculated (Kochanska et al., 1997), with higher scores indicating greater IC.

2. 3. 2 Circle Drawing Task

Adapted from Bachorowski and Newman (1985), participants were asked to complete a response inhibition task where they drew a circle on a sheet of paper between two
existing circles. Similar to the Walk-a-Line task, participants completed an initial baseline trial, then another trial where they were asked to draw the circle as slowly as they could, and the final trial where they were asked to draw the circle as quickly as they could. Each trial was timed in seconds, and the participant's times were recorded. In line with previous research, the difference between the time to draw the slow circle and the baseline trial was calculated (Kochanska et al., 1997).

2. 3. 3 Simon Says Game

The participant was asked to perform various movements only if the research assistant said “Simon Says” before the movement (9 trials) and to inhibit all other commanded movements (9 trials). Only the trials requiring inhibition were coded (0: full movement performed, 1: partial movement performed, 2: no movement; Kochanska et al., 1997). The scores were summed (possible range: 0 – 18), with elevated scores indicating higher IC.

2. 4 Procedure

After being recruited from an existing database, participants were randomly assigned to one of three conditions (i.e., container types). Participants were grouped by age, then by gender within their age group, and subsequently assigned to a container condition within that age and gender group.

Parents brought their child into the lab to engage in play-like activities with the research assistant. During this interaction, the research assistant opened one of the three (child was randomized to container type) risk or control containers (whether risk of control container was presented first was counterbalanced) with two distractor toys present. Specifically, the RA opened the risk container under the guise of wanting to
take the medication/vitamins and did so as she spoke with the child explaining this
desire inside (e.g., *I have some vitamins and before we get started I am going to take one*). The control container was also opened under the guise of wanting to consume
what was inside (e.g., *Look what I have! These taste really good*).

First, the RA brought the risk/control container into the room and opened it
accordingly while speaking to the child (i.e., indirect modelling). The RA then left the
room to find colouring paper, and the child was left alone in the testing room with the
closed container and toys on the table in front of the child; they remained there for a
maximum of two minutes or until the container was opened. The child's interest in and
behaviour towards the container was observed via video camera on a monitor in
another room. After two minutes or until the container was opened, the research
assistant re-entered the room with the other colored paper, another container (risk or
control) and two new distractor toys. The RA removed the previously presented
container and distractors from the table ('Let me just clean up'). The RA then opened
the new container as they spoke to the child (see wording above). The new container
and toys were then put on the table and the assistant then left to go retrieve some
additional items for the next task; again, the child was then left alone in the room for a
maximum two minutes or until the container was opened. The RA then entered the
room and removed the container and distractors, and the participant then completed the

If the child had not previously opened the risk or control container, the research
assistant explicitly modelled how the container was opened and provided the child two
minutes to attempt to open the container independently as the assistant watched. This
was to determine if the child was able to open the container, even if they showed limited interest or opening behaviours when previously left alone. The child was then debriefed with the aim of educating youth about poisons and injury risks in their home. They were cautioned about the dangers of opening unfamiliar containers and doing so only with parental approval. At study conclusion, each child received a small toy, and each parent received a $5.00 gift card for their involvement.

2.5 Data Coding

Child interest levels were measured during the two minutes they were left alone with each (risk/control) container. Interest level was coded using the following scale, with higher scores indicating greater interest: 0 = no interest; 1 = looked at the container but did not touch; 2 = touched the container but did not pick up; 3 = picked up the container; 4 = picked up and tried to open the container; 5 = opened the container. For analyses, the mean interest level was compared within each condition (risk vs. control) and across conditions for risk containers (push, twist, flip). Ten percent of videos were coded by a second observer, and interest level ratings had 91% agreement. All participants only tried to open the container once if they showed any interest, so repeated efforts were not coded. Each participant’s ability to open both CRCs and control containers was coded (0: not opened, 1: opened) if the participant opened the container spontaneously and if they opened it after explicit modelling. Scores obtained across each of the IC tasks were standardized, and an average IC score was calculated for each participant. Higher scores indicated higher levels of IC.
2. 6 Analytic Approach

All analyses utilized Bayesian estimation rather than a frequentist approach (e.g., maximum likelihood estimation) due to power and normality issues that arise when using a mixed-model approach (i.e., between- and within-subject factors) with small sample size. Additionally, Wagenmakers (2007) outlines several issues related to null-hypothesis significance testing that were also accounted for when using a Bayesian approach. The author posits that $p$-values rely on hypothetical data through sampling distributions which creates data that is never truly observed (creating logical impasses); $p$-values are more susceptible to researcher bias through questionable research practices (e.g., optional stopping) and are therefore heavily dependent on sample size as one can continue to collect data until significance is achieved, and further, a $p$-value of .05 in a study with 200 participants is interpreted to have more statistical significance than a study with the same $p$-value and 20 participants (Wagenmakers, 2007). Finally, Wagenmakers (2007) highlights that $p$-values do not provide evidence comparing the null hypothesis to the research hypothesis, but rather the strength of evidence against the null hypothesis (i.e., only provides information about the extremes/tail ends of the data). Given these shortcomings of a frequentist approach, a Bayesian approach was utilized. The Bayes Factor does not rely on hypothetical data but instead accounts for the likelihood of the data under the null and alternative hypotheses. Further, Bayes Factors are not sensitive to changes in sample size because they are ratios of probabilities, and thus the same Bayes Factor will be achieved irrespective of sample size (Wagenmakers 2007). Therefore, this analytic method provides a more
conservative assessment of the evidence and is particularly useful with small sample sizes.

For these analyses, uninformative priors were used, providing a probability distribution of the estimates while still producing the same estimate as a frequentist approach. Bayes factors are interpreted based on widely accepted thresholds (Jefferys, 1961; see Table 1). SPSS version 28 was used for all analyses.

Table 1: Interpretive thresholds outlined by Jefferys (1961).

<table>
<thead>
<tr>
<th>Bayes Factor</th>
<th>Support for ( H_1 ) (Jefferys, 1961)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 3</td>
<td>Anecdotal</td>
</tr>
<tr>
<td>3 – 10</td>
<td>Substantial</td>
</tr>
<tr>
<td>10 – 20</td>
<td>Strong</td>
</tr>
<tr>
<td>20 – 30</td>
<td>Strong</td>
</tr>
<tr>
<td>30 – 100</td>
<td>Very Strong</td>
</tr>
<tr>
<td>100 – 150</td>
<td>Decisive</td>
</tr>
<tr>
<td>&gt;150</td>
<td>Decisive</td>
</tr>
</tbody>
</table>

3. Results

3.1. Do children’s interest levels differ for control vs risk containers?

Participants’ interest level was evaluated both within participants (2: risk container, control container) and across container conditions (3: push, flip, and twist risk containers). For each condition (3: push, flip, twist), a within-participant (2: risk, control) One-Way Repeated Measures Analysis of Variance (ANOVA) was conducted with Bayesian estimators. Descriptive statistics are reported in Table 2.

3.1.1 Twist

Based on the five-point rating scale, participants’ interest in the twist containers (\( N = 10 \)) was substantially greater for control (\( M = 4.40, SD = 1.35 \)) than for risk (\( M = 1.50, SD = 1.43 \)). An estimated Bayes factor indicated that the data are 2865.91 times more likely to occur under the alternative hypothesis (i.e., that a difference exists in interest level
across risk containers) than the null hypothesis (i.e., no difference exists), providing Very Strong support for the conclusion that a difference exists between risk and control twist containers in level of interest, with children showing greater interest in the control than the risk twist container.

3. 1. 2 Flip

Participants’ interest in the flip containers (\(N = 11\)) was considerably larger for control (\(M = 4.55, SD = 1.51\)) than for risk (\(M = 1.36, SD = 1.8\)). An estimated Bayes factor indicated that the data are 998.38 times more likely to occur under the alternative hypothesis (i.e., that a difference exists in interest level across risk containers) than the null hypothesis (i.e., no difference exists), providing Very Strong support that a difference exists between risk and control flip containers in level of interest, with children showing greater interest in the control than the risk flip container.

3. 1. 3 Push

Participants’ interest in the push containers (\(N = 7\)) was similar for control (\(M = 2.86, SD = 2.12\)) and risk (\(M = 2.14, SD = 1.96\)). An estimated Bayes factor indicates that the data are only 2 times more likely under the null hypothesis, indicating no difference exists between risk and control push containers in level of interest.

In summary, a significant difference in interest level exists for twist and flip between risk/non-risk containers but there is no significant difference for push containers. These findings suggest that children had a higher interest in the control container than the CRC for both the twist and the flip conditions, but not the push container.
Table 2: Bayesian Estimates of Group Means\textsuperscript{a} and Bayes Factor\textsuperscript{b} for children's interest in study containers.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean (5 = max)</th>
<th>SD</th>
<th>95% Credible Interval</th>
<th>Bayes Factor</th>
<th>Support for $H_1$ (Jefferys, 1961)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twist Risk</td>
<td>1.50</td>
<td>1.43</td>
<td>.68 - 2.32</td>
<td>2865.91</td>
<td>Decisive</td>
</tr>
<tr>
<td>Twist Control</td>
<td>4.40</td>
<td>1.35</td>
<td>3.58 - 5.22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flip Risk</td>
<td>1.36</td>
<td>1.80</td>
<td>.43 - 2.30</td>
<td>998.38</td>
<td>Decisive</td>
</tr>
<tr>
<td>Flip Control</td>
<td>4.55</td>
<td>1.51</td>
<td>3.61 - 5.48</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Push Risk</td>
<td>2.14</td>
<td>1.95</td>
<td>.75 - 3.54</td>
<td>0.520</td>
<td>Anecdotal support for $H_0$</td>
</tr>
<tr>
<td>Push Control</td>
<td>2.86</td>
<td>2.12</td>
<td>1.46 - 4.25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\textsuperscript{a} Posterior Distribution was estimated based on the Bayesian Central Limit Theorem.
\textsuperscript{b} Method: BIC approximation. Testing model versus null model.

3. 2 Do children’s interest levels vary across type of CRC?

Participants’ interest level in CRCs was compared across risk conditions (3: twist, push, flip) by conducting a linear regression with a Bayesian estimator. Results were not significant, $F(2, 27) = 0.37, p = 0.70, R^2 = 0.028$. An estimated Bayes Factor indicated that the data are 200 times more likely under the null hypothesis (i.e., that no difference exists in interest level across risk containers) than the alternative hypothesis, suggesting no difference in interest level across risk containers.

3. 3. What types of containers are children able to open spontaneously or after modelling?

To investigate the types of containers that children were able to open both spontaneously and after explicit modelling and a request to open them, a One-Way Repeated Measures ANOVA was conducted for each condition separately. Results are presented in Table 3 and Table 4, respectively. Additionally, a One-Way Repeated Measures ANOVA was conducted for each condition to evaluate if a difference existed in children’s ability to open risk containers spontaneously or after modelling (Table 5).
Table 3: Bayesian Estimates of Group Means\(^a\) and Bayes Factor\(^b\) for participants’ ability to open study containers spontaneously

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean</th>
<th>SD</th>
<th>95% Credible Interval</th>
<th>Bayes Factor</th>
<th>Support for H(_1) (Jefferys, 1961)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tw</td>
<td>Risk</td>
<td>0.00</td>
<td>0.00</td>
<td>-.18 (\text{Lower Bound})</td>
<td>13203.76</td>
</tr>
<tr>
<td>Tw</td>
<td>Control</td>
<td>0.80</td>
<td>0.42</td>
<td>.62 (\text{Upper Bound})</td>
<td></td>
</tr>
<tr>
<td>Fl</td>
<td>Risk</td>
<td>0.09</td>
<td>.30</td>
<td>-.08 (\text{Lower Bound})</td>
<td>52912.66</td>
</tr>
<tr>
<td>Fl</td>
<td>Control</td>
<td>0.91</td>
<td>.30</td>
<td>.26 (\text{Upper Bound})</td>
<td></td>
</tr>
<tr>
<td>Pu</td>
<td>Risk</td>
<td>.14</td>
<td>.38</td>
<td>-.17 (\text{Lower Bound})</td>
<td>1.22</td>
</tr>
<tr>
<td>Pu</td>
<td>Control</td>
<td>.43</td>
<td>.54</td>
<td>.46 (\text{Upper Bound})</td>
<td>1.75</td>
</tr>
</tbody>
</table>

Note: Means reflect the proportion of children who opened the container spontaneously.
\(\text{a. Posterior Distribution was estimated based on the Bayesian Central Limit Theorem. Method: BIC approximation. Testing model versus null model.}\)

3.3.1 Twist

Participants’ opening of twist containers \((N = 10)\) spontaneously was significantly greater for control \((M = 0.80, SD = 0.42)\) than for risk \((M = 0.00, SD = 0.00)\). An estimated Bayes Factor indicated that the data are 13203.76 times more likely under the alternative hypothesis, providing Decisive support that a difference exists between opening risk and control twist containers spontaneously, with more spontaneous opening of control than risk containers.

However, participants’ ability to open twist containers after the action was modeled and the child asked to do so was only slightly greater for control \((M = 1.00, SD = 0.00)\) than for risk \((M = 0.50, SD = 0.53)\). An estimated Bayes Factor indicated that the data are only 1.85 times more likely under the alternative hypothesis (i.e., that a difference exists between risk and control groups) than the null hypothesis, providing only Anecdotal support for the alternative hypothesis and suggesting that no difference exists between ability to open risk and control twist containers when the action is modeled and the child is asked to do so.
Participants opened more risk twist containers after explicit modelling ($M = 0.50, SD = 0.53$) than spontaneously ($M = 0.00, SD = 0.00$). An estimated Bayes Factor indicated that the data are 12.89 times more likely under the alternative hypothesis, providing Strong support that a difference exists between opening risk twist containers spontaneously and after being asked to do so once the action was modeled for the child.

Table 4: Bayesian Estimates of Group Means\textsuperscript{a} and Bayes Factor\textsuperscript{b} for participants’ ability to open study containers after explicit modelling.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean</th>
<th>SD</th>
<th>95% Credible Interval</th>
<th>Bayes Factor</th>
<th>Support for H\textsubscript{1} (Jefferys, 1961)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twist</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk</td>
<td>0.50</td>
<td>0.53</td>
<td>.28 - .78</td>
<td>1.85</td>
<td>Anecdotal</td>
</tr>
<tr>
<td>Control</td>
<td>1.00</td>
<td>0.00</td>
<td>.78 - 1.22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flip</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk</td>
<td>0.50</td>
<td>0.53</td>
<td>.28 - .72</td>
<td>12.89</td>
<td>Strong</td>
</tr>
<tr>
<td>Control</td>
<td>1.00</td>
<td>0.00</td>
<td>.78 - 1.22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Push</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk</td>
<td>1.00</td>
<td>0.00</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Control</td>
<td>1.00</td>
<td>0.00</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

Note: Means reflect the proportion of children who opened the container after explicit modelling.

\textsuperscript{a} Posterior Distribution was estimated based on the Bayesian Central Limit Theorem.

\textsuperscript{b} Method: BIC approximation. Testing model versus null model.

3. 3. 2 Flip

Participant’s opening of flip containers ($N = 11$) spontaneously was substantially greater for control ($M = 0.91, SD = 0.30$) than for risk ($M = 0.09, SD = 0.30$). An estimated Bayes Factor indicated that the data are 52912.66 times more likely to occur under the alternative hypothesis, providing Decisive support that a difference exists between opening risk and control flip containers spontaneously with more spontaneous opening of control than risk flip containers.

Additionally, participants’ ability to open flip containers after explicit modelling and a request to do so was greater for control ($M = 1.00, SD = 0.00$) than for risk ($M = 0.50, SD = 0.53$). An estimated Bayes Factor indicated that the data are 12.89 times
more likely to occur under the alternative hypothesis, providing Strong support for the alternative hypothesis that a difference exists between the ability to open risk and control flip containers after modelling.

Participants opened more risk flip containers after explicit modelling \((M = 0.50, SD = 0.53)\) than spontaneously \((M = 0.10, SD = 0.32)\). An estimated Bayes Factor indicated that the data are 4.49 times more likely under the alternative hypothesis, providing Substantial support that a difference exists between opening risk containers spontaneously and after modelling.

Table 5: Descriptive Statistics \(a\) and Bayes Factor\(^b\) for participants’ ability to open risk containers spontaneously and after modelling.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean</th>
<th>SD</th>
<th>Bayes Factor</th>
<th>Support for (H_1) (Jefferys, 1961)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twist</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spontaneous</td>
<td>0.00</td>
<td>0.00</td>
<td>12.89</td>
<td>Strong</td>
</tr>
<tr>
<td>Model</td>
<td>0.50</td>
<td>0.53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flip</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spontaneous</td>
<td>0.10</td>
<td>0.32</td>
<td>4.49</td>
<td>Substantial</td>
</tr>
<tr>
<td>Model</td>
<td>0.50</td>
<td>0.53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Push</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spontaneous</td>
<td>0.14</td>
<td>0.38</td>
<td>4378.81</td>
<td>Decisive</td>
</tr>
<tr>
<td>Model</td>
<td>1.00</td>
<td>0.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Means reflect the proportion of children who opened the container spontaneously or after explicit modelling.

\(a\). Posterior Distribution was estimated based on the Bayesian Central Limit Theorem.
\(b\). Method: BIC approximation. Testing model versus null model.

3.3 Push

Participants’ ability to open push containers \((N = 7)\) spontaneously was slightly greater for control \((M = 0.43, SD = 0.54)\) than for risk \((M = 0.14, SD = 0.38)\). An estimated Bayes Factor indicated that the data are only 1.22 times more likely under the alternative hypothesis, providing only Anecdotal support which suggests no difference between their ability to open risk and control twist containers spontaneously.
All participants were able to open both the CRC and the control container after modelling in this condition, so analysis to compare opening ability within this condition was not possible.

Participants opened more risk push containers after explicit modelling (\(M = 1.00, SD = 0.00\)) than spontaneously (\(M = 0.14, SD = 0.38\)). An estimated Bayes Factor indicated that the data are 4378.81 times more likely under the alternative hypothesis, providing decisive support that a difference exists between opening risk containers spontaneously and after modelling.

3. 4 Does inhibitory control relate to children’s interest in, or their spontaneous opening of risk containers?

Next, the effect of IC on children’s spontaneous opening behaviours and interest in the study containers was investigated. An IC score was created for each participant by averaging the standardized scores across the three IC tasks. Scores for interest level were obtained by averaging interest level across risk and control containers, and scores for spontaneous opening was the sum of all containers opened spontaneously for each participant. Pairwise Pearson Correlations were conducted to investigate the nature of the relationships between IC and the number of containers opened spontaneously, and children’s’ interest level across both risk and control study containers.

A Pearson correlation coefficient was computed to assess the relationship between IC, participants’ interest in risk containers, and the number of risk containers opened spontaneously (Table 6). The relationship between children’s IC and number of risk containers opened spontaneously was weak and negative, \(r(28) = -.005\). Participants’ IC and average interest in risk containers was moderately and negatively
related, $r(28) = -.31$. Finally, children's interest level in risk containers and the number of risk containers they opened spontaneously was moderately related, $r(28) = .57$.

Taken together, these findings suggest that lower levels of IC were associated with higher interest in the risk container. Additionally, higher interest shown towards risk containers was associated with more spontaneous openings.

Table 6: Bayes Factor (BF) Inference on Pairwise Correlations ($r$) between IC, Spontaneous Opening of risk containers, and Interest Level in risk containers.

<table>
<thead>
<tr>
<th></th>
<th>1.</th>
<th>2.</th>
<th>3.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Inhibitory Control Score</td>
<td>-</td>
<td>-.31</td>
</tr>
<tr>
<td>2.</td>
<td>Average Interest Level</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Number of Containers Opened Spontaneously</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

4. Discussion

Unintentional poisonings can occur when children access potentially harmful products commonly found in most homes. Children’s increased levels of curiosity, limited understanding of hazards, and poor impulse control further increase their susceptibility (Jirout & Klahr, 2012; Schwebel, 2004). Packaging guidelines and standards have been created to limit children’s ability to open CRCs (CSA, 2021). However, these tests do not consider the potential impact of modelling and children’s imitation of adults’ or older siblings’ behaviors, which is a common antecedent of unintentional pediatric poisonings (Rodgers et al., 2012). The current study applied a novel behavioural design to address this gap and determine if modelling influences opening ability. Participants aged five to eight observed a research assistant open containers under two conditions - indirect modelling and explicit modelling. The most popular containers for over-the-counter medicine were used to ensure that data was gathered for the products children are likely to encounter in their homes. Additionally, children’s interest in three types of
commonly used CRCs was measured in the presence of toys, simulating what the child would experience in their environment. Children also completed three behavioural measures of IC, rather than asking their parents to complete rating scales. The IC scores obtained were less subject to potential biases from parents (e.g., reference bias, social desirability bias), had multiple measurements, and could more accurately capture a child’s ability to suppress behavioural responses. The findings from this research provide important insights into aspects of the efficacy of currently used CRCs, specific child risk factors for unintentional poisoning, and add to the existing literature about design features of CRCs that may be more unwittingly interesting to school-aged children.

Young and school-aged children are curious about their surroundings and are eager to investigate novel objects, despite their limited understanding of potential risks (Jirout & Klahr, 2012). CRCs are commonly found in the home, and many have colourful labels (e.g., vitamin containers, pain killer bottles). The current study sought to investigate children’s interest in these different CRCs and evaluate if their interest levels varied across the different types. Results demonstrated that children had more interest in the control containers than the CRCs for the flip and twist conditions, but not the push condition. This is likely because the flip and twist control containers (orange and green M&M containers and glass containers with colourful candy, respectively) held tempting treats and were brightly coloured. In contrast, the push control container (pack of Juicy Fruit gum) was perhaps less obviously candy and therefore was less desirable to participants. Interestingly, participants were equally interested in each of the CRCs presented to them as no significant difference in interest level existed across groups.
Despite the differences in the packaging (e.g., colour, size), participants were equally interested in all risk containers, likely due to their resemblance to medicine containers found in their homes.

More broadly, it is possible that children were more likely to open control containers than CRCs because of the way the contents were described (i.e., were not described as vitamins). Children clearly understood that contents in all containers, control and risk, were edible because that was explicitly stated. Nonetheless, their opening more control than risk containers suggests that they have an understanding that they should not engage with the types of substances in the risk containers (medicine, vitamins); presumably parents have told their children not to touch such containers. In contrast, the control substances were not categorized but simply described as ‘tasty’ which clearly indicates they are meant to be eaten. This suggests that when children believe a substance is to be eaten, and they have no prior information to avoid such substances, then they may be likely to spontaneously try to ingest these when left alone with the substance. Therefore, consumer products that look like candy they are familiar with (e.g., edible cannabis products) or products that could be edible because they are enticing and coloured like candy (e.g., detergent pods) pose great risk for children to consume them, which aligns with recent poison statistics (Cao et al., 2016; Valdez, 2014). For children at these young ages, labels on products indicating ‘poison’ and other such warnings are not likely to be effective to deter poisoning, especially because literacy level is low at these ages. Thus, children are influenced by what products look like and how they are described. Prevention strategies need to address these factors (e.g., avoid colourful packaging), encourage parents be
explicitly speak about poisons in the home, and encourage pharmaceutical companies to avoid making colourful products that may resemble candy (Schwebel et al., 2015; Valdez et al., 2014).

Self-regulation and IC are established factors related to unintentional injury risk (Schwebel, 2004). However, this relationship had not yet been investigated in the pediatric unintentional poisoning literature, particularly related to CRCs. This is an important area to explore, as poor impulse control could increase risk of unintentional poisoning events. The preliminary findings from this study suggest that participants with lower levels of IC were more interested in and more likely to spontaneously open CRCs. This provides some evidence to suggest that more impulsive children may be at higher risk of unintentional poisoning. This is consistent with previous literature that has identified that children with Attention-deficit/hyperactivity disorder (ADHD) have an increased risk of poisoning events (see Ruiz-Goikoetxea et al., 2018 for meta-analysis).

Modelling plays an important role in injury-risk situations (Christensen & Morrongiello, 1997, Morrongiello & Sedore, 2005, Plumert & Schwebel, 1997), and is relevant to poisoning because children are likely to often observe parents, adults and older siblings accessing dangerous products. However, this factor has been overlooked in the extant unintentional poisoning literature and in devising current regulations (CSA, 2021; Rodgers et al., 2012). Further, many parents store potentially harmful products within their children's reach. Some propose this is because many parents (erroneously) assume that the child-resistant mechanism is sufficient to prevent their child from accessing the contents (Viscusi, 1984). However, some research has found that over fifty percent of unintentional pediatric poisonings involve products that meet child-
resistant packaging requirements (Franklin & Rodgers, 2008). The current study extends these findings, as more children were able to open CRCs after the motion was explicitly modelled. However, it is possible that participants were less interested in opening the risk container spontaneously (perhaps because parents have told them to avoid such containers) rather than unable to open it entirely. Future research should extend these findings to further delineate the role of explicit modelling on children’s opening abilities. However, these findings provide preliminary evidence that child-resistant mechanisms are not entirely effective at preventing children from accessing the contents. Further, the current study provides evidence that covert and explicit modelling could affect a child’s ability to open CRCs.

4.1 Limitations and Directions for Future Research

Although this study provided important preliminary evidence about the efficacy of child-resistant containers, there are some limitations to note and consider in planning future research.

First, the study was underpowered due to the small sample size. Data collection is continuing so future comparisons can be made across age and gender groups in both opening ability and interest level. Across age groups, poisoning risk is increased in males (Mintegi et al., 2019). To better understand the nature and underlying factors of their increased susceptibility, it is important to understand if boys can access the contents of CRCs better than girls or if they are more interested in the containers. The low sample size precluded our examining these possibilities but these questions will be addressed as more data is gathered.
Previous research has established no relationship between IC differences across genders (Sadeghi et al., 2022, Solianik et al., 2016). However, impulsivity and male gender have been implicated as risk factors in unintentional injury more broadly, and some preliminary evidence suggests that risk factors for unintentional injury more broadly are also implicated in poisoning risk (Schwebel & Gaines, 2007). This relationship has not yet been examined in the context of unintentional poisonings and CRC. Understanding the relationship between IC, gender, and spontaneous opening of containers is paramount, as this provides important insights into potential child risk factors, informs parenting practices and policy development. Additionally, previous research has found that younger children are at an increased risk of unintentional poisonings due to their limited understanding of hazards (Schwebel, 2004). Future research should analyze if this risk is compounded by a lack of efficacy in the current child-resistant mechanisms for younger children. Understanding the ages at which children can open CRCs is critical, as it can inform parent safety practices.

Second, the sample was comprised of primarily white, educated, and middle-income families. Including a more culturally and economically diverse sample would extend the generalizability of the results, as previous findings have consistently demonstrated that children of lower socioeconomic status are at greater risk of unintentional injury (see Mahboob et al., 2021 for review). Extending this research to include a more diverse sample is critical in future work to determine the role of a child’s environment in their unintentional poisoning risk.

Finally, in future research it would be informative to explore children’s knowledge of poisonous substances directly (e.g., have they been taught not to touch medicine
containers) and relate this knowledge to their interest and attempt to spontaneously open risk containers. The fact that children spontaneously opened more control than risk containers suggests some knowledge that ‘being edible’ was not sufficient grounds for pursuing a substance and that medicine type substances should be avoided. However, explicitly interviewing children about their knowledge and the source of this information would yield important additional information relevant to poison prevention. It would also be informative to interview parents and examine the extent to which they teach children about poisons and if this varies with child age. There may be some teaching strategies that are more effective than others for children at different ages. Age was not examined herein but merits further attention in future research on child poison prevention.

The preliminary findings from this study exemplify the many internal and external factors that are imperative to consider at all social levels to decrease a child’s unintentional poisoning risk. Children must be aware of the dangers that containers in their homes can pose. Parents need support in understanding the precautions that must be taken in their home for their child. Manufacturers need to consider the danger that colourful products resembling candy can pose and produce and market products responsibly. Policy-level changes are necessary to recognize the role of labelling and modelling on children’s opening behaviours. Ultimately, the safety of children is the goal and must be a shared responsibility.
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design.


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## APPENDIX

### A. Study containers.

<table>
<thead>
<tr>
<th>Pair</th>
<th>Risk Container</th>
<th>Control Container</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (twist)</td>
<td><strong>Flintstones Multi-Vitamin Container</strong></td>
<td>Clear twist container filled with candy</td>
</tr>
<tr>
<td></td>
<td>(O.Berk, n.d.)</td>
<td>(Uline, n.d.)</td>
</tr>
<tr>
<td>2 (flip)</td>
<td><strong>Tylenol bottle</strong></td>
<td><strong>Mini M&amp;Ms</strong></td>
</tr>
<tr>
<td></td>
<td>(Carreau, 2022)</td>
<td>(M&amp;M’s, n.d.)</td>
</tr>
<tr>
<td>3 (push)</td>
<td><strong>Dequadin throat lozenge</strong></td>
<td><strong>Pack of gum</strong></td>
</tr>
<tr>
<td></td>
<td>(Health E-Mouth, n.d.)</td>
<td>(Health E-Mouth, n.d.)</td>
</tr>
</tbody>
</table>