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Seeing household chemicals through the eyes of children—Investigating influential factors of preschoolers' perception and behavior

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ABSTRACT

Introduction: Children who encounter household chemicals run the risk of unintentional injury. The aim of this study was to understand which factors heighten children's attention or misguide their decision-making concerning household chemicals. We hypothesized that certain product attributes (i.e., label, packaging, closure types), storage context, and parental beliefs play a role in this setting. *Method:* We conducted a laboratory study with $N = 114$ children ($M = 45$ months, $SD = 6.5$) and their parents ($M = 38$ years, $SD = 4.92$). Children completed a series of behavioral tasks in which they had to choose between products with different attributes, identify products in different storage contexts, and sort household chemicals. *Results:* The results confirmed that the children preferred products with cartoon-style labels compared to products without such labels. However, children's decision-making did not differ for products with different closure types (child-resistant vs sprayer-type closures). Regarding the storage context, our results showed that the children particularly struggled to identify dishwashing tabs when they were stored with other food items rather than household chemicals. In terms of parental beliefs, our study found that parents rated more household chemicals as child-safe than their children did. *Practical Application:* Parents should buy household chemicals with neutral labels and pay attention to how their household chemicals are stored. Manufacturers should consider potential adverse effects when developing new product designs.

1. Introduction

In 2020, children accounted for the majority of toxic exposures in Switzerland, and one-third of these incidents can be attributed to household chemicals (Tox Info Suisse, 2021). With roughly 15 reported accidental toxic exposures a day, these incidents are an important public health issue. Therefore, it is critical to understand when and how accidental exposure to household chemicals occurs and how we can prevent resulting injuries, such as poisonings and chemical burns of other organs (i.e., eye, skin; Le Roux et al., 2020; Williams et al., 2012). Previous research has found that the risk of unintentional injury in children can be significantly reduced by parental (e.g., supervision) or environmental (e.g., safeguarding) strategies (Morrongiello et al., 2004). However, children will encounter household chemicals eventually and interact with them (Schwebel et al., 2014). Parents do not always adapt their safety measures to their child's increasing mobility or behavior (Gibbs et al., 2005; Schwebel et al., 2006), or their storage decision of household chemicals is misguided by unfamiliarity with safety labels or misinterpretation of other packaging attributes (Basso et al., 2016; Bearth et al., 2017; Bearth & Siegrist, 2019; Buchmüller et al., 2020). Prior studies have specifically addressed the issue of product attributes and their effects on children's perception and behavior (e.g., Schneider, 1977; Schwebel et al., 2014). However, more research is needed to understand what factors make household chemicals appealing to children and lead them or their parents to draw incorrect conclusions about the risks of these products.

2. Theoretical background

Unintentional injuries of children are usually multi-causal incidents. Factors such as the situational context, product attributes, parental strategies, or the child's temperament play a role in these incidents (Basso et al., 2014; Bearth et al., 2017; Morrongiello et al., 2004, 2006; Morrongiello & Sedore, 2005; Schwebel et al., 2017).

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These factors could potentially influence whether children categorize household chemicals as dangerous or safe and change how they interact with these products.

To avoid injuries from household chemicals, children and their parents must categorize household products correctly as either safe to use or dangerous. From an early age, children start to form categories based on similarities (e.g., shape, texture, and more) and through associative learning (e.g., objects stored in the kitchen are for cooking; Gelman & Meyer, 2011; Rakison & Lupyan, 2008; Sloutsky, 2003). In infancy, children use perceptually similar attributes of objects to form categories (e.g., all drinking bottles have a pointy spout; Quinn & Eimas, 1996) or associate attributes with specific categories if these attributes are often relevant for such categorizations (Smith & Samuelson, 2006). For example, if children's products are often marketed with "cartoon figures," over time, this attribute will be associated with the category "for children." Likewise, specific attributes of household chemicals (e.g., label, packing, closure type) or contexts (e.g., storage) can influence children's categorization of the products' safety.

Research with adults has shown that product attributes can misguide perceptions of household chemicals in multiple ways. Adults judged products with food-imitating packaging as drinkable and associated the products with tastiness (Basso et al., 2010, 2014, 2016). Furthermore, adults perceive eco-friendly products as less effective and less dangerous for human health than conventional household chemicals (Bearth et al., 2017; Bearth & Siegrist, 2019). In line with these findings on adults, label design or product shape can also lead to differences in children's perception and influence their categorization of household chemicals (Schneider, 1977; Schwebel et al., 2014). Schwebel et al. (2014) found that certain product attributes, such as shape (e.g., squared bottles) or material (e.g., metal packaging), helped children categorize them as dangerous.

In addition to product attributes, the context in which these household chemicals are encountered plays an important role in categorization. These contexts become increasingly important as children begin to explore their environment on their own with decreasing parental control (Pollack-Nelson & Drago, 2002). During the first two years, children's mobility increases rapidly and enables them to reach places they were not able to reach before. Previous research found that parents sometimes neglect these changes in their children's mobility and unintentionally store household chemicals within reach of their children (Beirens et al., 2006; Gibbs et al., 2005; Roddy et al., 2004).

Lastly, parental beliefs on household chemicals might influence how parents teach and shape their children's experiences with household chemicals. These parental beliefs can be described as a broad set of attitudes and convictions about the risks and hazards of household chemicals (Bearth et al., 2022). To our knowledge, few studies have investigated the effects of parental beliefs on unintentional injuries, particularly concerning household chemicals (Morrongiello et al., 2014; Schwebel et al., 2004). Previous research found that children with high levels of safety understanding taught by their parents had a reduced injury risk (Morrongiello et al., 2014). A high level of safety understanding implies that the child has a well-founded understanding of the risks and hazards of household chemicals and thus has higher rule compliance and higher risk avoidance concerning these hazards (Morrongiello et al., 2014). This study indicates that parental beliefs and their resulting parenting can influence the child's behavior concerning unintentional injuries. However, more research must be done to understand the extent to which these parenting strategies can help children in the context of household chemicals.

3. Study aim and objectives

The aim of this study was to investigate how specific product attributes, storage contexts, and parental beliefs impact children's categorization of household chemicals. Based on existing knowledge, we formulated two specific hypotheses and two explorative research questions. Regarding product attributes, we focused on label design and different closure types. Previous research in the food domain found that children selected snacks with licensed characters (e.g., cartoon figures) more often than products that did not have these characters on their packaging (Roberto et al., 2010). Children may categorize products as child-safe based on previous experience that cartoon figures generally indicate something safe or fun to play with. Therefore, we hypothesize the following regarding cartoon figures:

H1: Preschoolers reach out more often for household chemicals with pictures of cartoon animals than for household chemicals without such pictures.

Based on social learning theory, children observe and model the behavior of others (Bandura, 1977). We assume that children might show an increased interest in household chemicals to model their parents' behavior. Subsequently, there is a higher risk of unintentional injury because of children's increased interest to interact with these products. For this study, we focused on sprayer-type closures because a large proportion of the Swiss population uses household chemicals with such a closure on a weekly basis (Zock et al., 2007). According to Gibson (1950, 1966), the perception of the environment inevitably leads to a certain action. These affordances indicate possible actions in the environment such as doorbells or buttons. Due to its interactive nature (i.e., pressing a lever and then a spray of liquid emerges), sprayer-type closures can be seen as high in affordance. Therefore, we hypothesize that children show an increased preference for sprayer-type closures:

H2: Preschoolers reach out more often for household chemicals with sprayer closures than for products with child-resistant closures.

To explore the impact of storage context on children's categorization, we compared household chemicals stored with other household products to household chemicals stored with food items. Based on the above-mentioned categorization processes (Rakison & Lupyan, 2008; Sloutsky, 2003), we assume that children may have difficulties correctly categorizing household chemicals depending on how similar they are to other products or the associations children have with the storage context. Therefore, we focused on dishwasher tabs and laundry pods because these tabs and pods are often described as candy-like and stored close to their point of use (i.e., in the context of food items) instead of a cleaning cabinet (i.e., in the context of household chemicals; Bearth et al., 2022; Valdez et al., 2014):

RQ1: To what extent do preschoolers mistake laundry pods and dishwasher tabs as something edible, and is this effect even stronger if these products are stored with other food items rather than with household chemical products?

Finally, we investigated the effect of three self-reported parental beliefs concerning household chemicals that were identified in a previous study: protective parental beliefs, educational parental beliefs, and pragmatic/trusting parental beliefs (Bearth et al., 2022). These three parental beliefs were related to the parents' behavior concerning household chemicals. Parents with strong

protective beliefs are likelier to control the environment and keep household chemicals away from their children (Bearth et al., 2022). Parents with strong educational beliefs are likelier to educate children on safe use and let children have experiences with household chemicals (Bearth et al., 2022). Parents with strong pragmatic or trusting beliefs were less concerned about controlling access to household chemicals, thinking that children are not interested in these products in general (Bearth et al., 2022). Children's categorization process is influenced by the associations they learned from previous experience (Rakison & Lupyan, 2008). Therefore, parental beliefs and the resulting parenting styles may impact children's experiences and thus their categorization of household chemicals. We examined this potential influence of parental beliefs with the following research question:

RQ2: Do parents' beliefs relate to their and their children's precautionary behavior regarding household chemicals?

4. Methods

4.1. Sample

From June to September 2021, we recruited $N = 114$ Swiss families with preschool children from the German-speaking part of Switzerland.[1] Participants were recruited through the panel of the Research Unit for Developmental Psychology: Infancy and Childhood at the University of Zurich. For each family, we collected data for one parent and one child. Of all children, 55 were male (48%) and 59 were female (52%), ranging in age from 35 to 55 months, with a mean age of 45 months ($SD = 6.55$). Of all parents, 11 were male (10%) and 103 were female (90%), ranging in age from 23 to 49 years, with a mean age of $M = 38$ years ($SD = 4.92$). Most parents held a university degree (81; 71%), four graduated from high school (3%), 28 completed vocational training (25%), and one finished compulsory school (<1%). Additionally, 17 parents stated that they work in a sector that manufactures, imports, trades, or uses chemical products (15%), and 91 stated that they do not work in such a sector (85%). The ETH Zurich Ethics Commission (Ref.-Num.: 2021-N-68) approved the study protocol and procedure. All parents provided informed consent, and the children received a gift valued at approximately CHF 5 and a certificate of participation.

4.2. Study design and procedure

The study was conducted at the Research Unit of Developmental Psychology: Infancy and Childhood at the University of Zurich. Before the actual study, the experimenter explained the procedure to the parent, obtained informed consent, and introduced themselves to the child. After the child felt comfortable, the researcher led the participants to the experiment room. During the study, the parents and their children could not see each other to prevent potential confounding effects. The study consisted of three tasks.

The first task (*product attribute task*) consisted of a cabinet filled with seven items, of which four bottles imitated household chemicals, as displayed in Fig. 1. These bottles differed in their labels (bird vs no bird) and in their closure type (child-resistant vs spray). The cabinet further contained three control items consisting of cleaning supplies commonly found in cabinets next to household chemicals (sponge, rubber gloves, and cleaning brush). The bottles were always placed in the back of the cabinet, while the control items were placed in the front. The positions (from left to right) of the bottles and the control items were randomized to control for potential systematic effects of placement. In the task, the researcher asked the child to hand one item from the cabinet that was the most interesting to them by asking the following question: "What do you like the most inside this cabinet?" This question was repeated three times. If a child did not select a bottle within these three questions, the experimenter additionally asked the child which of the four bottles he or she liked the most.

Fig. 1. Product Attribute Task: Representation of the Four Bottles Varying in Bottle Label and Closure Type, Including Three Cleaning Supplies. Note. Bottle position was randomized for every participant.

The second task (*storage situation task*) was conducted in a between-subject design. Children were assigned to either the food or the chemical context condition. We presented the child with a cabinet filled with one of three target products (dishwasher tabs, laundry pods, or candy), two neutral items (tissues and candles), and either two household chemicals or two glass containers containing food (Fig. 2). Target products were shown one by one, and the presentation order was randomized. The researcher pointed directly at the target product and asked the child if the content was edible. This procedure was repeated until the child had answered this question for all three target products.

The third task (*chemical product sorting task*) consisted of 16 household chemicals available on the Swiss market (see Appendix A). These products were selected based on results from a study with parents of preschoolers conducted by Bearth et al. (2022). The experimenter blindly selected each product from a storage box and presented them to the child one by one. For each product, the experimenter asked the child to sort it into one of two boxes marked with either an image of a child (for children) or with an image of two adults (for adults only). After all products were sorted, parents were asked to also sort these products according to whether they would let their child use these products by themselves. During this sorting process, the experimenter ensured that neither the parent nor the child saw how the other sorted the products.

All tasks were video recorded and later coded by the experimenter. For the *product attribute task*, the four choices made by the child were coded. For the *storage situation task*, verbal cues (e.g., "Yes" or "No") as well as behavioral cues (e.g., visible nodding) were considered to determine if the child deemed the target product edible or not. Finally, for the *chemical product sorting task,* we coded the categorization by the children and their parents into a *precaution score*. In this score, the sum of all products categorized as "adult only" was used as an indicator of how cautious the participants were regarding household chemicals.

4.3. Questionnaire

All scales from the questionnaire, including a complete list of all items, can be found in the supplementary materials. With the

[1] A small number of children had difficulties understanding some of the tasks or were too shy to complete a given task. Therefore, part of their answers could not be recorded; thus, sample sizes vary between analyses.

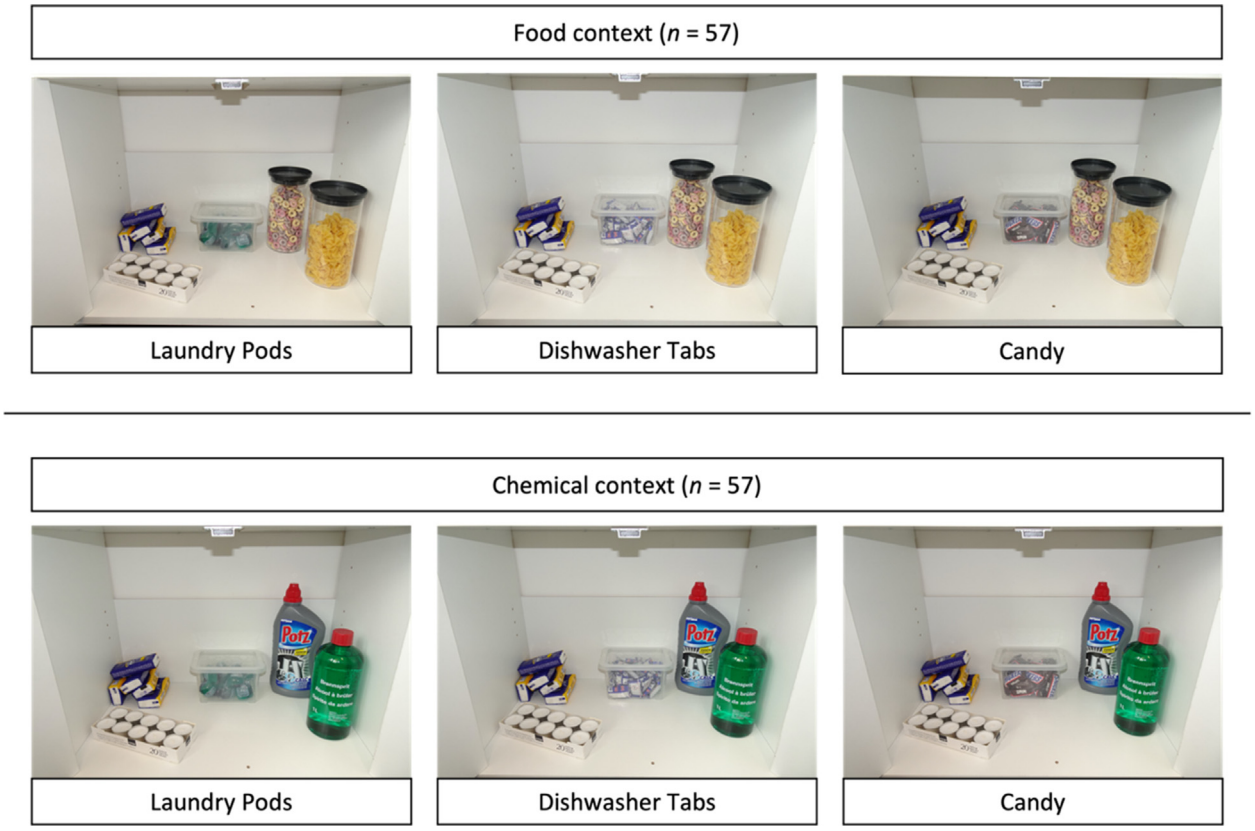

Fig. 2. Storage Situation Task: Arrangement of the Study Items for the Food and the Chemical Storage Condition. Note. Presentation order of the target items (dishwasher tabs, laundry pods, and candy) was randomized for every participant.

questionnaire, we assessed parental *beliefs* using a self-developed scale (Bearth et al., 2022) on the dimensions of *trusting-pragmatic, protective,* and *educational* that consisted of 12 items describing different beliefs like "Children tend not to be interested in household chemicals" or "Children should be taught how household chemicals should be used" (see Bearth et al., 2022). Parents had to rate all items on a five-point Likert scale (1 = *Do not agree* to 5 = *Fully agree*). The *belief* subscales of *trusting-pragmatic, protective,* and *educational* yielded internal consistencies of $\alpha = 0.67$, $\alpha = 0.69$, and $\alpha = 0.78$, respectively.

We also assessed caretakers' risk perception with two scales previously developed by Bearth et al. (2022). The scale *Risk Perception: Product Attributes* assesses parents' risk perception concerning product attributes by asking to what extent certain household chemicals might influence the interest of preschool children. Parents rated 10 items on a five-point Likert scale (1 = *Not at all interesting* to 5 = *very interesting*). This subscale yielded an internal consistency of Cronbach's alpha $\alpha = 0.79$. The second risk perception-related scale assessed environmental attributes that influence the caretakers' risk perception. For the *Risk Perception: Environmental Attribute* scale, parents rated different situations described in 15 items on a five-point Likert scale (1 = *No risk at all* to 5 = *very high risk*). These items ranged from situations like "Refilling of household chemicals (e.g., cleaning agents, antifreeze) into PET bottles" to "A cleaning cabinet that cannot be locked." The internal consistency of this scale was $\alpha = 0.91$.

We also assessed the *child's interest in household tasks* rated by the caretakers with three self-made items: "My child imitates my behavior when I am busy with household tasks," "My child wants to help me with my household tasks," and "My child independently acts out situations from everyday household life (e.g., cooking, cleaning, shopping)." The parents were asked how strongly they agreed with these statements and rated these items on a five-point Likert scale (1 = *Do not agree at all* to 5 = *Fully agree*). The Cronbach's alpha of this scale was $\alpha = 0.79$.

Finally, we assessed *parents' trust in their child* by rating three items: "My child is able to recognize dangers independently," "Generally, my child does not expose himself/herself to any dangers," and "My child protects himself/herself from danger." Again, the parents rated these items on a five-point Likert scale (1 = *Do not agree* to 5 = *Fully agree*). This scale yielded a Cronbach's alpha of $\alpha = 0.80$.

4.4. Data analysis

All data were analyzed with R 4.1.1 statistical software (R Core Team, 2021). For the *product attribute task*, an exact binomial test was used to test whether the different labels (bird vs no bird) or closure types (child-resistant vs spray) influenced the number of times the children chose the corresponding products. For the *storage situation task,* we conducted Chi-square tests to analyze whether the storage context (food vs chemical) or product type (dishwasher tab vs laundry pod vs candy) influenced children's categorization. For the *chemical product sorting task*, we summarized the number of products categorized as only for adults in a *precaution score* for both participants separately. We used correlations to investigate the relationship between parents' beliefs and the participants' sorting of household chemicals. Finally, we performed a Wilcoxon signed-rank test to determine whether parents and children differed in their *precaution scores*.

5. Results

5.1. Product attribute task

In Table 1, the frequencies of the children's choices are displayed. We analyzed the influence of product labels and closure

Table 1
Product Attribute Task: Number and Percentage (in Parentheses) of Children Selecting Specific Products Grouped by Label, Closure, and Control Items for the First, Second, and Third Choice.

	Bird Label		No Bird Label		Control		
Choices	Child-res. *n* (%)	Spray *n* (%)	Child-res. *n* (%)	Spray *n* (%)	Brush *n* (%)	Sponge *n* (%)	Glove *n* (%)
First (n = 109)	14 (13)	21 (19)	9 (8)	6 (6)	35 (32)	12 (11)	12 (11)
Second (n = 106)	20 (19)	14 (13)	13 (12)	9 (8)	15 (14)	25 (24)	10 (9)
Third (n = 104)	17 (16)	9 (9)	9 (9)	16 (15)	15 (14)	16 (15)	22 (21)
Total (n = 319)	51 (16)	44 (14)	31 (10)	31 (10)	65 (20)	53 (17)	44 (14)

types in two scenarios: *first choice* and *general preference*. The *first-choice* scenario focused on children's initial choice. This simulates a brief unsupervised period commonly encountered at home in which children only have time to make one choice (Pollack-Nelson & Drago, 2002). Approximately half of the children selected one of the bottles in their first choice (Table 1). To test whether the label or closure type of these bottles influenced children's preferences, we carried out an exact binomial test. The observed probability (P_O) was tested against an expected probability (P_E) of $P_E = 0.50$ for all tests. An expected probability of $P_E = 0.50$ indicates no difference in preference between bottles with or without specified attributes. Children selected a bottle with a cartoon bird label significantly more often than a bottle without one in their first choice $P_O = 0.70$, $p = .007$, $n = 50$, 95% CI [0.55, 0.82], implying a *first-choice preference* for cartoon bird labels. However, we did not observe a difference regarding the *first-choice preferences* for sprayer-type closures $P_O = 0.54$, $p = .672$, $n = 50$, 95% CI [0.39, 0.68].

To support the results of the *first-choice* scenario, we examined the first bottle selected by each child in the entire task in a *general preference* scenario. In Fig. 3, we display the resulting proportions of children's first selected bottles grouped for each product attribute. The results of an exact binomial test show that significantly more children selected a bottle with a cartoon bird label first compared to a bottle without one $P_O = 0.70$, $p < .001$, $n = 105$, 95% CI [0.60, 0.78]. Comparing the two closure types, we again did not find a significant difference in preference for sprayer-type closures, further strengthening the assumption that sprayer-type closures do not influence the children's preferences in such a scenario $P_O = 0.53$, $p = .558$, $n = 105$, 95% CI [0.43, 0.63].[2] Therefore, these results suggest that product labels had a significant impact on children's preferences, while closure types did not.

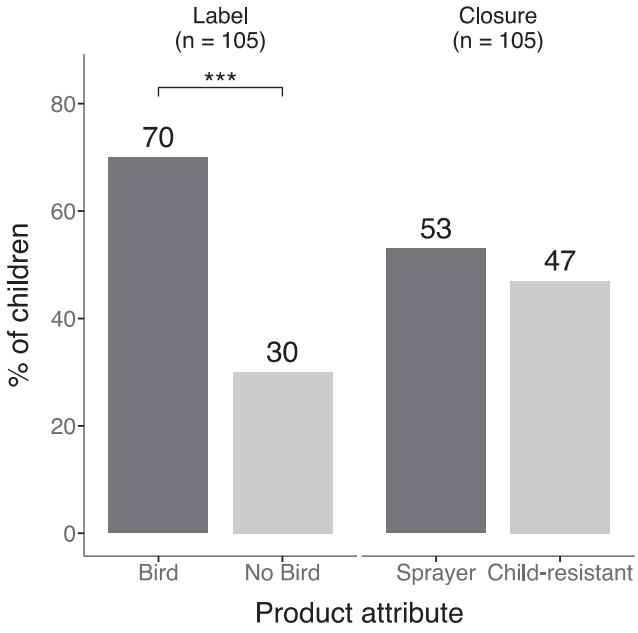

Fig. 3. *Product Attribute Task: Percentage of Children Selecting a Specific, Bottle First Grouped by Either Label or Closure Type in the General, Preference Scenario (n = 105), Note.* *** $p < .001$.

5.2. Storage situation task

Table 2 shows the number of children who categorized the given target product in a certain condition as something edible or not. We first investigated the answers of all children, regardless of their experimental condition. As shown in Table 2, 65 out of 112 children rated dishwasher tabs as edible. Regarding the laundry pods, 35 out of 113 children considered them edible, and 90 out of 107 children rated candy to be edible. The results suggest that more than half of the children seemed to struggle with correct categorizations of dishwasher tabs, and one-third had difficulty with laundry pods regardless of their storage condition.

Regarding the storage condition, the children categorized dishwasher tabs more often as something edible in the food context than in the chemical context, χ^2 (1, $n = 112$) = 8.25, $p = .004$ (see Table 2). In terms of laundry pods, we did not find a significant difference between the two conditions, meaning that for these items, the storage context did not influence the children's ability to categorize them correctly, χ^2 (1, $n = 113$) = 0.45, $p = .500$. Finally, for candy, we also did not find a significant difference between the two conditions, χ^2 (1, $n = 107$) = 0.56, $p = .452$, confirming our assumption that children were able to recognize candy as something edible regardless of the context.

5.3. Chemical product sorting task

Fig. 4 shows the percentage of children and parents who categorized a specific product as child-safe. Overall, at least 20% of children rated each product as child-safe, leading to the assumption that children in general struggled to identify household chemicals as such. Furthermore, there seems to be a clear difference between children and their parents in their categorization of most of the products. The largest discrepancy (at least 40%) between parents and their children can be seen within the dishwasher detergents category. Interestingly, parents do not distinguish between different editions of dishwasher detergents by the same brand, whereas children do. Compared to the classic packaging, dishwasher detergents with lemon or bird packaging were rated about 10% more often by the children as child-safe. We can observe the same effect within the product category of scouring milk. Both scouring milks were from the same brand, but the one with cartoon-style packaging was rated as child-safe by 18% more children than the classic packaging. These observations further strengthen the effect of children's preference for cartoon-style labels found in the product attribute task. Around 32% of parents rated essential oil as child-safe, despite the common warning labels on that specific product. Consequently, parents were either unaware of these warning labels or ignored them.

[2] Controlling for potential positioning effects, by excluding children that grabbed the bottle closest to their hand, led to the same conclusion.

Table 2
Storage Situation Task: Number of Children Rating Item as Edible or Not (n), Total Observations for Each Condition (nc), and Chi-Square Test Statistic for Candy, Pods, and Tabs.

		Chemical context		Food context			
Item	Answer	*n* (%)	n_c	*n* (%)	n_c	$\chi^2(1)$	*p*
Tabs (*n* = 112)	Edible	25 (45)	56	40 (71)	56	8.25	0.004
	Not edible	31 (55)		16 (29)			
Pods (*n* = 113)	Edible	16 (28)	57	19 (34)	56	0.45	0.500
	Not edible	41 (72)		37 (66)			
Candy (*n* = 107)	Edible	44 (82)	54	46 (87)	53	0.56	0.452
	Not edible	10 (18)		7 (13)			

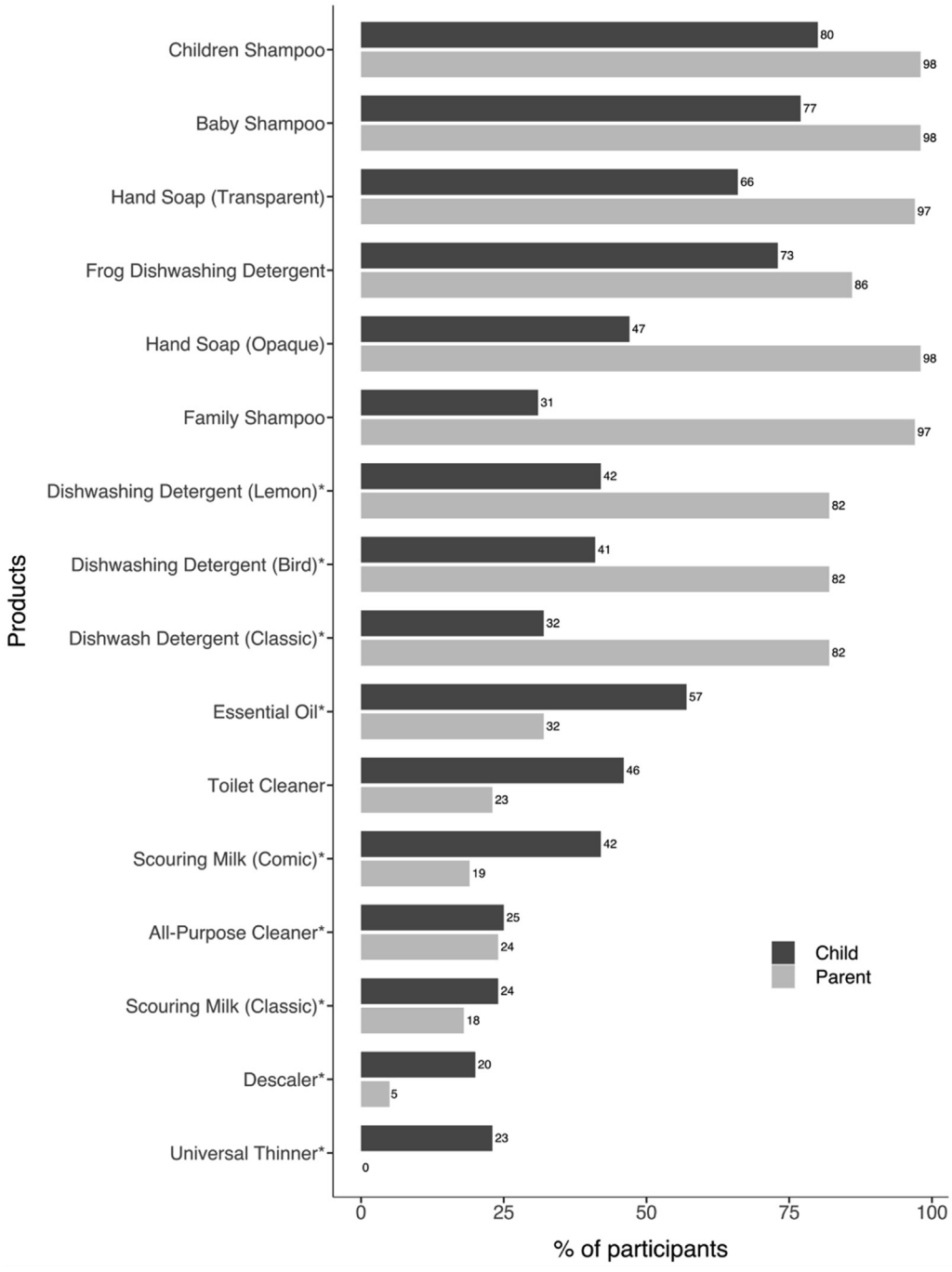

Fig. 4. Chemical Product Sorting Task: Percentages of Children and Their Parents who Categorized Household Chemicals as Child-Safe. Note. Sample size varies between 110 and 114 because not every participant categorized every item. * Products with at least one printed warning label on the packaging.

As an estimate for parents' and their children's overall level of caution, we assumed that the more products the participants sorted as "adults only," the more cautious their behavior regarding household chemicals is. Therefore, we calculated a *precaution score* by summing the number of all products that the participants rated as "adult only." We performed a Wilcoxon signed rank test on the participants' *precaution scores* to quantify the observed differences in the categorization between parents and children. The test revealed that parents ($Mdn = 7$) had a significantly lower *precaution score* compared to their children ($Mdn = 9$), $V = 4366$, $p < .001$, $n = 114$. In Table 3, we summarize the correlations between parental beliefs and the *precaution scores* of children and their parents. No parental belief was significantly related to children's *precaution scores*. However, we found significant correlations between the parents' *precaution scores* and their beliefs. Parental educational beliefs were negatively related with their *precaution score*, implying that the higher the parental educational beliefs, the more children were allowed to use household chemicals or vice versa ($r = -0.22$, $p = .017$). Furthermore, we found a positive relationship between protective parental beliefs and their *precaution scores*, supporting our assumption that the higher the *precaution score*, the more cautious the decision-making toward household chemicals or vice versa ($r = 0.23$, $p = .014$). Finally, a significant negative relation between pragmatic or trusting parental beliefs and parental risk perception of either product or environmental attributes emerged ($r = -0.24$, $p = .011$). This negative relation implies that parents with pragmatic or trusting beliefs tend to perceive the product or environmental attributes of household chemicals as less risky for their children and vice versa.

6. Discussion

Unintentional injuries with household chemicals occur when children are left unattended or when these products are not stored in a safe way. When children encounter household chemicals without an adult guiding them, children must decide by themselves whether these products pose a risk. This highlights the importance of clear product attributes, storage contexts, and parenting styles to help children in their categorization process and the safe handling of household chemicals. In this study, children preferred household chemicals with cartoon-style labels and more often interacted with products with such labels, whereas the closure type did not influence their preference. The preference for cartoon-style labels was found to be consistent not only in a *general* scenario but also in a *first-choice* scenario simulating a situation in which children only have a brief time to make a decision. Although we used only a cartoon bird label in our study, results from the *chemical product sorting task* and previous research further strengthen our finding that cartoon-style labels increase the preference of children (Ogle et al., 2017; Roberto et al., 2010). According to categorization theory (Gelman & Meyer, 2011; Rakison & Lupyan, 2008; Sloutsky, 2003), children might have difficulties categorizing household chemicals with cartoon labels because they associate these products with similar child-safe products. Furthermore, we found that the children struggled to correctly categorize laundry pods and dishwasher tabs. This is in line with previous findings that hospitalizations after exposure to household chemicals of this type are most common in children within the age group of this study (Swain et al., 2016; Valdez et al., 2014). In the current study, the children particularly struggled with the correct categorization of single-packed dishwasher tabs. However, it was not clear what specific factor led to this increase in the miscategorization of dishwasher tabs. Based on categorization theory (Sloutsky, 2003), we can assume that similarities between individually packed dishwasher tabs and the packaging of candy might lead to these difficulties. Due to ambiguous attributes (e.g., candy-like packaging), children may not have been able to categorize the household chemicals based on their similarities alone and had to rely on the context. Thus, children might have used their associations with the given context to categorize the given household chemicals, as assumed in categorization theory (Rakison & Lupyan, 2008). However, these assumptions have yet to be confirmed. Regarding parental beliefs on household chemicals, we found a significant association between parental beliefs and their decisions on the hazardousness of household chemicals but not with their children's decisions. While previous work found a relation between parenting and children's risk-related behavior (Morrongiello et al., 2014, Schwebel et al., 2004), our findings hint at potential limitations of parenting on behavior-related processes (e.g., cognitive decision whether product is child-safe).

Taken together, our findings suggest parents or caregivers should pay attention to the package design of the products they purchase, as the design can play an important role in how children interact with the product. As a practical implication, parents could cover labels that might be misleading to their children (e.g., cartoon characters, food). Furthermore, manufacturers need to consider product attributes like labels not only regarding their marketing strategy, but also regarding the potential effect on children's ability to categorize these products as household chemicals. Additionally, the results highlight the importance of dedicated cleaning cabinets. Next to the fact that the storage cabinets for household chemicals should be lockable and elevated, dedicated cleaning cabinets provide a clear context for children and help them associate the stored products with household chemicals. This suggestion is in line with multiple other studies on the prevention of unintentional injuries with household chemicals (Beirens et al., 2006; Gibbs et al., 2005; Jaques et al., 2018; Morrongiello et al., 2006). Finally, the results of this study suggest that the way parents handle household chem-

Table 3
Chemical Product Sorting Task: Pearson Correlation Coefficients for Both Participants Precaution Scores, Parenting Styles, Parents' Beliefs, Risk Perception, Child's Interest in Household Tasks, and Trust in Their Child (n = 114).

Scale	1	2	3	4	5	6	7	8	9	10	11
1: Precaution Score Children	-										
2: Precaution Score Parents	0.04	-									
3: Childs Age	-0.09	-0.12	-								
4: Childs Sex	-0.10	0.12	-0.17	-							
5: Parents' Beliefs (Pragmatic / Trusting)	0.05	-0.04	0.06	-0.08	-						
6: Parents' Beliefs (Educational)	-0.07	-0.22*	-0.21*	-0.18	0.03	-					
7: Parents' Beliefs (Protective)	0.04	0.23*	-0.08	-0.03	-0.03	-0.36***	-				
8: Risk Perception: Product Attributes	0.06	0.01	0.05	0.14	-0.24*	0.02	0.04	-			
9: Risk Perception: Environmental Attributes	-0.07	0.22*	-0.14	0.13	-0.24*	-0.03	0.27**	0.45***	-		
10: Childs' Interest in Household Tasks	0.05	0.00	-0.14	-0.22*	-0.22*	0.27**	-0.07	0.10	0.03	-	
11: Trust in Child	-0.06	-0.18	0.32***	-0.01	0.49***	0.02	-0.12	-0.18	-0.17	-0.09	-

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

icals at home might not influence children's ability to correctly categorize household chemicals. Therefore, policy makers should rather focus on parents' ability to identify household chemicals as hazards and improve their knowledge about the risks posed by these products, as these factors relate to reduced numbers of hazards at home (Mayes et al., 2014).

6.1. Limitations and implications for further research

One goal of this study was to provide insights into how children perceive product attributes and how these products' attributes influence children's decision-making toward them. However, regarding product labels, we only tested for one specific cartoon figure on the label; thus, it is not fully clear whether cartoon figures or cartoon-style labels in general are more interesting to children. Research in the food domain already suggests that cartoon figures generally lead to higher preferences of food (Ogle et al., 2017; Roberto et al., 2010). Thus, future research should focus on the general effect of cartoon figures on children's risk perception of household chemicals. Furthermore, this study aimed to investigate how product attributes in combination with contextual information influence children's categorization. Although our findings have helped to understand how children categorize unfamiliar objects depending on their contextual information, it is not entirely clear what leads children to consider context in their decision-making in the first place. Future research should explore the assumption that the ambiguity of product packaging leads children to focus more on context rather than the product itself. Additionally, this study helped to provide insights into the relation between parental beliefs and children's decision-making regarding household chemicals. However, future studies should focus more on risk communication between parents and their children and on the effectiveness of different communication approaches through the different developmental stages of their children. In general, this study provided valuable insights on children's cognitive decision-making regarding household chemicals. However, epidemiological data suggests that most children exposed to household chemicals are even younger than our sample (McKenzie et al., 2010). Future research could look at whether cognitive decision-making regarding household chemicals remains the same in an even younger population.

7. Conclusions and Practical Applications

This study systematically investigated the effects of product attributes, contextual information, and parental beliefs on children's decision-making toward household chemicals. The fact that in this study the children's decision-making was influenced by product attributes and contextual information, but not by parental beliefs, emphasizes the responsibility of manufacturers, policymakers, and parents. Manufacturers must consider that their design decisions could potentially lessen the risk perception by parents and their children and highlight the need for further investments in the development of adequate product packaging. Furthermore, policymakers should consider that to prevent accidents, parents must be aware of the risks these household chemicals pose. Thus, it is important that policymakers develop evidence-based measures to spread awareness of these risks.

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Declaration of Interest

The authors declare no conflict of interests.

CRediT authorship contribution statement

Noah Bosshart: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Visualization, Writing – review & editing. **Angela Bearth:** Conceptualization, Formal analysis, Methodology, Supervision, Validation, Writing – review & editing. **Stephanie Wermelinger:** Conceptualization, Formal analysis, Methodology, Supervision, Validation, Writing – review & editing. **Moritz Daum:** Conceptualization, Methodology, Supervision, Validation, Writing – review & editing. **Michael Siegrist:** Conceptualization, Methodology, Supervision, Validation, Writing – review & editing.

Appendix A

A.1. Additional tables

See Table A1.

Table A1
Products Used in the Chemical Product Sorting Task.

 Children Shampoo	 Baby Shampoo	 Hand Soap (Transparent)	 Frog Dishwashing Detergent
 Hand Soap (Opaque)	 Family Shampoo	 Dishwashing Detergent (Lemon)	 Dishwashing Detergent (Bird)
 Dishwashing Detergent (Classic)	 Essential Oil	 Toilet Cleaner	 Scouring Milk (Comic)
 All-Purpose Cleaner	 Scouring Milk (Classic)	 Descaler	 Universal Thinner

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jsr.2022.09.015.

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