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Consumers' Risk Perception and Safe Handling of Chemical Household Products

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Summary

The aim of this thesis is to improve our understanding of how consumers handle chemical household products and which factors contribute to the safe handling of these products. Chemical household products are frequently involved in household accidents, with young children especially often being the victims. However, little is known about consumers' perception and handling of such products. Prevention campaigns and specific warnings on the packaging of chemical household products do exist, but their effectiveness remains unclear.

Therefore, first, we examined consumers' perception of chemical household products (Chapter Two). To do this, we conducted a representative online survey in three of the four language regions of Switzerland. The results showed that although consumers know that such products can be dangerous, they do not intuitively think of the risks associated with them. Additionally, we conducted a cross-cultural online survey in eight European countries (Chapter Three). Only a few regional differences were found. Moreover, this survey showed that consumers use not only hazard-related information to judge the risks of a specific product, but also product- and marketing-related information.

Then, we examined consumers' decision-making process when selecting a chemical household product (Chapter Four). To obtain observable measures of consumers' behaviour, we conducted a laboratory study in a virtual environment with eye tracking implemented to the system. The data of this experiment revealed that if consumers are not prompted about the risk, they hardly look at the warnings or other risk-relevant information. We also showed that consumers who selected a safer product with no pictograms from the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) had studied the products more thoroughly than consumers who selected more dangerous products with GHS pictograms.

Finally, in the last study presented in this thesis, we examined the influence of packaging design on consumers risk perception (Chapter Five). As consumers do not seem to notice the warnings on the packaging, other packaging features may influence consumers' risk perception. To investigate this, we conducted an online experiment. Indeed, we found that the colour of the packaging (pink or black packaging versus the original packaging), pictures of flowers on the label and food-imitating elements on the packaging all significantly influenced participants' risk perception.

The factors that influence consumers' risk perception described above would have little impact on the number of accidents if they appeared in isolation. However, their simultaneous presence makes the likelihood of an accident a lot higher.

Résumé

L'objectif de ma thèse est d'élargir notre compréhension sur la manière dont les consommateur·rice·s manipulent les produits chimiques ménagers et quels sont facteurs qui contribuent à un comportement sûr en la matière. En effet, ces produits sont souvent cités comme étant la cause directe ou indirecte de nombreux accidents ménagers, dont les enfants en basse âge sont principalement les victimes. Malgré cela, on connaît relativement peu sur la perception des consommateur·rice·s de ces produits et sur la manière des consommateur-e-s de les manipuler. Des campagnes de prévention existent et des messages d'alerte sur les risques figurent sur les emballages, mais leur efficacité n'est pas démontrée.

Cela étant donné, nous avons étudié la perception des consommateur·rice·s vis-à-vis des produits chimiques ménagers (chapitre deux). Dans cette perspective, nous avons effectué un sondage en ligne dans trois des quatre régions linguistiques de la Suisse. Les résultats démontrent que même si les consommateur·rice·s connaissent les risques des produits chimiques ménagers, ils ou elles n'y pensent pas de manière intuitive. Nous avons également conduit une enquête en ligne dans huit pays européens (chapitre trois). Peu de différences régionales ont ainsi pu être mise à jour. Nous avons pu cependant démontrer dans cette enquête que les consommateur·rice·s n'utilisent pas uniquement des informations en lien avec les risques pour évaluer la dangerosité d'un produit, mais également des informations en lien avec le produit et le marketing.

Dans une troisième étude, nous avons examiné la manière qu'ont les consommateur·rice·s de choisir un produit chimique ménager (chapitre quatre). Afin d'avoir des mesures observables, nous avons conduit cette expérience laboratoire dans un environnement virtuel et avec un système d'oculométrie (système de suivi oculaire) implémenté. Les données de cette étude montrent que si les consommateur·rice·s ne sont pas rendus attentifs aux risques : ils ou elles font rarement attention aux avertissements de mise en danger ou à d'autres informations sur des risques potentiels. Nous avons aussi pu mettre en évidence que les personnes qui ont choisi un produit plus sûrs et sans pictogrammes du système général harmonisé de classification et d'étiquetage des produits chimiques (GHS) avaient examiné les produits avec plus de rigueur que les personnes qui ont choisi un produit plus dangereux et avec des pictogrammes GHS.

Finalement, dans la dernière étude présentée dans cette thèse, nous avons examiné l'influence de l'aspect marketing de l'emballage sur la perception des risques des

consommateur·rice·s à l'aide d'une enquête en ligne (chapitre cinq). Étant donné que les consommateur·rice·s ne semblent pas s'apercevoir des avertissements de mise en danger figurant sur les emballages, on peut constater que d'autres éléments du design de l'emballage sont susceptibles d'avoir une influence sur la perception des risques des utilisateur·rice·s. En effet, nous avons pu démontrer que la couleur de l'emballage (rose ou noir versus la couleur originale), des fleurs sur l'étiquette ainsi que des éléments d'emballage imitant de la nourriture ont tous une influence significative sur la perception des risques par les consommateur·rice·s.

Tous les facteurs influençant la perception des risques que je viens de décrire auraient peu d'importance s'ils apparaissaient de manière isolée. Mais leur présence simultanée accroit nettement le risque d'accident avec des produits chimiques ménagers.

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Abbreviations

A.I.S.E.	International Association for Soaps, Detergents and Maintenance Products
ANOVA	Analysis of Variance
CI	Confidence Interval
DIY	Do-It-Yourself
EU	European Union
FIP	Food Imitating Products
GHS	Globally Harmonized System of Classification and Labelling of Chemicals
M	Mean
Mdn	Median
PCA	Principal Component Analysis
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
SD	Standard Deviation
TV	Television
UK	United Kingdom
US	United States of America
VR	Virtual Reality

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General Introduction

1.1 Introduction

Household accidents with chemical products regularly make the headlines. To give a recent example, at the beginning of 2020, with the rise of the COVID-19 pandemic toxicological centres in multiple countries reported a strong increase in intoxications with disinfectants and other household cleaners, especially for children. It seems that the increased availability of these products in private households and the lack of risk awareness on behalf of parents led to a substantial number of involuntary poisonings (Crescioli et al., in press; Harding, 2020; Mahmoud et al., 2021; Schenk-Jäger et al., 2020).

The example above is not an isolated case. Chemical household products, such as detergents and cleaners, are regularly involved in household accidents (Tox Info Suisse, 2020). Young children are involved especially often, but besides young age, other risk factors might also increase the risk of intoxication, such as dementia or being under the influence of drugs, alcohol, sleep deprivation or stress. Furthermore, some accidents occur without any seemingly reasonable mitigating factors, as was the case with the so-called *Tide Pod challenge*, which involved adolescents eating laundry capsules, probably without being aware of the toxic characteristics of these products (Interlandi, 2018).

Chemical household products are all chemical consumer products that cannot be eaten and are neither cosmetics nor medications. This product category mainly includes cleaning agents and detergents as well as more specific chemicals, such as essential oils or lamp oil. While these products bring many advantages, such as increased hygiene, they do also carry certain risks for human health and the environment, like intoxication, when used in an unsafe manner (International Association for Soaps Detergents and Maintenance Products & International Scientific Forum on Hand Hygiene, 2021).

The aim of this thesis is to study the factors that influence consumers' risk perception and behaviour in relation to chemical household products. Therefore, we studied consumers' perception of chemical household products, the way that consumers choose chemical household products when shopping and, finally, the influence of packaging on consumers' perception of these products.

1.2 Use of Chemical Household Products and Related Accidents

First, I will describe the available data and estimations regarding the different types of accidents with chemical household products. Then, I will discuss behaviour that can lead to accidents with chemical household products.

1.2.1 Incidence

The consequences of accidents involving chemical household products can vary. While many people instinctively think of intoxication in relation to chemical household products, such products can also lead to burns and corrosion when inhaled or in contact with skin (Swiss Federal Office of Public Health, 2014). Unfortunately, to the best of my knowledge, when it comes to the frequency of accidents caused by chemical household products, we can only rely on assumptions, as comprehensive data have not been collected so far.

However, some toxicological centres publish the number of queries that they receive on their hotlines. Most toxicological centres run a hotline that can be used both by professionals (e.g. emergency rooms, pharmacies, general practitioners) and lay people alike. The number of requests is indicative of the frequency of intoxications. However, it should be noted that not all victims of intoxications seek professional help and that some victims will seek help elsewhere (e.g. general practitioners, pharmacies). In Switzerland in 2019, more than 25% of all queries received by the national toxicological centre were related to intoxications involving household products (Tox Info Suisse, 2020). Similarly, in the United States in 2019, cleaning substances were the second most frequent category in intoxications due to single substance exposures (e.g. only one substance involved rather than multiple products) (Gummin et al., 2020). These data show that compared to other substances, chemical household products are often involved in intoxications.

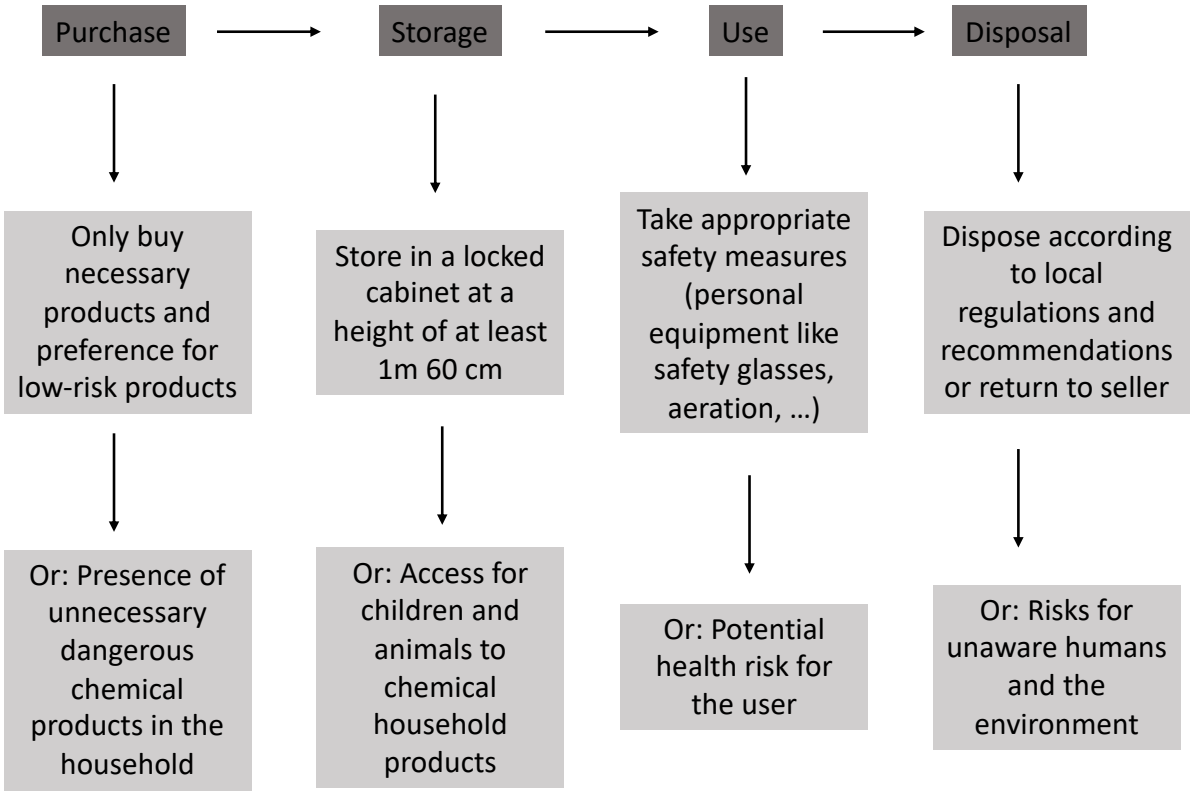
Regarding accidents other than intoxications, some medical insurance companies have collected data. While these data are not representative, as they only include the customers of the insurance companies, they do provide an initial insight into the scope of the risk. For example, the mandatory accident insurance for all employees in Switzerland revealed an incidence of 0.005% a year for eye injuries caused by chemical substances (Tschopp et al., 2015). While this may seem like a low incidence, one should not forget the high economic cost of every accident (e.g. treatment costs as well as loss of workforce capability by the victim and relatives if the victim needs care) and the significant personal suffering of the victims and their relatives.

1.2.2 Critical Situations

Human behaviour in different situations can lead to (future) accidents with chemical household products, which do not exclusively occur when the products are being actively used (see Figure 1). Potentially dangerous situations can occur when (i) when consumers select and purchase a chemical household products, (ii) when they store chemical household products in their home, (iii) when they use the chemical household products and (iv) when they dispose of

the chemical household products (Swiss Federal Office of Public Health, 2018). In what follows, these four situations are described in more detail.

Figure 1. *Critical Situations When Handling Chemical Household Products and Recommendations for Safe Use.*



First, the products that are stored in private households and can potentially lead to accidents depend on consumers' purchases. If a consumer only buys products with low-risk profiles, then the consequences of potential accidents will be smaller. Therefore, the choice of a specific chemical household product at the point of sale impacts the safety of consumers and their families.

After the purchase of such products, it is important to consider their storage. According to the official Swiss guidelines, chemical household products should be stored in their original packaging at a minimum height of 160 cm in a locked cupboard (Swiss Federal Office of Public Health, 2018). There are two reasons for these guidelines. First, children and pets, even if only visiting, should not have access to the products. Second, chemical household products should be securely stored so that they are not mistaken for food - for example, when someone is very

tired, stressed or under the influence of alcohol, drugs or medication. A Turkish study found that incorrect storage was most often the main reason for poisoning accidents with cleaning agents by young children (Erkal & Şafak, 2006). Similarly, this can also be expected in other developed countries.

Accidents can also occur when chemical household products are being used. However, besides implementing safety measures in general, users also need to choose the correct measures. For example, it is more important to wear glasses than gloves when cleaning a toilet, as many toilet cleaners are corrosive, and burns to the eyes have far more severe long-term consequences (e.g. blindness) than burns to the hands (e.g. scars).

Finally, chemical household products have to be correctly disposed of to no longer pose a risk to human health and the environment. If such products are not correctly disposed of, the same risks can occur as if they were incorrectly stored. In fact, other people can be harmed if they find the packaging with content and are not expecting a chemical product (Slack et al., 2005).

1.3 Consumers' Risk Perception and Behaviour

Risk perception is a prerequisite for consciously engaging in safe behaviour. In this section, I will discuss the most important aspects that influence lay people's risk perception in relation to chemical household products. Then, I will discuss the relation between risk perception and actual behaviour.

1.3.1 Risk Perception of Lay People versus Toxicologists

Contrary to toxicologists and experts, lay people cannot rely on their professional expertise to perform objective risk assessments of chemical products. They usually have neither the resources (e.g. time) nor the knowledge to carry out objective risk assessments. Therefore, lay people's risk perception strongly differs from the perception of toxicologists and other experts in the field (Kraus et al., 1992; Mertz et al., 1998; Neil et al., 1994; Slovic et al., 1995; Slovic et al., 1997).

Among other differences, the use of heuristics to determine risks is widespread among lay people (contrary to toxicologists or other experts). Heuristics are mental shortcuts, commonly known as "rules of thumb." While the use of heuristics, in most cases, is a very efficient and effective way of assessing an unknown characteristic, heuristics do entail a certain error rate. This is somewhat problematic when the consumer is assessing the potential risks of a dangerous product and (i) underestimates the risks due to a heuristic and does not take the necessary precautions or (ii) overestimates the risks and, therefore, takes unnecessary safety

measures, thus using resources (e.g. safety equipment, time, attention) that could be used elsewhere.

Some heuristics are assumed to be typically used when assessing the risks of chemical household products. For example, lay people tend to rely on the so-called halo effect: assessing a product's unknown characteristics (e.g. the product's risk level) via information on known similar characteristics of that product. For example, previous research has shown that organic products are considered to be safer than synthetic products by many lay people (Bearth et al., 2017), because naturalness is a characteristic that evokes positive attributes (Rozin, 2005; Rozin et al., 2004). Furthermore, products resembling foods (food-imitating products [FIP]) tend to also be perceived as less dangerous (Basso et al., 2014).

1.3.2 Relation between Risk Perception and Safety Behaviour

Consumers' safety behaviour is predicted by various factors. Although, in an ideal world, human beings would assess the risks and benefits of every decision that they make, this is not practical in everyday life. For example, it is unlikely that anyone would compare the risks of taking the stairs versus taking the lift every time they leave a building by considering both the severity of all potential risks (e.g. the age of the lift, the last service of the lift, the number of steps in the staircase and their height, the illumination of the staircase) and their probability and then comparing them with potential benefits. Therefore, human beings do not base their daily behavioural decisions on scientific and objective risk assessment; rather, they rely on other factors, such as their feelings or intuition. While there are different models proposed in the literature that describe lay people's decision-making (e.g. the Health Belief Model by the US Health Service (Janz & Becker, 1984) or the Theory of Planned Action by Ajzen (1991)), risk perception plays a significant role in all of them. However, a person's level of risk perception does not directly translate into preventive behaviour due to the influence of other factors, such as lack of resources (see also the intention-behaviour gap described by Sheeran (2002)). As described above, a person actually perceiving the risks is a prerequisite for taking safety measures intentionally and not only by habit; therefore, risk perception explains at least a part of a person's behaviour in risky situations.

1.4 Warnings

The use of warnings is one possible way of mitigating the lack of risk perception. Warnings increase risk perception and are a way of promoting safe behaviour when risk perception is lacking. However, warnings are useful only if users see them, understand them and, finally, are motivated to respect them (Laughery & Wogalter, 2014).

If consumers do not see or notice a warning, then, for obvious reasons, this warning will not be effective. For warnings to be seen, they must be easily visible on the packaging. Prior research has shown that warnings are more likely to be followed if they are placed on the front of the packaging (Laughery et al., 1993) or directly before use instructions (Wogalter et al., 1987).

Then, the warnings should inform users about the risks and provide the users with information about possible mitigation measures (Laughery & Wogalter, 2014; Wogalter et al., 1987). Effective warnings should serve as the only necessary source of information, without consumers having to rely on heuristics or guessing.

Finally, warnings will only be respected if users have enough motivation to follow them (Laughery & Wogalter, 2014). Consequently, users need to not perceive too many barriers (e.g. lack of time) to taking the appropriate safety measures and must have sufficient resources (e.g. protective equipment, such as glasses or gloves).

1.5 Current Regulatory Situation Regarding Warnings

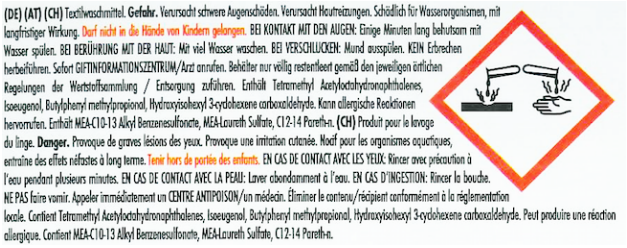
Currently, the sale of chemical household products underlies many regulations in most countries. There have been some efforts by the United Nations to unify these regulations at the international level with the aim of simplifying international trade and increasing the security of these products by reducing misunderstandings due to national differences (United Nations Economic Commission for Europe, 2017). Furthermore, the European Union (EU) has adopted common regulations regarding the registration, evaluation, authorisation and restriction of chemicals (REACH) for all their member states (The European Parliament and The Council of the European Union, 2006). In Switzerland, the regulation of chemical household products is a cantonal matter, but due to international trade, many EU regulations apply de facto.

1.5.1 Globally Harmonized System (GHS)

In 1992, as part of the AGENDA21 report, the aim was set to establish a worldwide unified labelling system for chemical products (United Nations Economic Commission for Europe, 2017; Winder et al., 2005). These labels (see Figure 2) consist of pictograms that indicate the most serious dangers and of precautionary and hazard statements that provide additional information about the nature of the hazard and possible mitigation measures (United Nations Economic Commission for Europe, 2017). The GHS was ratified in 2002 and has since been implemented in many countries worldwide (United Nations Economic Commission for Europe, 2017; Winder et al., 2005).

The validity of the GHS was not studied prior to its ratification. However, a few studies have been conducted after its ratification and before its implementation as well as since its implementation. These studies indicate that lay people have difficulties in understanding the meaning of some of the GHS pictograms (Boelhouwer & Davis, 2010; Hesse et al., 2010).

Figure 2. *Example of a GHS Label.*



1.5.2 Safe Use Icons

In an effort to provide more understandable labels, the International Association for Soaps, Detergents and Maintenance Products (A.I.S.E.) developed the Safe Use Icons (see Figure 3). These are used in addition to the GHS labels by many manufacturers of chemical household products. However, to the best of my knowledge, few studies evaluating their validity have been published. One study found that lay people preferred simplified versions of the icons used, although this had no influence on their risk perception or behaviour when handling the products (Geuens et al., 2021).

Figure 3. *Example of a Safe Use Icon.*

1.5.4 Consumer Groups Demands

Worldwide consumer groups regularly demand safer chemical household products as well as simplified and unambiguous labelling. While some of their demands are not practical (e.g. zero risk products are technically impossible), others highlight problematic practices,

especially with regard to ambiguous product design (Institut national de la consommation, 2019; Miller et al., 2006; Perton, 2006). In an attempt to tackle this problem, a labelling system for chemical household products, similar to the *nutriscore*[1], was developed in France in 2019 by a consumer organisation. The aim of this system, known as *Ménag'Score,* is to provide the consumer with a simplified rating of a chemical household product's risks (Institut national de la consommation, 2019). However, the system has not been implemented so far. Furthermore, it remains unclear how the scores are determined and whether the concentration of the components is considered.

1.6 Methodological Challenges

Given the problematic outlined so far, potentially risky behaviour regarding chemical household products is an interesting topic of research. However, studying potentially risky behaviour regarding chemical household products comes with some methodological challenges. These challenges and possible solutions will be discussed below.

1.6.1 Social Desirability

Humans like to present themselves in a favourable light. This means that in surveys, participants tend to give socially biased answers and that in laboratory studies, participants do not always act as they would in their day-to-day life (Nederhof, 1985). Regarding risky behaviour, it is socially expected that we should try to avoid risky situations or take safety measures to mitigate the risks. However, despite this expectation, for different reasons (e.g. lack of motivation, perceived barriers), many people engage in risky behaviour, as the numbers of accidents show (Tox Info Suisse, 2020). Therefore, it is important that participants do not feel judged regarding their opinions and behaviour and, for laboratory experiments, that the experimenter is as non-obtrusive as possible. This, for example, can be obtained by conducting experiments in virtual reality (VR), whereby the experimenter has no active role during task completion.

1.6.2 Recall Bias

Even if participants answer surveys honestly, their responses can be biased. In fact, humans are incapable of remembering every detail and are not aware of all the processes that take place when making a behavioural decision (Clarke et al., 2008; Khare & Vedel, 2019). For example, it is unlikely that you can remember what you ate for supper eleven days ago.

[1] The nutriscore is a labelling system for food products that indicates their healthiness.

Similarly, participants are unlikely to remember all chemical household products they use or how exactly they use these products.

The best way to tackle this issue is to measure participants' behaviour via laboratory experiments instead of surveys. If this is not possible, the limited cognitive resources of human beings should be accounted for. For example, one should choose realistic recall lengths (Clarke et al., 2008), and one can provide the participants with mental aids for finding the correct answer (Khare & Vedel, 2019) – for example, "Think of your last weekly shopping. How many chemical products did you buy?" rather than "How many chemical products did you buy in the past ten years?".

1.6.3 Ecological Validity

Observing participants has the advantage of eliminating recall bias. However, experiments often take place in laboratories to standardise the setting. Such settings cannot perfectly mimic everyday life - for example, because the exterior surroundings are different from what the participant is used to. Additionally, participants are aware during laboratory experiments that they are participating in a study, which can result in overattentive behaviour, also known as the Hawthorne effect, because they wish to be "good" participants (Merrett, 2006).

1.6.4 Ethical Challenges

Ideally, when studying a certain behaviour, one observes people performing the studied behaviour. However, for obvious reasons, it is ethically unacceptable to let participants engage in risky behaviour during a study. Therefore, participants either have to be questioned about their risky behaviour or this has to be imitated, be it through projection scenarios or VR. However, even with these techniques, care has to be taken not to harm the participants psychologically, as dangerous situations can be stressful.

1.7 Outline of the Thesis

In the following section, I will briefly describe the studies included in this thesis. Chapters Two to Five will be dedicated to these studies. Finally, in Chapter Six, I will provide a general discussion of these studies.

1.7.1 Chapter 2: Consumers' Perceptions of Chemical Household Products and the Associated Risks

The aim of the first study was to obtain an overview of consumers' perception of chemical household products. We conducted an online survey in all major cultural areas of

Switzerland. The results showed that Swiss consumers know of the risks stemming from these products but do not think of them unless explicitly prompted.

1.7.2 Chapter 3: Barriers to the Safe Use of Chemical Household Products: A Comparison across European Countries

A second online survey was aimed at studying the barriers to the safe use of chemical household products and discovering potential cultural differences across different European countries. We found that consumers use both hazard-related as well as product- and marketing-related information to form their risk perception. Only small cultural differences were found.

1.7.3 Chapter 4: Consumers' Decision-Making Process When Choosing Potentially Risky Chemical Household Products

The previous two studies were based on the consumers' perception and recall of their behaviour. The aim of the subsequent study was to measure consumers' behaviour to obtain more objective data. We conducted an eye tracking laboratory study and measured consumers' visual attention to different areas of packaging when choosing a chemical household product as well as the influence of their visual attention on product choice. We found that consumers rarely look at the warnings systematically when choosing chemical household products if not prompted about the warnings.

1.7.4 Chapter 5: The Influence of Packaging on Consumers' Risk Perception of Chemical Household Products

As we showed in the previous study, when unprompted, consumers only rarely look at the warnings on the packaging. Therefore, it is likely that other parts of the packaging influence consumers' risk perception of specific products. In this study, we examined the influence of packaging design elements that objectively should not have an influence on consumers' risk perception of products. However, the results showed that this is not the case and that packaging design features do influence consumers' risk perception of products.

1.7.5 Chapter 6: General Discussion

Finally, I will discuss the implications of the four studies presented in this thesis. Furthermore, I will analyse the combined significance of these findings. Lastly, I will present methodological challenges related to this topic as well as avenues for future research.

Consumers' Perceptions of Chemical Household Products and the Associated Risks

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Abstract

Accidents with chemical household products represent an important public health issue. After medicines, they are the substances most frequently associated with unintentional poisonings in many countries worldwide. This study had five key aims. First, it has previously been shown that consumers rely on analytical factors (e.g. warning symbols) and potentially misleading heuristics when evaluating the riskiness of a given chemical household product. However, it remains unclear whether consumers are aware of the risks involved in their everyday encounters with such products, and more specifically, whether they accurately perceive the risks specific to these products. Utilizing a survey with Swiss consumers (N = 1109), we aimed to disentangle consumers' risk perception of chemical household products. Specifically, we measured consumers' free associations concerning four specific chemical household products (laundry detergent, mold remover, descaler, and essential oils). While the consumers were not intuitively aware of the risks, they did seem to be aware of them when prompted. Second, we measured their applied knowledge regarding the handling of chemical household products, as knowledge is a prerequisite for their safe handling. Then, we let participants evaluate their own behavior, and we asked them to rate possible barriers to safe behavior. Finally, we assessed the predictors of the perceived severity of accidents in order to estimate the potential behavioral changes that they might elicit. Aside from socio-demographic factors, the perceived severity was significantly related to personal risk awareness, laypeople's comparative evaluation of their own behaviors, chemophobia, and the perception of behavioral barriers.

Keywords: Chemical Household Products, Risk Awareness, Risk Perception

2.1 Introduction

Chemical household products are widely used in many of the activities associated with daily living, including cleaning tasks, do-it-yourself (DIY) projects, and garden maintenance. While chemical household products may offer many advantages, for example, permitting us to live in a hygienic and healthy environment, they are also associated with certain risks to our health and environment if they are employed in an unsafe way (Garcia-Hidalgo et al., 2017; Tox Info Suisse, 2019). Aside from acute poisonings, chemical household products also lead to other severe health risks, such as chemical burns from corrosive products or hazardous fumes, when bleach is combined with vinegar or drain cleaner (Habib et al., 2006; Swiss Federal Office of Public Health, 2014). Finally, such products often have a negative impact on the environment, especially when recommendations are disregarded (Slack et al., 2004). Risk-decreasing behavior can not only occur when using a product, but also when buying a product (e.g. choosing a lower-risk product rather than a product with a higher risk profile), when deciding how and where to store a product (e.g. out of reach of children and separately from food products), and finally, when disposing of a product.

The present study sought to provide specific insights into consumers' perceptions of chemical household products and the factors contributing to accidents. For this, a number of factors were investigated that have thus far received insufficient attention in the prior literature (e.g., Bearth et al., 2020; Bearth et al., 2017). Among other factors, general risk awareness, the perception of the severity of risky situations and perceived barriers to the safe handling of chemical household products were investigated.

2.2 Theoretical Background

Toxicological reports from several Western countries (e.g. Switzerland, United Kingdom, United States) show that accidents involving chemical household products represent an important public health issue (Gummin et al., 2018; Tox Info Suisse, 2019; Williams et al., 2012). In Switzerland, for example, the national toxicological helpline reported over 8000 poisonings with chemical household products in 2018 (Tox Info Suisse, 2019). This makes chemical household products the second most commonly involved substance in accidents after medicine and a common risk especially for young children. These numbers are likely to be an underestimation, as there is no legal requirement to report a poisoning, even if medical help is sought. Additionally, health issues other than poisonings, such as burns or eye injuries, can result from exposure to chemical household products (Tschopp et al., 2015). Similarly, according to the American Poison Control Centers, household cleaning substances are the

second most common cause of unintentional poisonings in the United States (Gummin et al., 2018).

In recent years, the risks associated with chemical household products have changed. While some products are no longer available due to safety reasons (e.g. cleaners and laundry detergents containing environmentally problematic surfactants), certain newly available products pose an additional risk. For example, the introduction of laundry pods has resulted in an increase in poisonings and injuries. These products can be mistaken for sweets, and they are highly concentrated, which renders them more dangerous in cases of exposure (Claudet et al., 2014; Wyke & Desel, 2018).

If chemical household products are to be handled safely, different prerequisites must be met. First and foremost, people must be aware of the potential risks that chemical household products can pose. Second, people must have the knowledge necessary to adopt adequate measures to protect themselves. Third, people must have sufficient motivation to engage in safe behavior (Laughery & Wogalter, 2014). The prior literature regarding these three issues will now be presented and discussed in light of the present study's goals.

2.2.1 Awareness of the risks concerning chemical household products

It is rare for people to knowingly behave in an unsafe way without any reason or incentive (Weegels & Kanis, 2000). Thus, a prerequisite for mitigating a risk is awareness that there is a risk in the first place. While laypeople seem to be cautious of chemicals (Jansen et al., 2019; MacGregor et al., 1999), to date these has been little research as to whether people are generally aware of the potential risks specific to household chemicals. For chemical household products, the research suggests that product attributes might be associated with a higher or lower level of risk awareness. For example, pre-school children find it easier to recognize an unsafe chemical household product if it is in a black, opaque, and square bottle or metal container (Schwebel et al., 2014). It can be assumed that, perhaps to a lesser extent, similar perceptions could apply to adults. Additionally, chemical household products are sometimes packaged in a similar way to food products (so-called food-imitating products) in order to increase their attractiveness (e.g. featuring flowers or berries on the label, or in bottles that resemble soft drinks). This could lead to lower levels of risk awareness (Basso et al., 2010). In line with this, some such products are associated with a higher number of poisonings (e.g. the all-purpose cleaner *Fabuloso*, which is available on the American market) (Basso et al., 2010; Basso et al., 2014). Basso et al. (2014) found that when their participants looked at soap that was packaged in a similar way to orange juice, the brain activity in the gustatory cortex areas was increased, although the participants were able to verbally differentiate the products.

Therefore, it is possible that adults, particularly when tired or drunk, might experience difficulty distinguishing these products, which could lead to unintentional poisonings.

2.2.2 Knowledge regarding chemical household products and their associated risks

Further, if chemical household products are to be handled safely, knowledge of how a particular risk can be reduced is necessary in order to engage in safe behavior. Many European countries introduced the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) between 2010 and 2015. Checking the different pictograms for each class of risk (e.g. corrosive, inflammable, toxic) should enable consumers to easily assess the type of risk associated with a specific product. Additionally, the pictograms are complemented by hazard and precautionary statements that provide information about how to safely handle the product in question (United Nations Economic Commission for Europe, 2017).

However, it has been shown that while signal words had an influence on individuals' risk perception, the presence of a GHS pictogram did not (Boelhouwer & Davis, 2010). It has also been shown that a considerable number of consumers are unaware of the relatively new GHS pictograms, meaning that they instead rely on defunct classification systems. Additionally, some consumers seem to be unfamiliar with part of the GHS pictograms. In fact, in a study conducted in 2018 in eight European countries, 65% of participants indicated never having seen the *health hazard* pictogram before. Equally, only 42% of participants indicated knowing the meaning of the *environmental hazard* pictogram (Bearth et al., 2020). In a British study examining the use of pesticides in households with children, nearly half of all parents indicated that they did not understand the label, although at the same time 90% of parents believed in following the warnings featured on the label (Grey et al., 2005). Another study involving British manufacturers, vendors, workers, and consumers used focus groups to explore the safety information featured on chemical products. While the study found that most people seemed to be aware of the labels, many of them did not seem able to understand the labels (Hinks et al., 2009). This finding is also reflected in observational studies showing that most laypeople do not even look at labels, let alone read them (Kovacs et al., 1997). It seems that while the warnings included on the label are appreciated by most consumers, some consumers find it difficult to understand the exact meaning of those warnings.

Thus, people might apply other strategies for judging the risks associated with household chemicals and protecting themselves from harm. Previous research shows that a number of shortcuts can be used by laypeople to determine a potential risk. For example, eco-friendly products are considered by laypeople to be safer than regular products, even when controlling for other factors (e.g. attractive packaging) (Bearth et al., 2020). This probably

reflects consumers' preference for natural products, as they believe that substances of natural origin are not generally harmful to human health or the environment (Bearth et al., 2017; Bearth & Siegrist, 2019; Kahraman & Kazançoğlu, 2019). Further, many consumers ignore the dose–response relation in terms of the way that a chemical product is considered to be either dangerous or safe (Saleh et al., 2019). This results in consumers not knowing that substances generally considered to be safe can prove to be toxic if they are ingested in a large enough quantity. Additionally, some laypeople include product- and marketing-related factors in their risk assessment. While risk-related aspects (i.e., warning symbols, ingredients) are judged to be important by most laypeople, some people also rate less-informative factors such as perceived effectiveness, previous experience with the product, and place of purchase of the product as being important (Bearth et al., 2020). Thus, consumers might believe that they are using a safe product because, for example, they bought it from a familiar shop, even though it is actually quite dangerous.

2.2.3 Motivation and barriers concerning the safe use of chemical household products

Even when risk awareness and knowledge regarding mitigating factors are given, accidents can still occur. The reasons for this could be the perceived barriers to safe behavior or a lack of motivation in terms of the additional effort required to apply safety measures.

Consumers who report their previous experience with a specific product to be a reason for their risk perception (Bearth et al., 2020) may be buying the same products out of habit, and thus, not see a reason for checking the product in detail every time they use it. For everyday household items, for example, cleaning products, consumers tend to choose the same product repeatedly without investing too many resources (e.g. attention, time) in making the choice. This phenomenon is strengthened when consumers are in a well-known shop (Park et al., 1989; Wood & Neal, 2009). Although habit is not bad per se, it may result in a lack of attention. In this case, changes in the market situation, for example, the appearance of a safer product alternative or the addition of a warning label, might go unnoticed.

Another aspect of relevance is whether the users of chemical household products believe that their own actions have an impact on safety. In an earlier study, we found that consumers with positive outcome expectancies, e.g. the belief that acting in a safe way results in the risk being decreased, exhibited safer behavior than consumers with negative outcome expectancies (Bearth et al., 2020). Further, consumers may opt to avoid taking safety precautions if they perceive them to involve a too high burden in everyday life. For instance, the parents of young children were found to prefer storing dangerous products within reach of their children because storing them in a safer place would have been inconvenient (Gibbs et

al., 2005). Equally, when consumers believed that sufficient precautionary measures had already been taken, for example, if the product comes in a child-resistant container, they were less likely to follow the storage recommendations (Gibbs et al., 2005). Lastly, when consumers perceived themselves to be familiar with the product in question, they felt less inclined to take the time and read the safety recommendations on its packaging (Grey et al., 2005).

2.2.4 Study goals and research questions

The intuitive perception of chemical household products in general, without prompting the participants with regard to the potential risks, has not previously been examined. People will likely not associate everyday household products that they habitually use with risk, unless prompted to think about this. Thus, investigating intuitive perceptions might reflect their actual risk perception in a more valid way. Prior studies have investigated the handling of chemical household products, although it has proved challenging to measure behavior due to retrospective and social desirability biases (Basso et al., 2010; Bearth et al., 2017; Habib et al., 2006; Wieck et al., 2018). In the present study, we attempt to tackle this issue by studying both the intuitive perception of chemical household products and the perceived severity of risky situations involving chemical household products, rather than studying self-reported behavior. This approach is based on the assumption that consumers need to perceive accidents involving chemical household products as being severe to develop an intention to adjust their behavior (Floyd et al., 2000). It is likely that consumers will go to greater lengths to prevent a severe health risk than to prevent a minor health risk. Thus, the perceived severity of potentially risky situations involving chemical household products might inhibit or prompt behavioral change.

Based on prior literature, we suggest that there are a number of factors that contribute to the perceived severity of potentially risky situations. First, awareness of the risk is necessary if laypeople are to start the process of thinking about both the severity and possible mitigating factors with respect to chemical household products. Therefore, we sought to answer the following research question:

1. How are different chemical household products perceived, and are consumers aware of the potential risks associated with such products?

Second, a high level of risk awareness alone is not sufficient to change behavior (Scolobig et al., 2012). People need the resources necessary to change their behavior. This includes applied knowledge of how the safe handling of chemical household products can be attained, and an understanding of how motivational factors can potentially hinder this behavior. Thus, we formulated the following questions:

2. How much knowledge concerning the use of chemical household products do consumers have?
3. How do consumers perceive possible motivational factors for safe behavior?

It has previously been shown that people's risk perception is conditional: when evaluating a risk, laypeople consider the protective measures that they have taken to evaluate the severity and thus, the personal relevance of a given risk. Therefore, a comparison between oneself and others with regard to safety measures will take place during the evaluation of a risk (Boehmert et al., 2016; Brewer et al., 2007). This leads to the next research question:

4. How safe do consumers perceive their own behavior to be with regard to chemical household products when comparing themselves to their peers?

These points are prerequisites for the safe handling of chemical household products, and they could explain unsafe behavior in situations in which consumers perceive a high degree of severity and exhibit the willingness to change their behavior. Therefore, we examined whether these factors predict the perceived severity of potentially risky situations.

5. Which individual and situational factors are relevant to the perceived severity of potentially risky situations involving chemical household products?

2.3 Method

2.3.1 Participants

Participants from three of the four language areas of Switzerland (German-, French-, and Italian-speaking areas) were recruited for the present study. The questionnaire was administered online via a market research company operating in all three language areas (N = 1109 participants). For this, quota sampling based on age and gender was applied. Both the French-speaking part (n = 295) and the Italian-speaking part of Switzerland (n = 41) were oversampled in order to have sufficient power for the statistical analyses. To increase the sample size in the Italian-speaking part of the country, the addresses of 600 people living in that part were purchased from another market research company. Thus, the Italian version of the questionnaire was also sent out via mail as a paper-and-pencil questionnaire (N = 146 participants). This resulted in a final sample size of N = 1255 for the Italian-speaking part. Some 49% of participants were male (n = 614), while the mean age was 50 years (SD = 17, range: 18–85). One participant preferred not to indicate their gender and age. When compared to the general Swiss population aged 18 years and older, our sample was comparable (M = 49 years for the Swiss population over 18). In terms of the gender distribution, our sample was

equally comparable to the general Swiss population (50% of the Swiss population is male) (Swiss Federal Statistical Office, 2019).

2.3.2 Questionnaire and measures

This study comprised part of a larger research project funded by the Swiss Federal Office of Public Health. In the present article, we focus on only certain parts of the questionnaire, although the full questionnaire is available from the corresponding author on request. The questionnaire was translated from German to French and to Italian by native speakers and then pretested in all three languages. Any irregularities that were revealed during the translation process were resolved by the first author. Additionally, toxicologists checked and provided input regarding the correctness of the questionnaire. A variety of measures were applied to investigate consumers' risk perceptions, attitudes, and behavior. These measures will be presented in more detail later in the article. Additionally, the following socio-demographic and control variables were assessed: age, gender, education level, language area (German-, French-, or Italian-speaking part), location (town, agglomeration, or countryside), household type, presence of children within the household, participation in household chores, and professional occupation dealing with chemicals.

2.3.2.1 Perception of chemical household products and risk awareness. For the first question, the participants were asked about their spontaneous associations concerning four specific chemical household products, namely laundry detergent, mold remover, descaler, and essential oil. Care was taken to choose a variety of products with regard to consumer familiarity, product attributes, and objective riskiness (based on annual poisoning and toxicity reports) (Tox Info Suisse, 2019). To ensure the clarity of the question, the participants were presented with pictures of the specific products. The participants were asked to indicate the first three things that came to their mind in relation to the four different chemical household products ("If you hear the term laundry detergent / mold remover / descaler / essential oils, what are the first words, images or thoughts that come to your mind spontaneously?"). For the analysis, a coding scheme was developed and the participants' answers were coded by the main author depending on whether a health or environmental risk was explicitly mentioned (e.g. toxic, harmful, dangerous, environmental problem) or whether other associations were mentioned (e.g. purpose, product use, evaluation). Associations that implied a risk but did not explicitly express that risk (e.g. health, aggressive, phosphates) were not coded as a risk. Empty fields or meaningless answers (e.g. answers like "ylsfnm"), were not considered for the analysis. In the case of descaler, a total of 2253 associations could be analyzed (with 1187 participants naming at least one valid association), while for laundry detergent there were 2484

associations (with 1192 participants naming at least one valid association), for essential oil there were 2239 associations (with 1150 participants naming at least one association), and for mold remover there were 2103 associations (with 1128 participants naming at least one association).

Next, the participants were presented with seven common household accident scenarios (Basso et al., 2014; Tox Info Suisse, 2019) in order to investigate the perceived severity of potentially risky situations. This measure was the main variable of interest in the present study, as it is indicative of the perceived consequences and perceived threat of chemical household products for consumers. For this, they were asked to judge the severity of the situation on a scale ranging from *1 = not severe at all (no intervention necessary)* to *6 = extremely severe (life threatening).* Scenarios concerning both severe and less severe situations, as previously judged by toxicologists, were included (cf. Figure 5).

Then, the participants' personal risk awareness, that is, the degree to which they felt personally concerned by the risks associated with chemical household products, was measured using five items on a scale ranging from *1 = do not agree at all* to *6 = totally agree* (c.f. Table 1). The participants were asked to consider the way they store and handle chemical household products in their response to these items.

2.3.2.2 Knowledge regarding the safe handling of chemical household products. Aside from a lack of risk awareness, a number of other factors might determine the participants' handling of chemical household products (Bearth et al., 2020; Weegels & Kanis, 2000). Therefore, we also measured their level of applied knowledge. To measure their applied knowledge, the participants were presented with two correct and two incorrect statements, and they were asked to decide whether the statements were true, false, or they did not know. All the statements are listed in Figure 6.

Lastly, the participants' irrational fear of synthetic chemicals, or chemophobia, was measured using a scale adapted from the one developed by Saleh et al. (2019) and used in a similar context by Bearth et al. (2019). For this study, only those items that showed erroneous beliefs and irrational fears were included (c.f. Table 2). Therefore, seven items were considered, and the participants' responses ranged from *1 = do not agree at all* to *6 = totally agree*.

2.3.2.3 Motivation and barriers to safe behavior regarding chemical household products. The barriers to safe behavior were examined by five items ("Official recommendations for storage, use and disposal of chemical household products are not always respected. It is important to us to know in which situations this happens. Please indicate how

pertinent the following reasons are for you.", cf. Table 3). The participants were asked to indicate how pertinent different reasons for unsafe handling were on a scale ranging from 1 = do not agree at all to 6 = totally agree.

Then, the participants were asked to evaluate their own behavior when compared with the behavior of the rest of the Swiss population ("If you compare yourself with other people in Switzerland, how safe do you estimate your own handling of chemical household products to be?") on a scale ranging from *1 = less safe than others* to *6 = safer than others*.

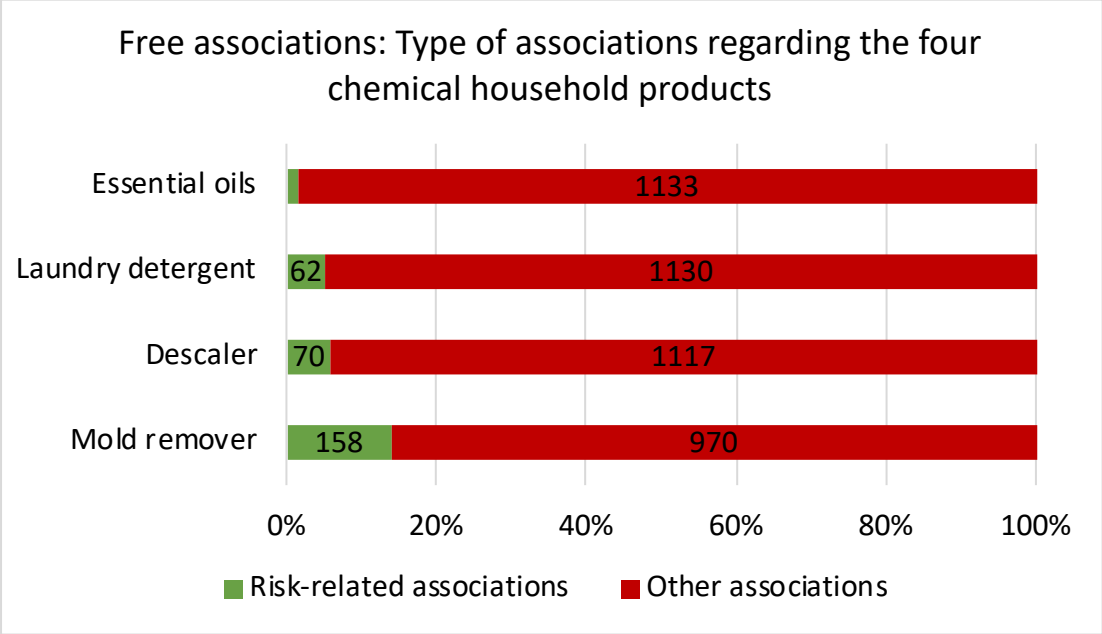
Additionally, after completing the questionnaire, the participants who answered the online version were asked to upload up to three pictures of their cleaning cabinet in order to investigate their adherence to storage guidelines. As a high dropout rate was expected for this task, it was clearly stated to be voluntary. A total of $n = 92$ participants (7%) uploaded at least one image. Due to the poor image quality, only $n = 88$ of these images could be coded and analyzed. The subsample that uploaded pictures was comparable to the original sample in terms of both gender, X^2 (1) = 0.20, $p = .66$, and age, $U = 48146.00$, $z = -1.59$, $p = .11$, $r = -0.04$. The images were coded according to the official guidelines for the safe handling of household chemicals (https://www.cheminfo.ch). More specifically, this meant that chemicals should be stored separately from food, in their original container with the original label, at a height of at least 1 meter 60 centimeters, and ideally, in a cupboard that can be locked.

2.4 Results

2.4.1 Perception of chemical household products and risk awareness

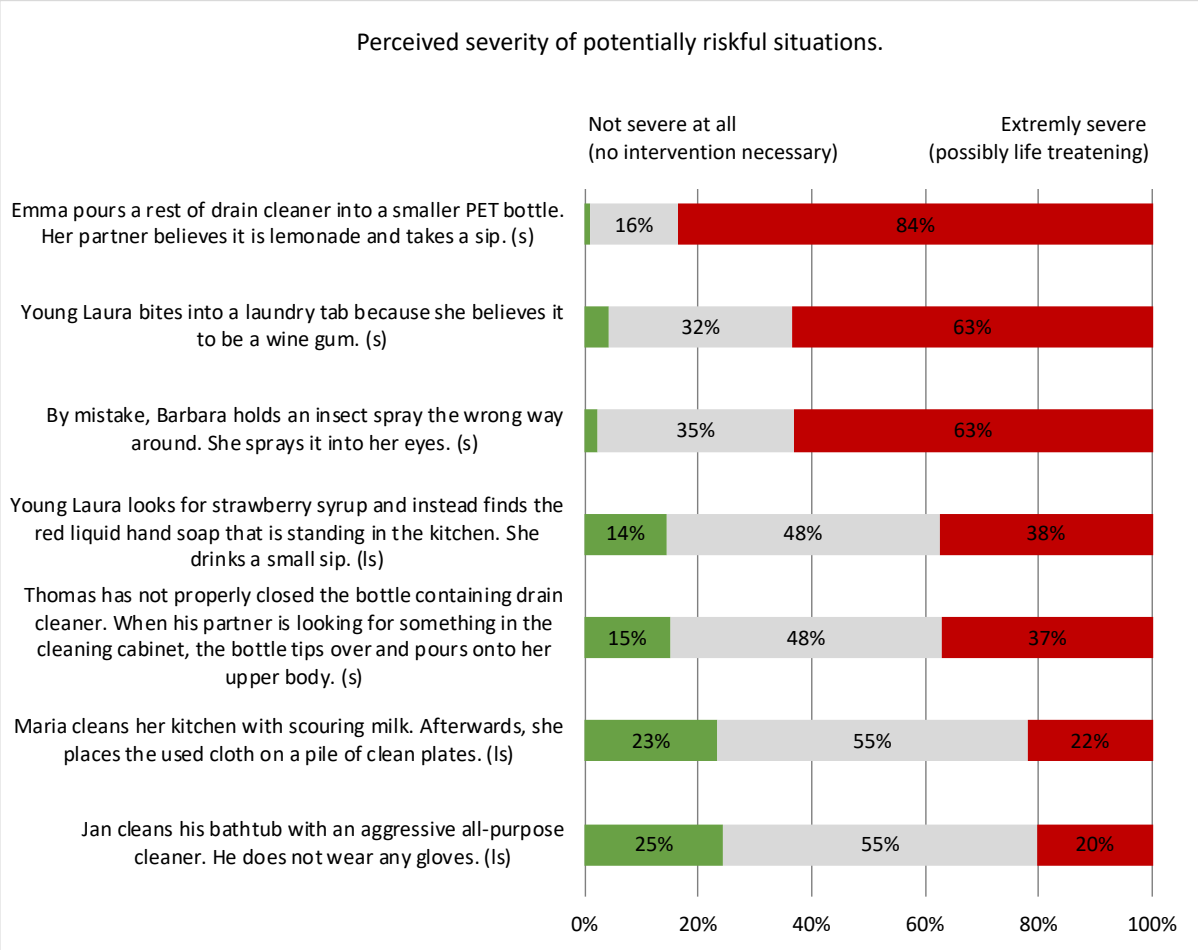
Only a minority of participants expressed risk-related associations concerning the four specific chemical household products (cf. Figure 4). Over all three associations, risks were mentioned most frequently with regard to the mold remover (14% of participants who gave valid answers named a risk at least once), followed by the descaler (6% of participants who gave valid answers named a risk at least once), the laundry detergent (5% of participants who gave valid answers named a risk at least once), and finally, the essential oil (1% of participants who gave valid answers named a risk at least once). The most frequent associations comprised the reasons for using the product, the place the product is used, and the product attributes (e.g. color of the product). For all the products combined, just 19% of participants named a risk-related thought at least once.

Figure 4. *Free associations: Type of associtaions regarding the four chemical household products.*



In terms of the items intended to measure the perceived severity of potentially risky situations, the seven items (cf. Figure 5) were analyzed by means of a principal component analysis (PCA), which exhibited one dimension. The Cronbach's alpha (α = .80) was also found to be good. The items were combined into a scale measuring the perceived severity of potentially risky situations by taking the mean over all the items.

Figure 5. *Perceived severity of potentially risky situations: Frequencies (N = 1254–1255).*



Note. (s): judged to be severe by toxicologists, (ls): judged to be less severe by toxicologists; participants responded on a scale ranging from *1 = not severe at all* to *6 = extremely severe*; responses 1+2, 3+4, and 5+6 are combined in the figure.

Further, the participants were asked to rate their personal risk awareness. The scale analysis of these items (PCA) suggested one dimension and a good Cronbach's alpha ($\alpha = .69$). Thus, the items were combined into one scale measuring personal risk awareness by taking the mean over all the items.

Table 1. *Personal risk awareness: Corrected item-total correlations, means (M), and standard deviations (SD) (N = 1254–1255).*

		Corrected item-total correlation	*M (SD)*
1	I often find the danger and safety recommendations on chemical household products exaggerated. (r)	0.24	4.56 (1.34)
2	I have the feeling that chemical household products could endanger my health.	0.52	4.05 (1.44)
3	In my daily life, I do not think a lot about whether chemical household products endanger my health. (r)	0.44	3.84 (1.62)
4	The dangers associated with chemical household products preoccupy me.	0.62	3.74 (1.55)
5	I am worried that I could endanger other people with chemical household products.	0.46	3.63 (1.78)

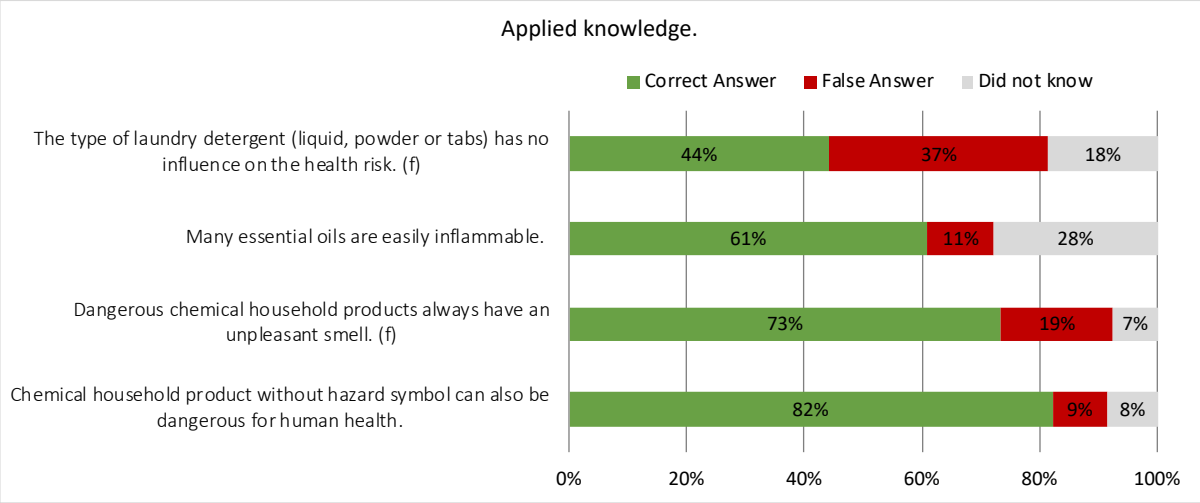
Note.(r): reversed items; *1: do not agree at all – 6: totally agree*.

2.4.2 Knowledge regarding the safe handling of chemical household products

Generally speaking, the participants exhibited a high level of applied knowledge (cf. Figure 6). However, some items proved more difficult to answer than others. Most participants (82%) were aware that products without danger symbols could potentially also be dangerous. Equally, a high number of participants (73%) knew that dangerous chemical household products do not necessarily have an unpleasant scent, and further, that essential oils are highly flammable (61%). Not quite half of all participants (44%) knew that the type of laundry detergent has an influence on the level of toxicity due to the different concentrations of liquid, powder, or tab laundry detergent.

Finally, with regard to chemophobia, a PCA was run for the seven relevant items, which resulted in one dimension and a good Cronbach's alpha (α = .83). Therefore, we computed a scale by taking the mean over all the items (M = 3.45, SD = 1.07). All the items and their means can be found in Table 2.

Figure 6. *Applied knowledge: Percentages (N = 1253–1255).*



Note. (f): false statements.

Table 2. *Chemophobia: Item-total correlations, means (M), and standard deviations (SD) (N = 1253–1255).*

		Corrected item-total correlation	*M (SD)*
1	I would like all chemical substances to be risk- free.	0.40	4.72 (1.40)
2	I do everything I can to avoid in my daily life contact with chemical substances.	0.56	3.75 (1.48)
3	I would like to live in a world where chemical substances don't exist.	0.67	3.62 (1.62)
4	The chemical industry is responsible for more people suffering from cancer.	0.59	3.54 (1.49)
5	Chemical substances scare me.	0.69	3.13 (1.55)
6	In a world without chemical substances, there would be no environmental disasters.	0.56	2.78 (1.55)
7	I am scared of chemical substances I cannot pronounce.	0.57	2.66 (1.60)

Note. [(r)]: reversed items; *1: do not agree at all – 6: totally agree.*

2.4.3 Motivation and barriers to safe behavior regarding chemical household products

In terms of the perceived barriers, a PCA with direct oblimin rotation was run to determine the dimensionality of the items. Based on the eigenvalues and the scree plot, two components were retained. One scale was composed of two behavioral barriers (distractions and lack of time; $\alpha = .70$), while the other scale consisted of three attitudinal barriers due to issues regarding official guidelines ($\alpha = .62$; cf. Table 3). The two scales were created by taking the mean over the respective items.

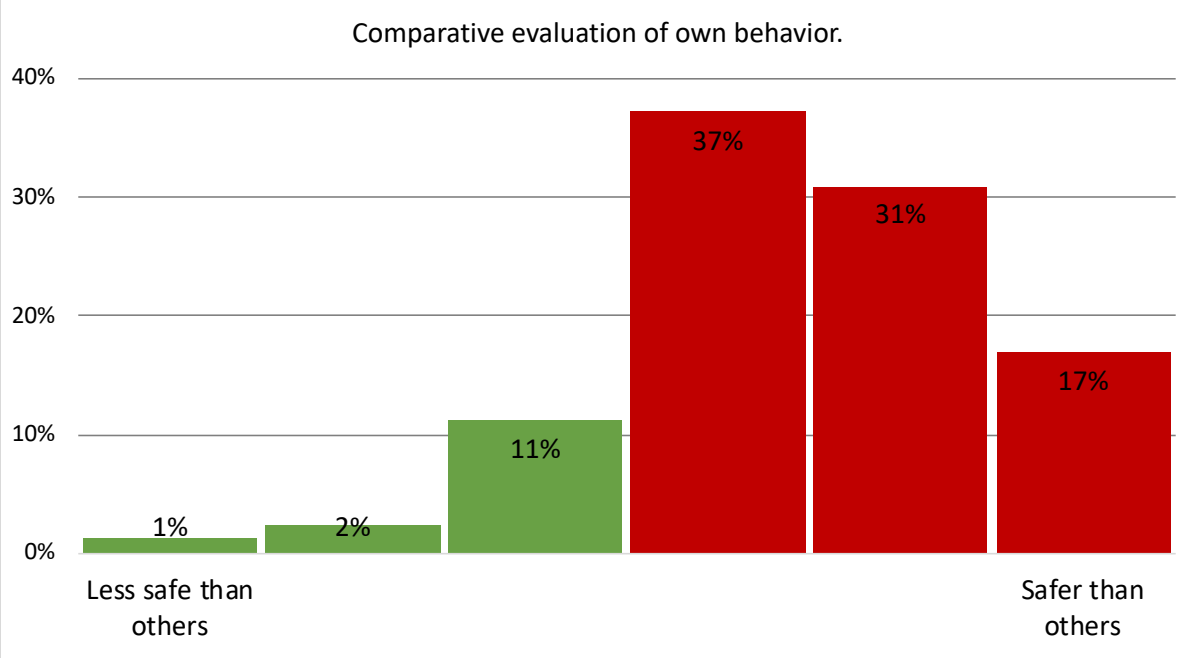
Table 3. *Perceived barriers to safe behavior: Item-total correlations, PCA with direct oblimin rotation (pattern matrix), means (M), and standard deviations (SD) (N = 1249–1253).*

		Attitudinal barriers	Behavioral barriers	*M (SD)*
1	Not enough time and time pressure	0.11	-0.81	3.53 (1.57)
2	Distractions (e.g. other tasks, children, domestic animals)	-0.08	-0.90	4.01 (1.50)
3	Safety recommendations are exaggerated	0.85	0.20	2.47 (1.41)
4	Safety recommendations are too complicated	0.79	-0.12	2.94 (1.47)
5	Safety recommendations are not known	0.54	-0.29	3.45 (1.55)

Note. 1: do not agree at all – 6: totally agree.

Next, the participants were asked to compare their behavior to the behavior of other people living in Switzerland (e.g. Figure 7). Some 85% of participants considered their behavior to be safer than the behavior of the average consumer ($M = 4.44$, $SD = 1.06$).

Figure 7. *Comparative evaluation of own behavior: Distribution (N = 1255).*



With regard to the subsample of participants who provided images of their cleaning cabinets, a considerable number of participants did not fully comply with safety guidelines. A minority of two participants (2% of n = 87) stored their cleaning products together with food. Only seven participants (8% of n = 84) did not store their products in the original packaging (e.g. transferred into a syrup bottle). A majority of participants (55 participants, 71% of n = 77) stored their products under a height of 1 meter and 60 centimeters, meaning that they were potentially accessible to children. Finally, 29 participants (36% of n = 81) did not store their products in a closed cabinet.

2.4.4 Predictors of the perceived severity of potentially risky situations

The correlations between the various scales were computed, and they are presented in Table 4. The participants who reported a higher perceived severity in relation to potentially risky situations also reported higher personal risk awareness, safer behavior according to their own comparative evaluation, higher chemophobia, and more perceived behavioral barriers. However, they perceived less attitudinal barriers. Furthermore, the strongest correlation was observed between chemophobia and personal risk awareness. Thus, the participants who perceived higher personal risk awareness also exhibited higher levels of chemophobia. No significant correlations were observed between personal risk awareness and behavioral barriers, people's comparative evaluation of their own behavior and chemophobia or behavioral barriers and finally between chemophobia and attitudinal barriers.

Table 4. *Pearson's correlations between the perceived severity of potentially risky situations, personal risk awareness, comparative evaluation of own behavior, chemophobia, behavioral barriers, and attitudinal barriers (N = 1252–1255).*

		1	2	3	4	5	6
1	Perceived severity of potentially risky situations	-					
2	Personal risk awareness	0.39***	-				
3	Comparative evaluation of own behavior	0.18***	0.10***	-			
4	Chemophobia	0.30***	0.49***	0.01	-		
5	Behavioral barriers	0.09**	-0.05	0.01	0.06*	-	
6	Attitudinal barriers	-0.11***	-0.25***	-0.08**	0.03	0.36***	-

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

We conducted a linear regression analysis to determine which factors are related to the perceived severity of potentially risky situations. We included the socio-demographic variables of gender, age, language, the regular presence of children within the household, and education level, as well as the psychological variables of personal risk awareness, comparative evaluation of own behavior, chemophobia, behavioral barriers, and attitudinal barriers. Table 5 presents the results of this linear regression analysis. The model was found to be significant, $F(11, 1237) = 32.22$, $p < .001$, and it explained 22.3% of the variance in the perceived severity of potentially risky situations. In terms of the socio-demographic variables, the most important factor concerning the perceived severity of potentially risky situations was gender, with female participants perceiving higher severity than male participants. Younger participants reported lower perceived severity when compared with older participants. Further, participants with children who are regularly present within their household perceived lower severity. The variables of education level and language area were not related to the perceived severity of potentially risky situations. With regard to the psychological factors, high personal risk awareness and high chemophobia were both related to the higher perceived severity of potentially risky situations. Participants who considered their own behavior to be safer than the behavior of others perceived a higher severity. Further, participants who acknowledged more behavioral barriers (e.g. time pressure, distractions) perceived a higher severity in relation to potentially risky situations.

Table 5. *Linear regression analysis with the perceived severity of potentially risky situations as the dependent variable (N = 1249).*

	B (SE)	*β*	*t*
Constant	2.27 *(0.15)*		14.59
Gender (0 = male, 1 = female)	0.12 *(0.04)*	0.08**	2.95
Age	0.00 *(0.00)*	0.06*	2.03
Language area (0 = German, 1 = French)	-0.09 *(0.05)*	-0.05	-1.76
Language area (0 =German, 1 = Italian)	-0.07 *(0.07)*	-0.03	-1.04
Children (0 = no children, 1 = children)	-0.10 *(0.05)*	-0.05*	-2.05
Education (0 = low education, 1 = high education)	-0.06 *(0.04)*	-0.04	-1.39
Personal risk awareness	0.25 *(0.03)*	0.32***	9.78
Comparative evaluation of own behavior	0.09 *(0.02)*	0.12***	4.46
Chemophobia	0.10 *(0.02)*	0.13***	4.33
Behavioral barriers	0.07 *(0.02)*	0.11***	4.19
Attitudinal barriers	-0.04 *(0.02)*	-0.05	-1.75

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

2.5 Discussion

This study had five key aims: (i) to examine consumers' unprompted and prompted perceptions of chemical household products, (ii) to determine consumers' applied knowledge regarding the handling of chemical household products, (iii) to determine the motivational factors to safe behavior perceived by consumers themselves, (iv) to measure how safe consumers' behavior is with regard to chemical household products, and (v) to identify the individual and situational factors that predict the perceived severity of potentially risky situations in order to assess the perceived consequences and threats associated with chemical household products.

2.5.1 Lack of risk awareness with regard to chemical household products

We asked the participants about the first three things that came to mind when thinking about four specific chemical household products (e.g. laundry detergent, mold remover, descaler, and essential oil). This technique allowed us to determine the free associations laypeople have in relation to these specific products (Schnabel & Asendorpf, 2013). Risk-related thoughts were only mentioned by a very few participants. Most participants responded by naming the reason for using the product, where the product is used, or the product attributes (e.g. nice smell). However, when asked specifically about problematic situations involving chemical household products, the participants were aware of the risks, and for most situations, they were able to correctly differentiate between hazardous and less hazardous situations. While the participants knew about the potential risks, they did not think of themselves and so had to be reminded of the risks. Therefore, we suggest that attempts to increase safe behavior should focus on activating the available awareness of the potential risks of chemical household products rather than on creating new awareness. This suggestion is in line with prior research regarding food-imitating products (Basso et al., 2010; Basso et al., 2014). Such studies have shown that laypeople have to be reminded of the potential risks if they are to correctly categorize a product and then adopt appropriate safety measures. We suggest that this could be achieved using distinctive packaging. Research concerning young children has shown that, for example, this could involve the use of the color black or the use of square bottles (Schwebel et al., 2014).

A special case is essential oils. These can not only be used for cleaning as well as for cooking and as medicine. However, the different products should not be used for applications other than their intended use. For instance, essential oils for cleaning should not be used for cooking. Nevertheless, their intended use is frequently unclear on the packaging. This could

result in ambiguity for the user and a problematic risk perception, as these different types of essential oils might not be distinguished based on their designated uses by the consumer (Basso, 2011).

2.5.2 Partial knowledge about the handling of chemical household products and unreasonable fears

The participants' responses showed an unreasonable fear of (synthetic) chemicals in general as well as a specific lack of applied knowledge regarding chemical household products. More specifically, in terms of their knowledge, the participants were unaware of the dose–response relationship. A high number of participants did not know that laundry detergent tabs are more hazardous due to their higher concentration when compared with laundry detergent powder or liquid. A similar lack of knowledge is reflected in the previous research (Jansen et al., 2020; Kraus et al., 1992; Ropeik, 2012; Saleh et al., 2019; Slovic et al., 1995).

Most participants seemed to consider chemicals as something that should be avoided. In particular, participants with high levels of chemophobia exhibited a high levels of personal risk awareness for chemical household products. This is not surprising, as it has been shown that many laypeople are particularly worried about synthetic chemicals (Jansen et al., 2019; Saleh et al., 2019). However, such an undifferentiated fear of certain chemicals or chemical substances can be problematic. Although laypeople may consider a substance to be natural or free of any synthetic chemicals, this does not necessarly mean that this particular substance is less hazardous than another one. Thus, this could result in laypeople neglecting safety precautions if they believe that they are using a "safe, chemical-free substance" rather than a "harmful, chemical substance".

2.5.3 Barriers and negligence concerning the safe handling of chemical household products

The participants were asked to rate their own behavior in comparison to the behavior of other Swiss people. Responses to this question revealed that the great majority of participants (85%) indicated that they behaved in safer ways than the average citizen. People seem to assume that only other people behave unsafely. This phenomenon could be described as an optimistic bias (i.e., the belief that negative events are less likely to affect oneself than others) or as illusory superiority (i.e., the belief that the one's own behavior is safer than the behavior of others). These phenomena have been identified in previous studies in relation to all sorts of risks, including accidents, natural disasters, and illnesses (Helweg-Larsen & Shepperd, 2001; Hoorens, 1993). Nevertheless, the participants seemed to be aware of the potential barriers to unsafe behavior, especially with regard to a lack of time and distractions. However, attitudinal barriers, e.g. in relation to safety recommendations and not influenceable

by lay people themselves, however were rated to be less important. This shows that consumers are willing to take on the responsibility for safe use of chemical household products. Equally, participants with high levels of personal risk awareness found that attitudinal barriers were not that important.

Similarly, for the subsample of participants who provided images of their storage cabinets, a widespread disregard for official recommendations was observed (see https://www.cheminfo.ch for the official recommendations). This is somewhat contradictory, as the participants also indicated knowledge of the safety recommendations, and further, reported that they were neither exaggerated nor too complicated. However, a similar disregard for basic safety precautions when storing chemical household products has previously been reported (Beirens et al., 2006; Habib et al., 2006).

2.5.4 Predictors of the perceived severity of risky situations involving chemical household products

A regression analysis was run to determine the perceived severity of potentially risky situations. The perceived severity of such situations, and therefore, the perceived consequences and threats associated with the use of chemical household products should have a significant influence on laypeople's behavioral changes toward the more cautious handling of chemical household products (Bearth et al., 2014; Rinker et al., 2014; Rundmo & Nordfjærn, 2017).

The results of our analysis show that personal risk awareness is an important predictor of the perceived severity of potentially risky situations, and therefore, a prerequisite for behavioral change and the uptake of safety precautions. As noted in prior studies, people are rarely aware of the risks before an accident occurs (Weegels & Kanis, 2000). Obviously, in these cases, people do not implement safety measures, even if they theoretically know of the risk and have the necessary resources and motivation to take precautionary action. Further, chemophobia, that is, the unreasonable fear of (synthetic) chemicals, also predicted the perceived severity of potentially risky situations. People who exhibit high levels of chemophobia might be more inclined to recognize what they believe to be dangerous chemicals. Therefore, they might perceive chemical household products to be more dangerous in general, and as a consequence, be more careful when handling such products.

The participants seemed to include their own comparative behavior in their perception of the severity of potentially risky situations. Additionally, those participants who acknowledged more behavioral barriers perceived the higher severity of potentially risky situations. This is due to the fact that a failure to take safety precautions renders risky situations more dangerous. This conditional risk perception phenomenon has been identified in relation

to other health risks, for example, radiation or Lyme disease (Boehmert et al., 2016; Brewer et al., 2007).

2.5.5 Limitations and implications for further research

The main limitation of this study concerns the use of self-reported measures. The participants might not be aware of their own mistakes when handling chemical products. Thus, they might experience difficulty recalling problematic behavior, or as a result of social desirability bias, they might report safer behavior than their actual behavior warrants. To overcome this, as well as to counter possible bias due to the presence of an observer, we suggest the use of new research methodologies such as virtual reality. This would allow researchers to place people in typical risky situations involving chemical household products without actually exposing them to a risk and without the participants seeing or interacting with the researchers.

Further, certain comments made by the participants suggested that not all of them were aware of the meaning of "chemical household products," as some participants explicitly mentioned that they did not use any chemical household products at all, preferring instead to use only natural products. This occurred despite a definition of what a chemical household product is being given to them during the survey. It cannot be excluded that some participants might have given different answers if it was clear to them that naturally made, organic, or environmentally friendly products are also chemicals. Such a misunderstanding on the part of laypeople seems to be a common problem in research in this field (Hartmann & Klaschka, 2017; Siegrist & Bearth, 2019). We suggest that future studies avoid the use of defined terms and instead work with easily relatable information such as pictures of the products in question.

Finally, our participants are all part of a market research panel and so are used to replying to online surveys. It cannot be ruled out that such people pay less attention to surveys than the average consumer. However, the responses of particularly fast participants were checked for abnormalities, and none were found. In fact, many of these participants provided lengthy and precise answers to the open questions.

2.6 Conclusion

In conclusion, there are a number of factors that can be used to positively influence the behavior of laypeople when it comes to handling chemical household products. First, it seems to be important to make consumers aware of the risks associated with chemical household products during every step involved in handling them (e.g. during purchase, when choosing a storage place, when using them, and when disposing of them), as they do not seem to intuitively think of the risks. Given that mistakes when handling chemical household products can occur

not only when using the product, but also during purchase, storage, and disposal, it seems best to design the products in such a way as to constantly prompt the consumer regarding the risks. For example, this could be achieved using distinctive packaging and front labels featuring large warning pictures or symbols (rather than the small pictograms featured on the back of products).

Second, knowledge concerning basic toxicological principles does not seem to be widespread. In fact, there seems to be a high level of fear regarding synthetic chemicals. Therefore, it seems that additional education could lead to more effective safety measures being initiated by consumers. If laypeople were more aware of what actually reduces the risks associated with a given product, they would be more likely to initiate appropriate safety measures rather than dedicating their limited resources to sometimes superfluous or non-effective measures.

Third, several factors were identified as being related to the perceived severity of potentially risky situations, e.g. personal risk awareness, comparative evaluation if own behavior, chemophobia and behavioral barriers. These factors might ultimately encourage behavioral change toward safer behavior. In terms of future national prevention efforts, it is likely to prove helpful to increase individuals' personal risk awareness.

Barriers to the Safe Use of Chemical Household Products: A Comparison across European Countries

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Abstract

Chemical household products, such as cleaning and washing products or pest control and garden chemicals, are frequently involved in poisonings in private households. Consumer research has identified a number of barriers that impede the safe use of these products, ranging from unfamiliarity to misconceptions and a lack of risk perception, to behavioural or situational barriers. This study aimed at investigating these barriers for consumers in eight European countries. Participants from eight European countries were recruited and asked to fill out an online questionnaire on their familiarity with hazard pictograms, perceptions and self-reported behaviour (Total: N = 5631, Austria: N = 731, Switzerland: N = 698, Germany: N = 711, France: N = 708, Italy: N = 695, Poland: N = 693, Sweden: N = 682, UK: N = 713). Across all countries, the lowest consumer familiarity was found for the meaning of the pictogram for "health hazard" (65% indicated having never seen it before). Small-sized differences between the eight countries were observed regarding people's familiarity, perceptions and self-reported behaviour. The results suggest that people apply hazard-related as well as product- and marketing-related strategies to judge the dangerousness of a chemical household product. These findings suggest a number of starting points for risk regulation and communication regarding hazardous household chemical products. Further, the results suggest that positive outcome expectancies and rules of thumb for judging the risks of a chemical household product are particularly relevant for people's self-reported safe use of chemical household products.

Keywords: Toxicology, Household Chemicals, Consumer, Risk Perception, Behaviour, Public Health

3.1 Introduction

Chemical household products, such as cleaning and washing products or pest control and garden chemicals, are frequently involved in health-related incidents in private households (Gummin et al., 2017; Williams et al., 2012). Aside from acute toxicity, these products can be corrosive, flammable or sensitising and thus pose a health risk to users and other people in the household. Moreover, many commonly available products may pose a problem for the environment if they are not used properly. Products that require particular care in transport, storage, handling or disposal are marked with pictograms, signal words and hazard and precautionary statements (United Nations Economic Commission for Europe, 2017). This labelling system, called the Globally Harmonized System of Classification and Labelling of Chemicals (GHS), was introduced between 2010 and 2015 in the EU and Switzerland (United Nations Economic Commission for Europe, 2017). Within this system, chemical products are classified by hazard type (e.g. flammable, corrosive), which is communicated to consumers via pictograms (e.g. red triangle with black exclamation mark), signal words and hazard statements. Evaluation studies yielded mixed results regarding consumers' understanding and use of the GHS and its communication elements but suggested overall that some pictograms might be ambiguous (Boelhouwer et al., 2013; Latham et al., 2013; Su & Hsu, 2008).

Previous studies have found that consumers make a number of potentially dangerous errors in the transport, use, storage, and disposal of chemical household products, such as storage in low cabinets or transfer into drink bottles (Smolinske & Kaufman, 2007; TNS Opinion & Social, 2017; Wieck et al., 2018; Williams et al., 2012). Additionally, consumer research has found a number of other barriers to the safe use of these products, including lack of awareness of the symbols (Dalvie et al., 2014; Su & Hsu, 2008), ignoring or misunderstanding their meaning (Boelhouwer et al., 2013; Rother, 2008) as well as behavioural or situational barriers, such as distractions or low risk perception (Grey et al., 2005; Habib et al., 2006; Slovic, 2016; Smolinske & Kaufman, 2007). Additionally, concepts from health psychology theories (Knoll et al., 2017) might function as barriers to the safe use of chemical household products. For instance, people may consider the safe handling of chemical household products unnecessary and time consuming (negative outcome expectancies), or people may not feel personally responsible for the safe use of these products (lack of perceived behavioural control). Research suggests that in some instances consumers apply simple heuristics to evaluate the risks of chemical household products instead of relying on objective information, such as pictograms or hazard and safety statements (Bearth et al., 2017; Bearth & Siegrist, 2019; Grey et al., 2005).

Previous studies (e.g. Jenny & Kaufmann, 2009; Smolinske & Kaufman, 2007; TNS Opinion & Social, 2017) have identified the barriers to the safe use of chemical household products individually, but these factors have rarely been investigated together to assess how influential each individual one is for the safe use of chemical household products. Furthermore, most studies were only conducted in one country or focused on a specific consumer group, such as parents of toddlers or farmers (e.g. Beirens et al., 2006; Hinks et al., 2009). The goal of the present study was to provide a comprehensive overview and comparison of European consumers' familiarity with GHS pictograms, and their perception and self-reported handling of hazardous household chemicals (e.g. cleaning and laundry products, Do-It-Yourself (DIY) materials, garden chemicals, essential oils). Furthermore, it aimed to identify psychological factors (e.g. perceptions, individual characteristics) are most closely related to people's self-reported behaviour, thereby providing starting points for further research and risk communication about chemicals.

3.2 Materials and methods

3.2.1 Study sample

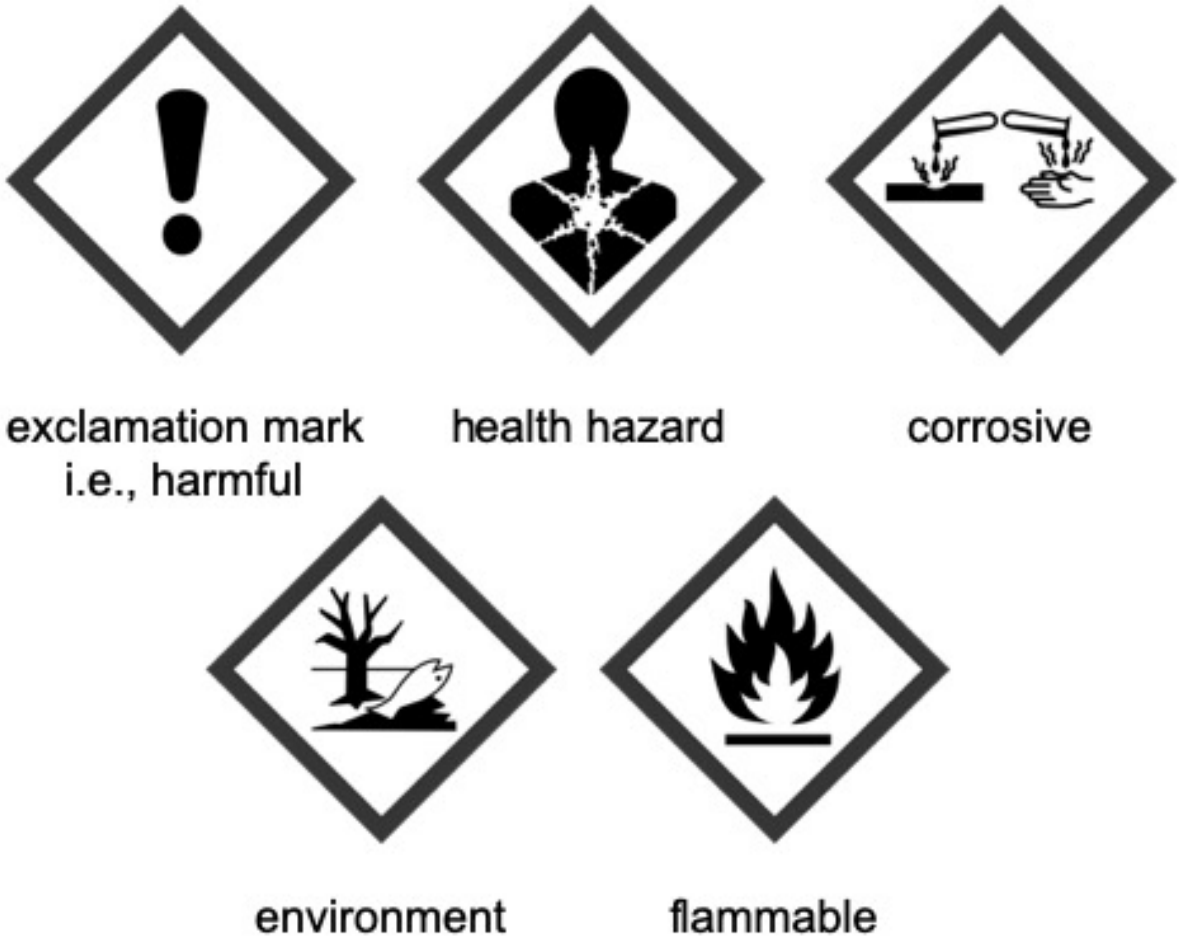
For this study, participants from eight European countries (Switzerland, Germany, Austria, France, Italy, Poland, Sweden, UK) were recruited with roughly 700 participants per country (Total: $N = 5631$, Austria: $N = 731$, Switzerland: $N = 698$, Germany: $N = 711$, France: $N = 708$, Italy: $N = 695$, Poland: $N = 693$, Sweden: $N = 682$, UK: $N = 713$; cf. Bearth et al. (2019) for more information regarding the sample). These particular countries were chosen based on cultural and historical differences in chemical regulation and because the GHS was simultaneously introduced in 2015 in these countries (United Nations Economic Commission for Europe, 2017). Recruiting was done with the support of a professional market research company. Speeders (i.e., individuals who filled out the survey in less than half the median duration) were screened out prior to data analysis. For all countries, quota sampling for age and gender was applied. There were significant differences in reported level of education in the national samples, which can mostly be attributed to the lack of comparability of the national education systems (c.f. Bearth et al., 2019).

3.2.2 Study design and materials

The results of this article were part of a larger survey that investigated people's knowledge of toxicological principles, which is presented elsewhere (Bearth et al., 2019). This article presents the results of the second part of the survey: people's perceptions of hazardous chemical household products. The questionnaire for this online survey was adapted from one

used in unpublished Swiss evaluation studies that had been conducted in the years 2012, 2013, 2015 and 2017 (c.f. Jenny & Kaufmann, 2009). The goal of these studies was to monitor people's familiarity with the GHS pictograms during the implementation phase, their attitudes and their self-reported behaviour (Jenny & Kaufmann, 2009). The questionnaire for the present study consisted of three parts. First, people's *familiarity* with five of the GHS symbols (see Figure 8) was assessed by sequentially showing them pictures of each these pictogram and asking whether they 1) had seen it before and knew its meaning, 2) had simply seen it before, 3) had never seen it before or 4) whether did not know.

Figure 8. *Pictures used in this study for measuring familiarity with GHS pictograms (original in colour with red frame and black symbol, without text).*



Second, participants' risk perception, the importance of different aspects when evaluating the risk of a chemical household product, outcome expectancies, and perceived control were measured. *Risk perception of chemical household products* was measured with four items,

including “Misuse of chemical household products can have serious health consequences.” It exhibited a relatively low reliability of α = .63 (Table A in the Appendix). The *importance of different aspects when evaluating the risk of chemical household products* was measured by presenting a list of 11 informative and non-informative aspects based on previous literature (e.g. Bearth et al., 2017; Hinks et al., 2009). The 11 aspects are presented in Table 8 in the results section and in Table A in the Appendix. *Positive and negative outcome expectancies* were measured with three positive and three negative statements and the scale exhibited an acceptable reliability of α = .76 (Table A in the Appendix). *Perceived personal control* was measured with the single item “It is my own responsibility to ensure that no accidents involving chemical household products happen.” *Perceived external control* was measured with the single item “Manufacturers and sellers are responsible for ensuring that no accidents involving chemical household products happen” (Table A in the Appendix).

Third, self-reported accidents in the past 12 months were reported along with self-reported behaviour. The measure *self-reported accidents* was assessed by asking the participants the following question: “Did you or another person in your household have an accident with chemical household products in the last 12 months” (1: yes, 2: no, 3: no response). The term “accident” was not defined further in the questionnaire. *Self-reported behaviour* was measured with six items pertaining to the storage, use and disposal of chemical household products (e.g. “I keep chemical household products separate from food products”) and exhibited a barely adequate reliability of α = .60 (Table A in the Appendix). For the perceptions and self-reported behaviour, participants were asked to respond on a scale from 1: “do not agree at all” to 6: “strongly agree.”

The questionnaire was originally written in German and was translated and back-translated by native speakers into English, French, Italian, Polish and Swedish, and pre-tested in all eight countries.

3.2.3 Data analysis

Reliability analyses (Cronbach’s alpha) was used to determine scale reliability. All multi-item scales were built by taking the mean over all items pertaining to the same scale. The 11 aspects used to judge the riskiness of a chemical household product were subjected to an exploratory principal component analysis (PCA, based on correlation matrix, with direct

oblimin rotation) to investigate the underlying dimensionality across all countries[2]. The Kaiser–Meyer–Olkin Measure was KMO = .846, which suggests sampling adequacy. Oblique rotation was chosen to accommodate for correlations between dimensions. To determine dimensionality, Kaiser's criterion was applied, and component loadings were interpreted based on Stevens (2002). With a sample size of $N = 700$, component loadings should be greater than .21 to be considered significant (Stevens, 2002). To test for differences between the countries, Chi-Square tests and one-way ANOVAs (with Tukey's post hoc tests) were conducted. To test for relationships among the included variables, Pearson correlation and linear regression analyses were conducted. All descriptive and multivariate analyses were done in SPSS 25 (IBM Corp., 2017).

3.3 Results

3.3.1 Familiarity with GHS pictograms

Across all countries, the highest consumer familiarity was found for the GHS pictogram "flammable," as over 90% of participants indicated that they were aware of its meaning (Figure 9). This was followed by "corrosive," "exclamation mark" (i.e., harmful) and "environment," and 40–60% of participants were familiar with these symbols. Less known was the meaning of "health hazard," as over 65% of the participants indicated that they had never seen it before. Significant differences in familiarity between the eight countries were observed for all GHS symbols, as assessed by Chi-Square Tests (Table 6 for frequency distributions). A relatively large number of German and Swedish consumers reported to never have seen the GHS pictogram "exclamation mark" ($X^2(14) = 162.6$, $p < .001$). For "health hazard" ($X^2(14) = 90.2$, $p < .001$), the following distributions were observed: It was more frequently known by Polish consumers, while consumers in Sweden and the UK more frequently reported never having seen it before. A similar result was found for the GHS pictogram "environment" ($X^2(145) = 174.9$, $p < .001$). Swedish and UK consumers reported having seen it less frequently. Finally, differences between countries were also significant, but they were less pronounced for the pictograms for "corrosive" ($X^2(145) = 64.4$, $p < .001$) and "flammable" ($X^2(145) = 57.7$, $p <$

[2] The analysis was conducted for all countries, as individual PCAs revealed similar dimensionalities in the eight countries. The results of the separated PCAs can be provided by the corresponding author.

.001). For these pictograms, significantly more Polish consumers reported that they had never seen it before.

Figure 9. *Awareness of GHS pictograms across all countries (N = 5631).*

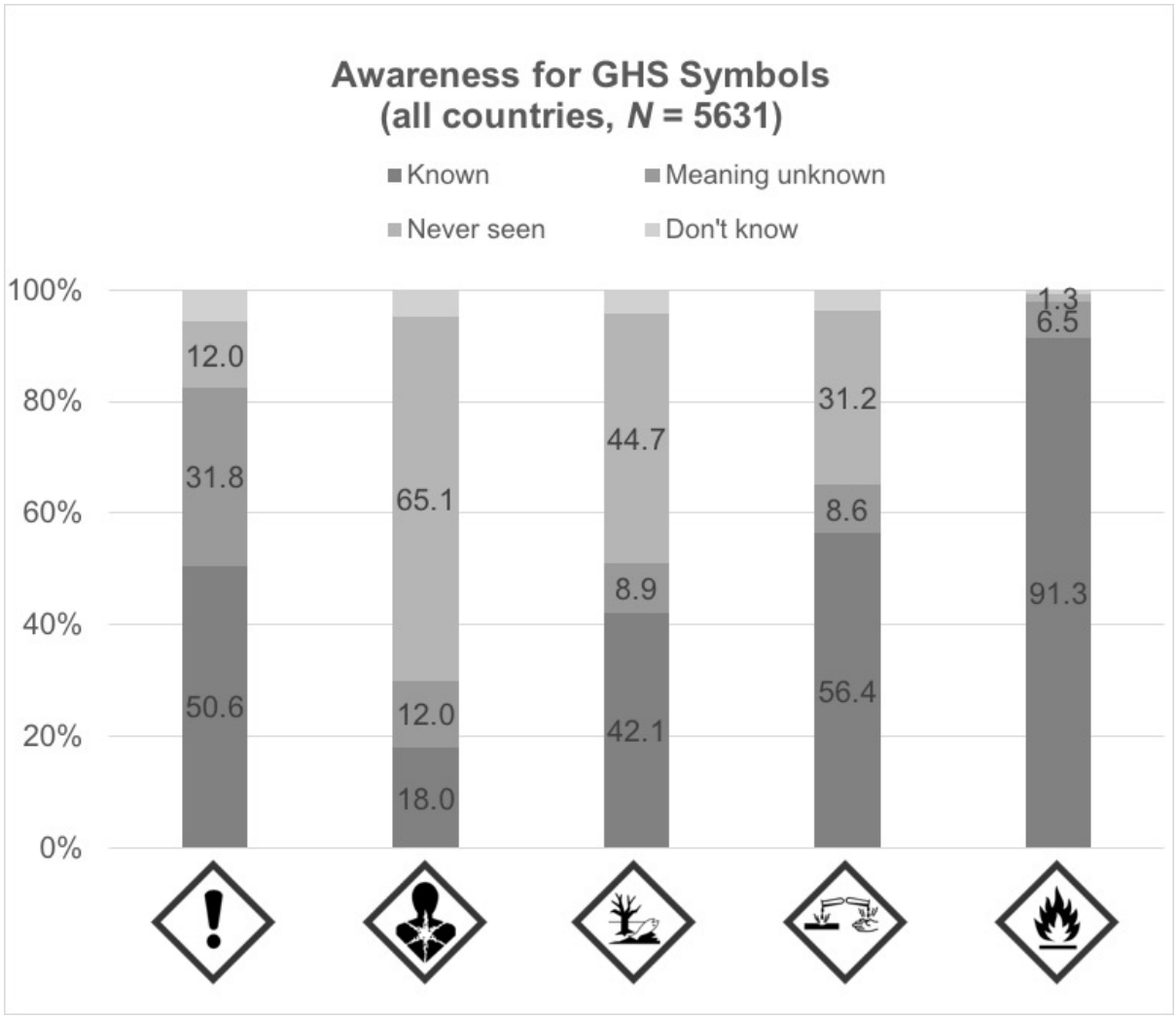


Table 6. *Awareness for GHS pictograms (absolute frequencies and percentages).*

		AT	CH	DE	FR	IT	PL	SE	UK
Total		N = 731	N = 698	N = 711	N = 708	N = 695	N = 693	N = 682	N = 713
GHS pictogram									
	Yes, and I know what it means	395 (54.0)	392 (56.2)	328 (46.1)	355 (50.1)	389 (56.0)	393 (56.7)	251 (36.8)	347 (48.7)
	Yes, but I don't know what it means	228 (31.2)	221 (31.7)	232 (32.6)	244 (34.5)	186 (26.8)	203 (29.3)	211 (30.9)	265 (37.2)
	No	76 (10.4)	53 (7.6)	104 (14.6)	75 (10.6)	90 (12.9)	48 (6.9)	156 (22.9)	76 (10.7)
	Don't know	32 (4.4)	32 (4.6)	47 (6.6)	34 (4.8)	30 (4.3)	49 (7.1)	64 (9.4)	25 (3.5)
	Yes, and I know what it means	141 (19.3)	145 (20.8)	129 (18.1)	138 (19.5)	119 (17.1)	170 (24.5)	90 (13.2)	81 (11.4)
	Yes, but I don't know what it means	93 (12.7)	92 (13.2)	83 (11.7)	90 (12.7)	89 (12.8)	95 (13.7)	58 (8.5)	74 (10.4)
	No	466 (63.7)	425 (60.9)	470 (66.1)	450 (63.6)	463 (66.6)	372 (53.7)	484 (71.0)	536 (75.2)
	Don't know	31 (4.2)	36 (5.2)	29 (4.1)	30 (4.2)	24 (3.5)	56 (8.1)	50 (7.3)	22 (3.1)
	Yes, and I know what it means	322 (44.0)	351 (50.3)	316 (44.4)	344 (48.6)	348 (50.1)	267 (38.5)	211 (30.9)	213 (29.9)
	Yes, but I don't know what it means	66 (9.0)	74 (10.6)	64 (9.0)	64 (9.0)	56 (8.1)	72 (10.4)	55 (8.1)	49 (6.9)
	No	317 (43.4)	238 (34.1)	305 (42.9)	268 (37.9)	270 (38.8)	305 (44.0)	377 (55.3)	435 (61.0)
	Don't know	26 (3.6)	35 (5.0)	26 (3.7)	32 (4.5)	21 (3.0)	49 (7.1)	39 (5.7)	16 (2.2)
	Yes, and I know what it means	439 (60.1)	397 (56.9)	438 (61.6)	434 (61.3)	374 (53.8)	311 (44.9)	376 (55.1)	409 (57.4)
	Yes, but I don't know what it means	44 (6.0)	56 (8.0)	59 (8.3)	75 (10.6)	69 (9.9)	82 (11.8)	44 (6.5)	57 (8.0)
	No	225 (30.8)	225 (32.2)	195 (27.4)	180 (25.4)	230 (33.1)	244 (35.2)	227 (33.3)	229 (32.1)
	Don't know	23 (3.1)	20 (2.9)	22 (3.2)	19 (2.7)	22 (3.2)	56 (8.1)	35 (5.1)	18 (2.5)
	Yes, and I know what it means	689 (94.3)	666 (95.4)	648 (91.1)	664 (93.8)	628 (90.4)	600 (86.6)	614 (90.0)	633 (88.8)

	Yes, but I don’t know what it means	35 (4.8)	28 (4.0)	46 (6.5)	39 (5.5)	47 (6.8)	62 (8.9)	47 (6.9)	63 (8.8)
	No	4 (0.5)	2 (0.3)	11 (1.5)	2 (0.3)	16 (2.3)	18 (2.6)	12 (1.8)	10 (1.4)
	Don’t know	3 (0.4)	2 (0.3)	6 (0.8)	3 (0.4)	4 (0.6)	13 (1.9)	9 (1.3)	7 (1.0)

Note. AT: Austria, CH: Switzerland, DE: Germany, FR: France, IT: Italy, PL: Poland, SE: Sweden, UK: United Kingdom.

3.3.2 Perceptions of chemical household products

Overall, the risk perception of chemical household products was rather high for all countries. Risk perceptions between the countries differed significantly, but with only a small effect size: $F(7, 5623) = 19.54$, $p < .001$, $\eta^2 = .02$. Only French consumers reported a higher risk perception than consumers from the other countries (cf. Table 7).

PCA showed that the responses to the 11 aspects used to evaluate the riskiness of chemical household products were correlated and could be grouped into three dimensions, comprising 3 to 5 aspects. Table 8 presents the component loadings for the 11 items. An inspection suggests the following dimensionality: Dimension 1 comprises five items (product-related aspects, such as perceived effectiveness), dimension 2 has three items (hazard-related aspects, such as danger warnings on packaging) and dimension 3 has three items (marketing-related aspects, such as the availability via online shipping). Table 7 presents the descriptives of all three scales separated by country. Across all countries, the hazard-related aspects (i.e. danger warnings on packaging, composition or ingredients, information and advice from sales staff) were correctly identified as highly important for judging the risk related to a chemical household product. There were small significant differences among the countries ($F(7, 5623) = 14.57$, $p < .001$, $\eta^2 = .02$). The results suggest that hazard-related aspects were less relevant for consumers from the UK and Sweden compared to consumers from other countries. There were significant differences among the countries in the product- and marketing-related scales (product-related aspects: $F(7, 5623) = 39.87$, $p < .001$, $\eta^2 = .05$; marketing-related aspects: $F(7, 5623) = 27.06$, $p < .001$, $\eta^2 = .03$). Particularly, Polish consumers gave more weight to product- and marketing-related aspects in their risk evaluations, such as the perceived effectiveness or the availability via online shipping (Table 7).

A large share of participants expressed high positive outcome expectancies regarding the safe handling of chemical household products, and the differences between countries were small ($F(7, 5623) = 9.37$, $p < .001$, $\eta^2 = .01$). The lowest positive outcome expectancies were found in Sweden, the UK and Italy. Regarding perceived control, participants more strongly agreed that the safe use of chemical household products is their own responsibility, rather than that of manufacturers and retailers. However, significant differences between the countries were uncovered for both personal ($F(7, 5623) = 12.27$, $p < .001$, $\eta^2 = .02$) and external perceived control ($F(7, 5623) = 79.99$, $p < .001$, $\eta^2 = .09$), with the latter having a large effect. Austrian consumers expressed the lowest levels of perceived control by manufacturers and retailers, while French and Italian consumers expressed the highest.

Table 7. *Perceptions and self-reported behaviour (M: Mean, SD: Standard Deviation; 1: do not agree at all – 6: strongly agree).*

	AT		CH		DE		FR		IT		PL		SE		UK	
	N = 731		N = 698		N = 711		N = 708		N = 695		N = 693		N = 682		N = 713	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Self-reported behaviour	5.28^{ab}	0.70	5.37^{a}	0.62	5.31^{ab}	0.70	5.19^{bc}	0.73	5.19^{bc}	0.82	5.00^{e}	0.84	5.01^{de}	0.78	5.13^{cd}	0.76
Risk perception of chemical household products	4.82^{ab}	0.90	4.77^{b}	0.88	4.93^{a}	0.87	5.16^{c}	0.84	4.83^{ab}	0.93	4.71^{b}	0.89	4.69^{b}	0.93	4.84^{ab}	0.85
outcome expectancies	5.08^{ab}	0.87	5.09^{ab}	0.83	5.12^{ab}	0.89	5.16^{b}	0.76	4.99^{ac}	0.94	5.07^{ab}	0.89	4.88^{c}	0.92	4.91^{c}	0.89
Perceived control: Personal	5.59^{a}	0.81	5.53^{a}	0.85	5.55^{a}	0.78	5.27^{b}	1.05	5.35^{b}	1.00	5.34^{b}	1.09	5.33^{b}	1.06	5.52^{a}	0.87
Perceived control: External	2.65^{a}	1.55	3.01^{b}	1.66	3.04^{b}	1.62	4.17^{d}	1.72	4.11^{d}	1.54	3.73^{e}	1.69	3.41^{c}	1.61	3.22^{bc}	1.64
Product-related aspects	4.13^{ab}	1.00	4.08^{bc}	0.98	4.11^{bc}	1.03	3.96^{bc}	1.10	4.03^{c}	1.06	4.66^{d}	0.88	3.85^{c}	1.09	3.95^{bc}	1.10
Hazard-related aspect	4.78^{abc}	1.13	4.83^{b}	0.96	4.79^{abc}	1.00	4.64^{cd}	1.06	4.79^{abc}	1.01	4.84^{b}	0.96	4.42^{e}	1.09	4.56^{de}	1.12
Marketing-related aspects	2.93^{a}	1.09	3.04^{ab}	1.04	3.07^{ab}	1.17	3.00^{ab}	1.17	3.33^{c}	1.24	3.62^{d}	1.17	3.18^{bc}	1.12	3.02^{ab}	1.24

*Note. *: reverse-coded items; different superscript letters (e.g, a, b, c) indicate significant differences according to Tukey post hoc tests ($p < .05$); AT: Austria, CH: Switzerland, DE: Germany, FR: France, IT: Italy, PL: Poland, SE: Sweden, UK: United Kingdom.*

Table 8. *Dimensionality of aspects for the risk perception of chemical household products (PCA with direct oblimin rotation, pattern matrix, N = 5631).*

	M (*SD*)	1 Product-related aspects	2 Hazard-related aspects	3 Marketing-related aspects
Effectiveness	4.54 (1.45)	.89	-.06	-.11
Odour	4.00 (1.52)	.61	.02	.20
Experience with this or a similar product	4.62 (1.27)	.61	.33	-.18
Size of packaging (quantity)	3.46 (1.63)	.56	-.14	.42
Biodegradable packaging	3.86 (1.63)	.49	.17	.22
Danger warnings on packaging	5.16 (1.17)	.04	.83	-.08
Composition and ingredients	4.75 (1.35)	.11	.77	-.06
Information and advice from sales staff	4.22 (1.47)	-.07	.66	.35
Packaging (colour, font)	3.19 (1.61)	-.11	.16	.77
Availability via online shipping	2.56 (1.61)	.15	-.19	.67
Place of purchase (retail vs. special trade)	3.68 (1.57)	.24	.19	.52
Eigenvalues		**3.77**	**1.54**	**1.01**
% of variance		**34.30**	**14.02**	**9.18**
α		**.74**	**.69**	**.58**

Note. M: Mean, SD: Standard deviation, α: Cronbach's Alpha

3.3.3 Self-reported accidents and handling of chemical household products

Italy had the highest number of participants that reported an accident with chemical household products in the past 12 months (n = 32, 4.6%), followed by Poland (n = 19, 2.7%), Austria (n = 14, 1.9%), the UK (n = 12, 1.7%), France (n = 12, 1.7%), Sweden (n = 11, 1.6%), Switzerland (n = 11, 1.6%) and Germany (n = 7, 1.0%). Furthermore, there were significant differences in self-reported behaviour among the eight countries, with Swiss, Austrian and German consumers reporting the safest and Poland the least safe behaviour ($F(7, 5623) = 23.10$, $p < .001$, $\eta^2 = .03$) (cf. Table 7).

Table 9 shows the correlation coefficients among the included variables, which suggest medium to strong relationships between self-reported behaviour and perceptions, such as risk perception, outcome expectancies and perceived control, in all countries. External perceived control was not significantly related to self-reported behaviour in Austria, Switzerland, Germany, Italy, Poland and Sweden. In the UK however, external control was negatively related to people's self-reported behaviour. Separate linear regression analyses in each of the eight countries (cf. Table 10) indicated that outcome expectancies were most strongly related to self-reported behaviour in the eight countries. In all countries, the personal perceived control was more relevant than the external one. Age was significantly positively related to self-reported behaviour in all countries except for Italy. Gender was only significantly related to self-reported behaviour in Sweden.

Table 9. *Bivariate correlations between self-reported behaviour and perceptions.*

	AT N = 731	CH N = 698	DE N = 711	FR N = 708	IT N = 695	PL N = 693	SE N = 682	UK N = 713
Risk perception of chemical household products	.34*	.36*	.48*	.44*	.68*	.52*	.48*	.49*
Outcome expectancies	.49*	.50*	.57*	.50*	.70*	.60*	.59*	.56*
Perceived personal control	.35*	.38*	.43*	.33*	.59*	.43*	.34*	.35*
Perceived external control	-.07	-.05	-.05	.14*	.04	.06	.04	-.10*

*Note. *: p < .001; AT: Austria, CH: Switzerland, DE: Germany, FR: France, IT: Italy, PL: Poland, SE: Sweden, UK: United Kingdom.*

Table 10. *Linear regression analyses with self-reported behaviour as dependent variable.*

	AT **N = 731**		**CH** **N = 698**		**DE** **N = 711**		**FR** **N = 708**	
	B ***(95% CI)***	**t**	***B*** ***(95% CI)***	**t**	***B*** ***(95% CI)***	**t**	***B*** ***(95% CI)***	**t**
Constant	2.45 (2.04, 2.86)	11.72***	2.92 (2.56, 3.29)	15.76***	2.06 (1.68, 2.43)	10.80***	2.04 (1.65, 2.43)	10.30***
Risk perception	0.05 (-0.01, 0.12)	1.70	0.07 (0.01, 0.12)	2.37*	0.10 (0.03, 0.16)	2.90**	0.17 (0.10, 0.24)	4.96***
Outcome expectancies	0.29 (0.22, 0.35)	8.22***	0.24 (0.18, 0.31)	7.76***	0.29 (0.23, 0.36)	8.60***	0.28 (0.21, 0.36)	7.39***
Perceived personal control	0.17 (0.11, 0.23)	5.57***	0.13 (0.08, 0.18)	5.11***	0.20 (0.15, 0.26)	7.12***	0.10 (0.05, 0.14)	4.17***
Perceived external control	0.01 (-0.02, 0.04)	0.56	0.00 (-0.02, 0.02)	0.03	0.01 (-0.02, 0.03)	0.49	0.01 (-0.01, 0.04)	1.03
Gender (0: female)	-0.02 (-0.11, 0.07)	-0.49	-0.08 (-0.15, 0.00)	-1.90	-0.05 (-0.13, 0.03)	-1.31	-0.08 (-0.17, 0.01)	-1.70
Age	0.00 (0.00, 0.01)	2.86**	0.01 (0.00, 0.01)	4.22***	0.01 (-0.13, 0.03)	3.07**	0.01 (0.00, 0.01)	5.47***

	IT N = 695		PL N = 693		SE N = 682		UK N = 713	
	B ***(95% CI)***	**t**	***B*** ***(95% CI)***	**t**	***B*** ***(95% CI)***	**t**	***B*** ***(95% CI)***	**t**
Constant	1.29 (0.98, 1.59)	8.30***	1.51 (1.12, 1.90)	7.62***	2.35 (1.98, 2.71)	12.63***	2.13 (1.74, 2.52)	10.69***
Risk perception	0.26 (0.19, 0.32)	7.84***	0.19 (0.12, 0.26)	5.07***	0.12 (0.06, 0.19)	3.59***	0.16 (0.09, 0.23)	4.63***
Outcome expectancies	0.29 (0.22, 0.35)	8.34***	0.36 (0.28, 0.44)	8.72***	0.35 (0.27, 0.42)	9.20***	0.30 (0.23, 0.37)	8.75***
Perceived personal control	0.22 (0.17, 0.27)	9.16***	0.11 (0.06, 0.16)	4.12***	0.08 (0.03, 0.12)	3.09**	0.11 (0.06, 0.17)	3.91***
Perceived external control	0.01 (-0.02, 0.03)	0.41	0.03 (0.00, 0.06)	2.19*	0.02 (-0.01, 0.05)	1.47	-0.01 (-0.04, 0.02)	-0.57
Gender (0: female)	-0.04 (-0.12, 0.04)	-1.03	-0.08 (-0.18,0.02)	-1.60	-0.19 (-0.28, -0.10)	-4.02***	-0.06 (-0.15, 0.03)	-1.28
Age	0.00 (0.00, 0.00)	1.34	0.01 (0.00, 0.01)	2.36*	0.01 (0.00, 0.01)	2.65**	0.01 (0.00, 0.01)	3.22**

*Note. *: $p < .05$, **: $p < .01$, ***: $p < .001$; AT: Austria ($R^2 = .28$, $F(6,724)=47.37$, $p < .001$), CH: Switzerland ($R^2 = .31$, $F(6,691)=52.31$, $p < .001$), DE: Germany ($R^2 = .40$, $F(6,704)=78.27$, $p < .001$), FR: France ($R^2 = .34$, $F(6,701)=60.70$, $p < .001$), IT: Italy ($R^2 = .60$, $F(6,688)=170.95$, $p < .001$), PL: Poland ($R^2 = .42$, $F(6,686)=81.60$, $p < .001$), SE: Sweden ($R^2 = .39$, $F(6,675)=73.11$, $p < .001$), UK: United Kingdom ($R^2 = .37$, $F(6,706)=68.97$, $p < .001$).*

3.4 Discussion

This study offers a comparison of the importance of a variety of literature-based barriers to the safe use of hazardous chemical household products. The results suggest that positive outcome expectancies are particularly relevant for people's self-reported safe use of chemical household products. The implications of the use of misleading rules of thumb for the risk evaluation of chemical household products should be addressed further. Additionally, this study offers general and country-specific insights into people's perceptions and handling of hazardous chemical household products and thus implications for a variety of stakeholders aiming to promote public health. Next, these findings and their implications are discussed in more detail and in light of previous literature.

3.4.1 Barriers to the safe use of household chemicals and implications for policy and risk communication

The lack of awareness of the presence of and unfamiliarity with the meaning of the GHS pictograms is an important first barrier to the safe use of chemical household products. In this study, a significant number of participants were unaware of or unfamiliar with the GHS pictograms. A comparison of these numbers to the ones found in a study from 2012 (European Chemicals Agency, 2012; TNS Political & Social, 2013) shows that, particularly for the pictograms "health hazard" and "exclamation mark," only minor improvements in public familiarity were achieved since the introduction of GHS. Previous research suggests that consumers that are aware of the safety and hazard information on chemical household products and make use of it when actively asked to judge the risk of the exposure to this product (Bearth et al., 2017; Boelhouwer & Davis, 2010). However, in real-life situations, participants might ignore the hazard information (pictograms, safety and hazard statements) or perhaps worse, misinterpret the meaning of the pictograms. For instance, this has been shown in previous research with children, who interpreted the pictogram "corrosive" as "for hand washing" (Latham et al., 2013). Thus, specific consumer education regarding the meaning of the lesser known pictograms (i.e. "health hazard" or "environment") could promote the safe use of hazardous chemical household products. These educational and informational efforts could already be implemented at primary school levels or in information campaigns (Boelhouwer et al., 2013; Latham et al., 2013).

Due to the fact that the GHS was introduced simultaneously in 2015 in all eight countries, the significant differences in consumers' familiarity with the GHS pictograms between countries is somewhat surprising. However, the differences might arise from national differences in the usage of particular products, differences in policies for the supply of private

persons with dangerous chemical products or the availability of particular products (Remoundou et al., 2014; TNS Opinion & Social, 2017). For example, chemical household products with the pictogram "health hazard" might be more commonly used in Poland than in Sweden or the UK. This would explain the differences in familiarity with the pictogram. Another explanation could be the differing communication strategies during the GHS implementation in the eight countries. For instance, in Switzerland, the GHS introduction was paired with a public communication campaign, raising awareness of the new pictograms through TV and radio spots or on banner ads (Swiss Federal Office of Public Health, 2009). Perhaps these communication efforts were less prominent in other European countries.

An important barrier to people's use of pictograms to judge the risks of a chemical household product is the use of simple rules of thumb, such as the notion that cleaning products with biodegradable packaging are safer for health than regular cleaning products. These rules of thumb might cause consumers to consider misleading information (e.g. biodegradable packaging) and underestimate hazardous chemical household products, thus, applying suboptimal strategies during the transport, storage, handling or disposal of these products (compare Bearth et al., 2017). For example, a lower risk perception of chemical household products with particular attributes (e.g. in biodegradable packaging, eco-products, food-imitating products) might lead consumers to store them less safely than regular household products (e.g. within the reach of children) (Basso et al., 2016; Bearth et al., 2017; Bearth & Siegrist, 2019; Beirens et al., 2006). Previous research further suggested that parents overestimate the safety of child-resistant caps and store products with such caps within reach of children (Gibbs et al., 2005).

In all countries, misconceptions and the reliance on misleading information should be addressed for accident prevention. Particularly in Poland, potentially misleading product- and marketing-related aspects were rated as relevant by the participants. Similarly, in Sweden and the UK, hazard-related aspects that might provide valuable risk information (e.g. danger warnings on packaging, information and advice from sales staff) were rated as less important than in the other countries. Thus, informational campaigns targeting these specific countries could focus on strengthening the use of hazard-related aspects (i.e. increase awareness of hazard information, increase familiarity with meaning of pictograms, encourage retail information provision) and weakening the effects of misleading aspects (i.e. appearance of biodegradable packaging).

Other aspects that might be of high relevance include addressing situational barriers, such as negative outcome expectancies (i.e. careful handling is too time consuming or unnecessary),

and increasing consumers' perceived personal control. Consumers who view themselves as being in control reported safer practices regarding hazardous chemical household products. The role of perceived external control should be clarified in future studies, as the negative correlation in the UK suggests that higher perceived external control is related to unsafe self-reported behaviour. Furthermore, most chemical household products are used frequently, on a daily or weekly basis (e.g. laundry detergent, toilet cleaner). Isolated instances of incorrect transport, handling or disposal do not necessarily lead to immediate negative consequences, which reduces people's risk awareness and the likelihood that they will take future precautions. Aside from raising risk awareness and perception, research should also focus on ways to address situational barriers. For instance, situational cues and nudges, such as reminders to wear gloves or store the product in a particular manner, might be a promising way to ensure that consumers' keep themselves and other people safe when they are in contact with chemical household products.

3.4.2 Limitations and implications for further research

A number of limitations of this study should be addressed. First and foremost, the study made use of self-reporting, which is susceptible to bias due to socially desirable responses or the failure to remember critical incidences. The goal of this study was to compare knowledge, perceptions and self-reported behaviour in different countries. Thus, response bias likely has a similar impact on the consumers from all countries, which allows interpreting differences between countries. However, a relevant future task for behavioural research is to address ways to measure people's actual behaviour with chemical household products rather than relying on self-reporting. Otherwise, evaluation studies that investigate the effect of informational and behavioural interventions might fail to uncover changes in behaviour. For this, observational approaches or the use of innovative technologies (e.g. tracking of behaviour, observation of behaviour in virtual reality) could be promising strategies. Another potential limitation is that participants were recruited from a professional market research company. Thus, they are part of a consumer panel and are regularly invited to participate in market research and research. This suggests a prior interest in studies and might suggest a higher educational level for this sample compared to the population. Another limitation is that based on household composition and the presence or absence of particular chemical household products, the behavioural variables have different implications. For example, incorrect storage of potentially dangerous household products has different implications for a single household than for one with toddlers. This should be addressed in future studies by targeting particular groups of consumers, such as parents of toddlers or pet owners.

3.5 Conclusion

In conclusion, there are a number of starting points for risk regulation and communication regarding the safe handling of potentially risky chemical household products. First, risk awareness and familiarity with the meanings of the GHS pictograms need to be raised to improve people's abilities to recognise potentially dangerous household chemicals. Second, the use of misleading cues should be reduced to ensure that these pictograms are acknowledged and taken seriously. Finally, situational barriers should be addressed by considering new approaches, such as nudging.

Consumers' Decision-Making Process When Choosing Potentially Risky Chemical Household Products

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Abstract

Chemical household products are a common cause of accidents in the domestic sphere. Despite such products being associated with certain risks in the event of swallowing or contact with the skin or eyes, they are used in nearly every household worldwide for hygiene purposes. In most European countries, chemical household products feature warnings of the Globally Harmonized System (GHS) as well as other warnings. In this eye-tracking study (N = 167), which was conducted in a virtual environment, we examined (i) whether consumers use such warnings when choosing a chemical household product at the point of sale, (ii) whether they consider information irrelevant to risk assessment and (iii) whether such information influences their final product choice. Further, we studied the impact of chemophobia on consumers' product choice strategies. The results indicate that the warnings found on products are effective when they are used, although the majority of consumers do not look at the warnings. Therefore, we suggest that the alternative placements of warnings or the use of simplified warnings should be considered to improve consumers' awareness of potential risks.

Keywords: Warnings, Chemical Household Products, Risk Perception, Eye Tracking, Virtual Environment (VR)

4.1 Introduction

Accidents involving chemical household products often occur in the domestic environment, with such accidents frequently concerning young children (Tox Info Suisse, 2020). In light of this, and as chemical household products are used in nearly every household and frequently are stored in the home even if no longer in use, it is important to recognise that the risk of severe accidents would be reduced if less dangerous products were used and stored at home (Grey et al., 2005; Sawalha, 2007). The range of products found at home is determined by the choices consumers make when purchasing chemical household products. Thus, the choice of a chemical household product at the point of sale can have widespread consequences in terms of potential accidents. Indeed, accidents in the domestic environment involving chemical household products can only occur if consumers buy, store and use potentially dangerous chemical household products. Moreover, when an accident does occur, its gravity depends on the level of toxicity of the chemical household product involved.

In most European countries, chemical household products feature warnings based on the Globally Harmonized System (GHS). To the best of our knowledge, while prior studies have examined whether consumers are aware of the meaning of these warnings and whether they recall using them (self-report), no study has used observational measures to examine whether consumers consider these warnings when actually buying a chemical household product (Bearth et al., 2020; econcept, 2015; Hesse et al., 2010). The aim of the present study was therefore to measure the use of GHS warnings in an observational manner by using eye-tracking measures. The remainder of this paper proceeds as follows. First, we discuss consumers' perception of chemical household products and the labels as well as personality-related factors that can influence consumers' risk perception. Second, we explore the methodological issues of relevance when studying these questions.

4.1.1 Consumers' Risk Perception of Chemical Household Products

Consumers' risk assessment can be biased by aspects that should be irrelevant. For example, consumers appear to be biased by the design of packaging (Basso et al., 2014). Some chemical household products are designed to look similar to food products for marketing reasons. Such products are suspected of being perceived differently than products with a more traditional packaging and are therefore more commonly involved in poisoning incidents (Basso et al., 2010; Basso et al., 2014; Miller et al., 2006). With regard to children, it also has been shown that the colour of the packaging, the shape of the container and the closure can all have an influence on the perceived risks of a product (Schneider, 1977; Schwebel et al., 2014).

Furthermore, consumers consider products labelled as organic or natural to be safer than their traditional counterparts, although this is not necessarily true (Bearth et al., 2017; Rozin, 2005).

Previous research has indicated that while consumers are aware of the risks of chemical household products, they do not think of them intuitively (Buchmüller et al., 2020). In fact, consumers have to be prompted to think of the risks. When asked about their spontaneous associations regarding such products, consumers are more likely to think about the way they use these products or about product characteristics such as the smell. However, when specifically asked about the magnitude of the risk involved in handling such products, consumers are generally aware of the risks (Buchmüller et al., 2020). In the same line, Habib et al. (2006) found that Lebanese women regarded detergents as necessary to create a safe home environment for their family, and did not perceive the risks stemming from the detergents themselves. Similar results were found for other, non-chemical household products (Leonard & Wogalter, 2000).

4.1.2 Labelling of Products

Given the above, the unambiguous labelling of chemical household products appears important in relation to reminding consumers about the risks associated with such products (Leonard & Wogalter, 2000). Therefore, classifying, labelling and packaging chemical household products appropriately is a legal requirement in many countries, including all the member countries of the European Union (The European Parliament and the Council of the European Union, 2008). In fact, a variety of consumer products feature warnings, and those warnings can have different functions. While in the case of chemical household products the aim is to prompt consumers to take adequate safety measures and be aware of the risks, the warning labels found on other products (e.g. tobacco or unhealthy foods) aim to discourage consumers from buying them in the first place. In addition, labels can also be used to facilitate consumers' comparison of different products (e.g. Nutri-Score, energy labels for household appliances).

Previous research concerning the effectiveness of warnings has revealed that several factors determine the success of a given warning: (i) the warning must be noticed by the consumer, (ii) the consumer must be able to understand the warning and (iii) the consumer must be willing to follow the warning (Laughery & Wogalter, 2014). In order to achieve this, the design of the warning plays a role. Ideally, an effective warning should be composed of a signal word, a hazard statement informing the consumer about the risks as well as potential consequences and, finally, instructions so that the consumer can mitigate the risks (Wogalter et al., 1987). Moreover, the placement of the warning on the product also plays an important

role. In fact, a warning will only be effective if consumers can see it. For example, if the warning is placed immediately before the instructions for use, it is more likely to increase consumers' compliance with safety measures when compared with being displayed after the instructions for use (Wogalter et al., 1987).

In the case of products that are frequently used, such as chemical household products, habituation plays a role in the effectiveness of warnings. Indeed, if consumers use a given product frequently, they are likely to underestimate the risks associated with it and, furthermore, are unlikely to even check the label. For example, Geuens et al. (2021) found that for laundry detergents, most participants did not take the time to read the entire label even though they were instructed to do so.

4.1.2.1 Globally Harmonized System (GHS) for Chemical Products. In this section we will discuss the labels specific to chemical household products. First, we will look at the GHS labels, which are compulsory in most countries worldwide, and then we will consider the safe use icons, which are frequently found on chemical household products in Europe. The United Nations decided to develop the GHS to label chemical products in 1992, and the system was adopted in 2002. The GHS was developed as a universal labelling system for professionals (e.g. regulators and industry) and lay people alike. While the use of the GHS in relation to consumer products is not compulsory on an international level, it is widely used in many European countries. With the GHS, each product is labelled with pictograms indicating the most important dangers associated with that product. Additionally, signal words and hazard sentences provide further information about the potential dangers (Winder et al., 2005). To the best of our knowledge, little research has been conducted to examine the validity of the GHS pictograms, signal words and hazard sentences. Boelhouwer and Davis (2010) studied the effects of the GHS labelling prior to the system's implementation. They showed different labels to their participants and asked them about the perceived risks. The researchers found that the signal words and hazard sentences significantly predicted the participants' risk perception; however, the pictograms did not have an influence on the participants' risk perception. Su and Hsu (2008) compared college students' perception of the GHS warnings to their perception of traffic signs shortly before the system's implementation in Taiwan. Again, they showed their participants the labels and asked about their perception of the associated risks. They authors found that college students perceived the traffic signs more frequently, especially if they had not had any training in hazard communication. Finally, Hesse et al. (2010) studied lay people's understanding of the GHS pictograms. They found that lay people in both the United States (US) and Brazil considered that other people from their respective country would find it

difficult to understand the pictograms. Of the 20 GHS pictograms they tested, only one was judged by the participants to be likely understood in both the US and in Brazil by at least 85% of people. Unfortunately, while these three studies provide valuable information on consumers' understanding of the GHS labels, they do not demonstrate whether the labels are effectively used by consumers as a source of information regarding the risks of a chemical household product when choosing and purchasing such a product in daily life.

4.1.2.2 Safe Use Icons. In addition to the GHS labels, many producers use the safe use icons developed by the International Association for Soaps, Detergents and Maintenance Products. These icons are supposed to indicate appropriate safety measures to consumers in a more accessible way. However, to the best of our knowledge, little published research on their effectiveness exists. Geuens et al. (2021) compared these icons with simplified versions and found that while their participants preferred the simplified versions, this preference did not influence their risk perception or intended behaviour. Further research regarding the validity of the safe use icons is required.

4.1.3 Influence of Consumer's Chemophobia

Aside from external factors, personality factors concerning the individual consumer might have an impact on the use of warning labels. Some people exhibit an unreasonable fear of (synthetic) chemicals, which could potentially lead to the implementation of unnecessary safety measures when using synthetical chemicals and the neglect of necessary safety measures when using natural chemicals, which many lay people believe to be safe (Bearth et al., 2017). This fear, which has previously been labelled chemophobia, might influence consumers' decision-making process when buying chemical household products. In fact, previous studies have found chemophobia to be associated with a higher risk perception of chemical household products, lower levels of toxicological knowledge and, further, a lower level of acceptance of pesticides (Bearth et al., 2019; Buchmüller et al., 2020; Saleh et al., 2019; Saleh et al., 2021). It thus seems probable that consumers who exhibit high levels of chemophobia might be influenced by their fear when purchasing chemical household products.

4.1.4 Studying Risk Perception and Safety Behaviour

In this section we will discuss the implications of studying risk perception and safety behaviour. In actual fact, studying behaviour is problematic for a number of different reasons. For instance, study participants often have problems recalling their behaviour and the reasons that prompted their decision to omit or adopt a given behaviour. Recall bias is commonly identified in surveys, although it can be reduced by limiting questions to behaviour engaged in a relatively short time ago (Clarke et al., 2008). However, chemical household products

represent a frequently purchased type of consumer product, which means that the product choice is likely influenced by prior purchase decisions that may have been made several months, if not years, previously (e.g. a person who has been buying the same kind of laundry detergent for the past 15 years). Additionally, many participants appear reluctant to admit to engaging in unsafe behaviour due to an effect known as social desirability (Furnham, 1986; Nederhof, 1985). In fact, even during research studies, humans like to present themselves in a socially favourable way. Consciously engaging in unsafe behaviour is generally not perceived well and, therefore, there is a risk that participants deliberately do not report such unsafe behaviour (Furnham, 1986; Nederhof, 1985).

There are a number of ways to address the above-mentioned problems. One promising way of tackling such issues is to use eye tracking in a virtual environment. Eye tracking is a way to measure attention during the decision-making process without relying on participants' memories of the decision situation. Further, the use of virtual reality offers the advantage that eye-tracking measuring devices can be attached directly to the virtual-reality headset, thereby enabling more precise measurements (Meißner et al., 2019) and providing the same standardised environment for all participants (e.g. no differences in the placement of products or the incidence of light, no visual presence of an experimenter). Prior research has shown this method to be a valid means of studying consumers' decisions (Meißner et al., 2020; Meißner et al., 2019; Siegrist et al., 2019; Xu, Demir-Kaymaz, et al., 2021).

4.1.5 Study Aims

The present study had three key aims. The first aim was to examine whether participants look at the GHS warnings and other relevant information for risk assessment purposes when choosing a chemical household product. Relatedly, the study also sought to examine whether participants look at information that is irrelevant for risk assessment purposes (e.g. affirmations regarding the smell) when choosing a chemical household product. The second aim was to investigate whether the decision-making process and, more precisely, the intensity with which consumers consider their product choices influence on the outcome of the decision-making process and the risk level of the chosen product. The third aim was to study whether participants' levels of chemophobia influences their decision-making process. To accomplish these three aims using objective measures, an eye-tracking experiment was conducted in a virtual supermarket.

4.2 Method

4.2.1 Participants

In total, $N = 167$ participants were recruited for this study. For technical reasons (e.g. hardware crashes and unsuccessful calibration), $n = 20$ participants had to be excluded from the analysis of the eye-tracking data, leaving a final sample of $N = 147$. The participants were reimbursed for their travel expenses and time with CHF 22.50 (around USD 20.00). They were recruited from two panels comprising people who had previously participated in similar studies and expressed an interest in participating in future ones, in addition to advertisements placed in local shops and online platforms. The median age of the sample was $Mdn = 26$ years (range: 18 – 68 years) and 52.4% of the participants were women. The sample was, therefore, younger than the average Swiss population (Swiss Federal Statistical Office, 2019). Due to the use of virtual reality technology, people who suffered from motion sickness were not eligible to participate. Furthermore, as the study was conducted during the COVID-19 pandemic, people who were clinically vulnerable to that disease were also excluded from participation. The study received ethical approval from the Ethics Commission of ETH Zurich (EK 2020-N-115) and informed consent was obtained from all participants.

4.2.2 Measurement Setup

An HTC VIVE™ Pro headset was used to immerse the participants into the virtual supermarket surroundings. All the participants received two controllers (i.e. one for each hand) to enable them to interact with the environment. Two buttons (i.e. a touchpad and a trigger) on both controllers were used, one allowing the participants to grasp the products and one allowing them to enlarge the labels (see Figure 10). This made it possible for the participants to read the labels as they were otherwise too small to be readable.

Figure 10. *Example of an Enlarged Product.*

The headset was equipped with a binocular add-on eye tracker developed by Pupil Labs. The participants' eye movements were recorded using Pupil Capture software from Pupil Labs (Kassner et al., 2014). The virtual environment was implemented with Unity version 2018.3.7.

The virtual supermarket was designed to resemble a typical large Swiss supermarket in terms of its style and layout so that the participants would be familiar with their surroundings. The supermarket featured regular shelves, fridge units, half-height shelves used to display fruit and vegetables as well as cash registers. The shelves were filled with a large range of different food products. All of the displayed products and brands were widely available in Swiss supermarkets at the time of testing. The participants were able to grasp and enlarge the products displayed on one specific shelving unit. The products required by the participants for the task resolution were placed on that particular unit. For the actual experimental task, the participants were asked to choose a laundry detergent (see Figure 11) from a range of 14 different laundry detergents. Care was taken to ensure that a wide variety of brands with different price levels were displayed. None of the products were organic or shared large similarities with food products, as prior studies have reported the influence of such factors on consumers' risk perception (Basso et al., 2014; Bearth et al., 2017).

Figure 11. *The Virtual Supermarket (Left: View of an Aisle in the Virtual Supermarket; Right: Shelves Holding the Laundry Detergents).*

4.2.3 Experimental Design

The participants were randomly assigned to one of three experimental groups. These groups differed in terms of whether the participants were primed as to the potential risks of chemical household products or not. The participants in the risk group were asked to buy a laundry detergent for a family with children and in which the parents were worried about the risks such products posed to their children ('Choose a product for a family. The parents are

worried about the potential risks if their children should get hold of the product. They therefore want a product with as little risk as possible.'). The participants in the effectiveness group were asked to buy a laundry detergent for a family with adolescent children ('Choose a product for a family with two adolescents.'). Finally, the participants in the control group were simply asked to buy a laundry detergent ('Choose a product.').

First, the participants were asked to perform a training task to familiarize themselves with the surroundings and the functionalities of the virtual environment. One supermarket shelving unit contained products with which the participants could interact. For the training task, these products were two varieties of muesli. The participants were instructed to choose the healthier of the two mueslis displayed on the shelf. Prior to starting the task, the eye tracker was calibrated. Once the participants felt confident about using the virtual environment, they progressed to the actual task. For the actual task, the two varieties of muesli were replaced with 14 laundry detergents. The participants were then asked to choose a laundry detergent. As noted above, the exact task depended on which experimental group they were assigned to. Again, the eye tracker was calibrated prior to starting the task. Once the participants had chosen a laundry detergent, they were verbally asked for the reasons for their choice and then invited to complete a written questionnaire.

4.2.4 Questionnaire

Following the task in the virtual supermarket, the participants were verbally asked as to why they had chosen the specific product and then asked to complete a questionnaire regarding their socio-demographic details, the importance of different product characteristics to them and their ratings for various psychological scales.

4.2.4.1 Product Characteristics. The participants were asked why they had chosen the specific laundry detergent. To analyse these data, their answers were coded according to the reasons the participants indicated. If the participants indicated multiple reasons for their choice, all of those reasons were taken into account (i.e. the total number of reasons is higher than the total number of participants).

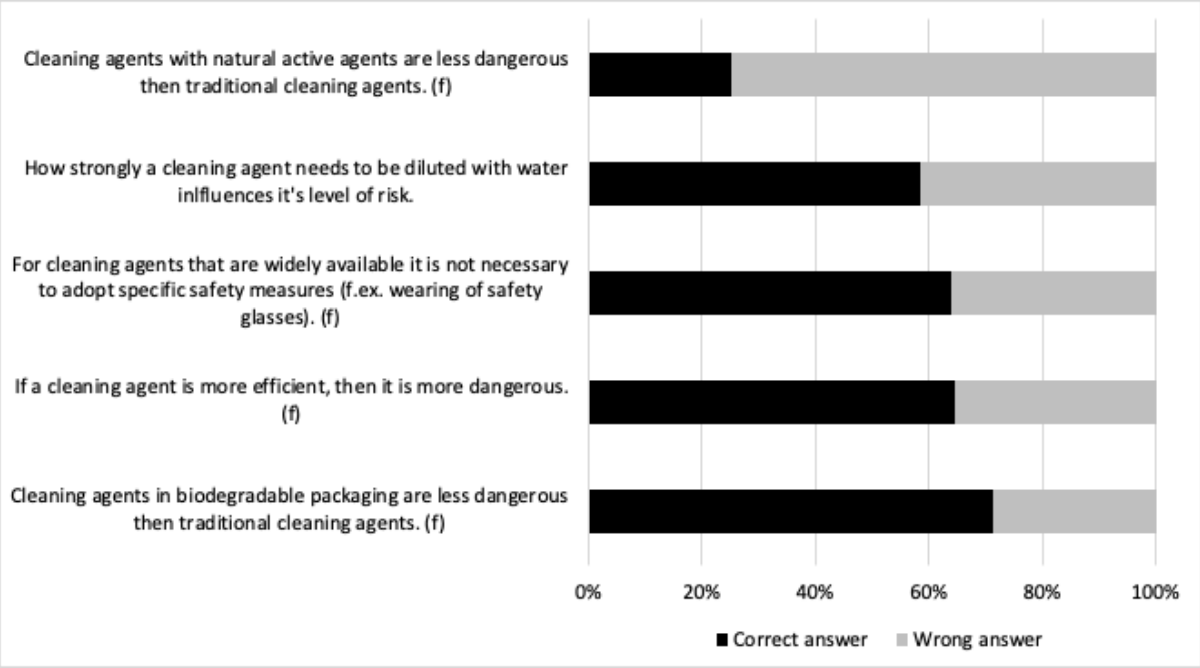
4.2.4.2 Knowledge. To determine the participants' practical knowledge regarding the use of chemical household products, they were asked to indicate the veracity of five statements (cf. Figure 3). They could answer that each statement was correct or false or that they did not know. If the participants indicated that they did not know, it was considered to be a false answer. The statements were constructed to examine the dose-response relationship,

knowledge regarding safety measures and erroneous beliefs about organic products and effectiveness. Four of the statements were incorrect, while one statement was correct.

4.2.4.3 Chemophobia. Participants' irrational fear of synthetical chemicals (e.g. chemophobia) might influence their choices when buying chemical household products. To determine the influence of chemophobia, the participants were presented with a scale featuring seven items and ranging from *1 = do not agree at all* to *6 = totally agree* (cf.

Table ***11***). A scale adapted from Saleh et al. (2019) was used in the present study (Buchmüller et al., 2020). A principal component analysis (PCA) was run for the seven items resulting in one dimension and a good Cronbach's alpha (α = .86).

Figure 12. *Consumers' Applied Knowledge Regarding the Safe Handling of Chemical Household Products: Frequencies (N = 147).*



Note. (f): Incorrect statements.

Table 11. *Chemophobia: Corrected Item-Total Correlations, Means (M), and Standard Deviations (SD) (N = 147).*

		Corrected item-total correlation	*M (SD)*
1	I would like all chemical substances to be risk-free.	.43	4.82 (1.54)
2	The chemical industry is responsible for more people suffering from cancer.	.65	2.83 (1.46)
3	I do everything I can to avoid in my daily life contact with chemical substances.	.71	2.49 (1.57)
4	In a world without chemical substances, there would be no environmental disasters.	.60	2.44 (1.68)
5	I would like to live in a world where chemical substances don't exist.	.69	2.30 (1.58)
6	Chemical substances scare me.	.71	2.04 (1.41)
7	I am scared of chemical substances I cannot pronounce.	.64	1.98 (1.37)

Note. Scale ranges from *1: do not agree at all* to *6: totally agree*.

4.2.5 Data Analysis

The analysis of the fixations were conducted using Pupil Player version 2.6.19 from Pupil Labs (Kassner et al., 2014). For all of the other analyses, IBM SPSS 26 was used. Both non-parametric and parametric tests were run and yielded the same results. Therefore, the results of the parametric tests are reported.

The fixations were counted if they had a minimum duration of 110 milliseconds, a maximum duration of 4000 milliseconds and a dispersion of 1.51 degrees. All of the fixations were manually coded with regard to (i) the product on which they occurred, (ii) whether the participant was grasping the product or enlarging the label and (iii), if the label was enlarged, the area of interest. Slightly more than 10% of all the fixations were double coded by the three raters, which resulted in a Krippendorff's alpha of $\alpha = .85$ (Hayes & Krippendorff, 2007).

When the participants fixated on the enlarged label of a product, it was differentiated whether the area fixated upon was relevant or not to a risk assessment concerning that product. In terms of the relevance to the risk assessment, the following areas were considered: GHS and facultative warnings (both written text and pictograms), instructions and composition. Affirmations regarding the product (e.g. it has a nice smell, it is natural, etc.) and other areas

of the packaging such as the lid or the bottom of a bottle were considered to be irrelevant to the participants' risk assessment. The relative fixation duration was computed by dividing the total duration of all the fixations in that area by the total task duration.

4.3 Results

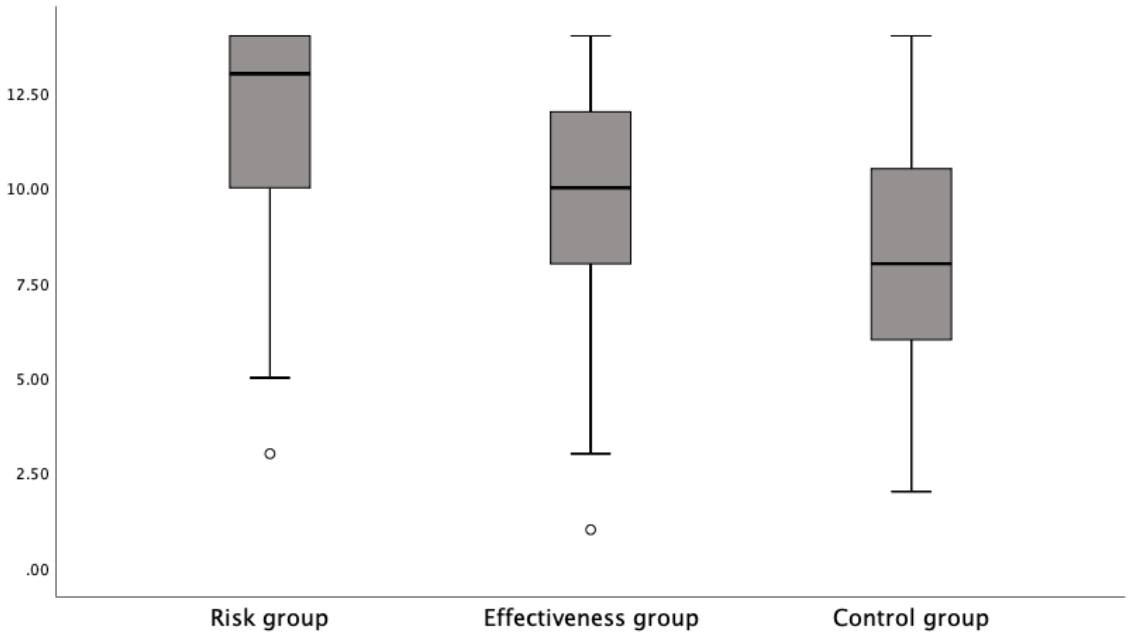
4.3.1 What Do Consumers Look At? How Do They Do This?

First, we examined how much time the participants needed to complete the task. As a next step, we examined both whether the participants looked at the products and whether they enlarged the products' labels. Further, we examined whether the participants used any systematic strategies to complete the task.

To examine whether the experimental groups differed significantly in terms of the time required to complete the task, we conducted an analysis of variance (ANOVA). We found significant differences between the groups, $F(2,144) = 24.39$, $p < .001$. Post-hoc tests using the Tukey B correction showed that the participants in the risk group needed more time to complete the task (M = 324.29 s, SD = 191.50 s) than the participants in the effectiveness group (M = 171.75 s, SD = 101.16 s) and the control group, (M = 146.56 s, SD = 95.84 s), $p < .05$. No significant difference with regard to the total task duration was found between the effectiveness and control groups, $p > .05$.

Again, we conducted an ANOVA to determine whether the number of products that the participants fixated on differed depending on the experimental group. A significant difference was found in this regard, $F(2,144) = 15.21$, $p < .001$ (cf. Figure 13). Post-hoc tests using the Tukey B correction revealed that the participants in the risk group (M = 11.85 products, SD = 2.87 products) looked at more products than those in the effectiveness group (M = 9.77 products, SD = 3.14 products), $p < .05$, or the control group (M = 8.38 products, SD = 3.35 products), $p < .05$. A significant difference was also found between the effectiveness group and the control group, $p < .05$.

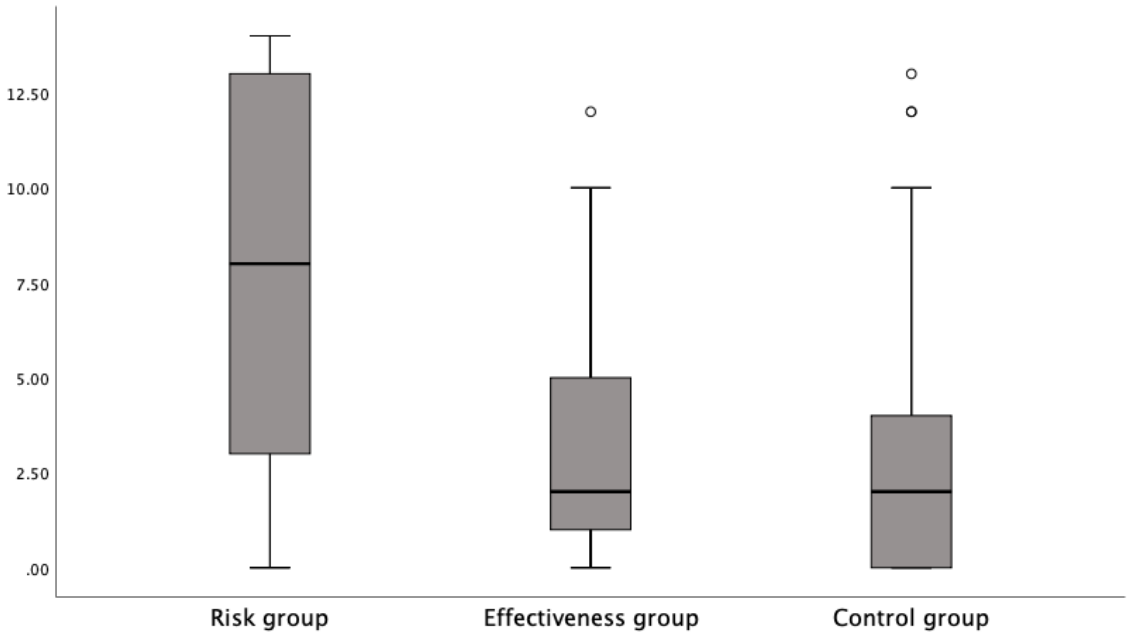
Figure 13. *Number of Fixated Products: Boxplots (N = 147).*



Note. The box denotes the first and third quartile; the whiskers denote the minimum and maximum values, outliers are defined as being smaller versus larger than one and half times the interquartile range).

Moreover, a significant difference between the experimental groups was found in terms of the number of products the participants enlarged, $F(2, 144) = 22.90$, $p < .001$ (cf. Figure 14). Post-hoc tests using the Tukey B correction showed that the participants in the risk group were more likely to have enlarged the labels of the products in order to read them ($M = 7.66$ enlarged products, $SD = 5.10$ enlarged products) than those in the effectiveness ($M = 3.02$ enlarged products, $SD = 3.08$ enlarged products), and risk groups ($M = 2.94$ enlarged products, $SD = 3.32$ enlarged products), $p < .05$. No significant difference was found between the effectiveness group and the control group, $p > .05$.

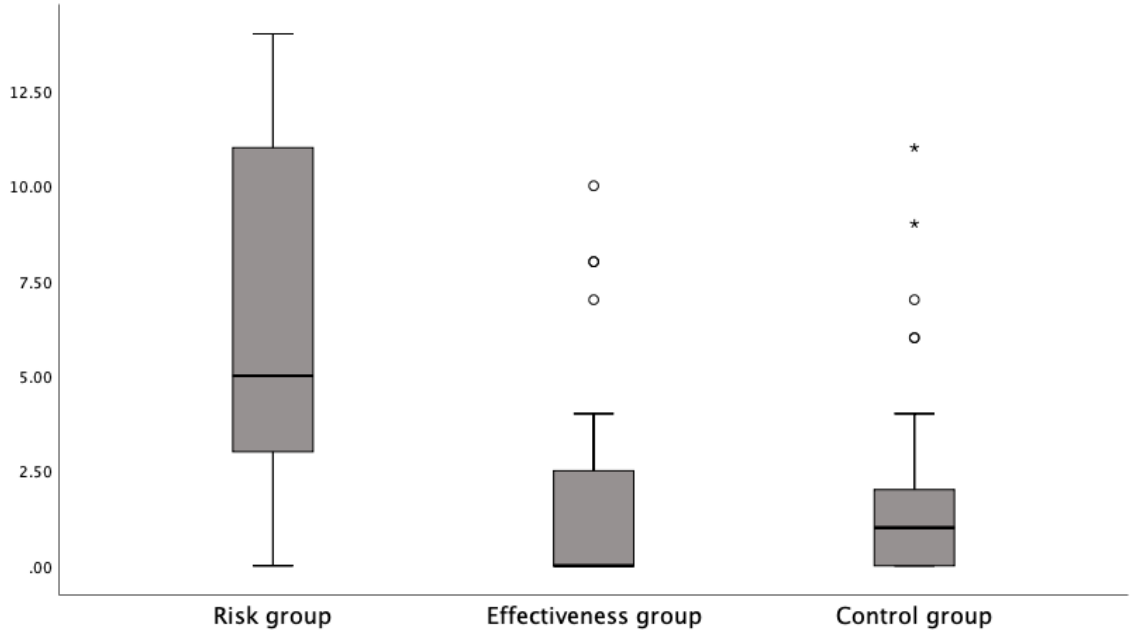
Figure 14. *Number of Enlarged Products: Boxplots (N = 147).*



Note. The box denotes the first and third quartile, the whiskers denote the minimum and maximum values, outliers are defined as being smaller versus larger than one and half times the interquartile range.

Finally, we found a significant difference between the experimental groups with regard to the number of products for which the participants looked at information relevant to the risk assessment, e.g. the GHS and facultative warnings, instructions and composition, $F(2, 144) = 28.51$, $p < .001$ (cf. Figure 15). According to Post-hoc tests run with the Tukey B correction, the participants in the risk group were more likely to look at information relevant to a risk assessment when enlarging the products (M = relevant information of 6.21 products, $SD = 5.02$) than the participants in the effectiveness group (M = relevant information of 1.56 products, $SD = 2.44$), and the control group (M = relevant information of 1.58 products, $SD = 2.43$), $p < .05$. No significant difference was found between the effectiveness group and the control group, $p > .05$.

Figure 15. *Number of Products for which Risk-Assessment-Relevant Information was Fixated: Boxplots (N = 147).*



Note. The box denotes the first and third quartile, the whiskers denote the minimum and maximum values, outliers are defined as being smaller versus larger than one and half times the interquartile range.

Furthermore, we examined whether the participants systematically fixated on one product after the other, from left to right. No participant did this for all of the products; however, some participants did this for one or two of the three shelves (each containing four to five products). More specifically, 17% of the participants in the risk group did this, as did 6.3% of the participants in the effectiveness group and 3.8% of the participants in the control group. However, these differences were not significant, X^2 (2) = 5.9, p = .052.

Some of the participants directly compared product pairs or directly compared three products. Their fixations only concerned those two or three products, and they did not fixate on other products or the surroundings in between. Significant overall differences between the experimental groups were found in this regard, X^2 (2) = 7.2, p = .027. Z-tests tests with the Bonferroni correction revealed significant differences between the risk and control groups. However, no significant differences between the risk group and the effectiveness group, or between the effectiveness group and the control group, were found. The exact distributions of the groups are shown in Table 12.

Table 12. *Participants Engaging in Comparative Choice Strategies: Distributions (N = 147).*

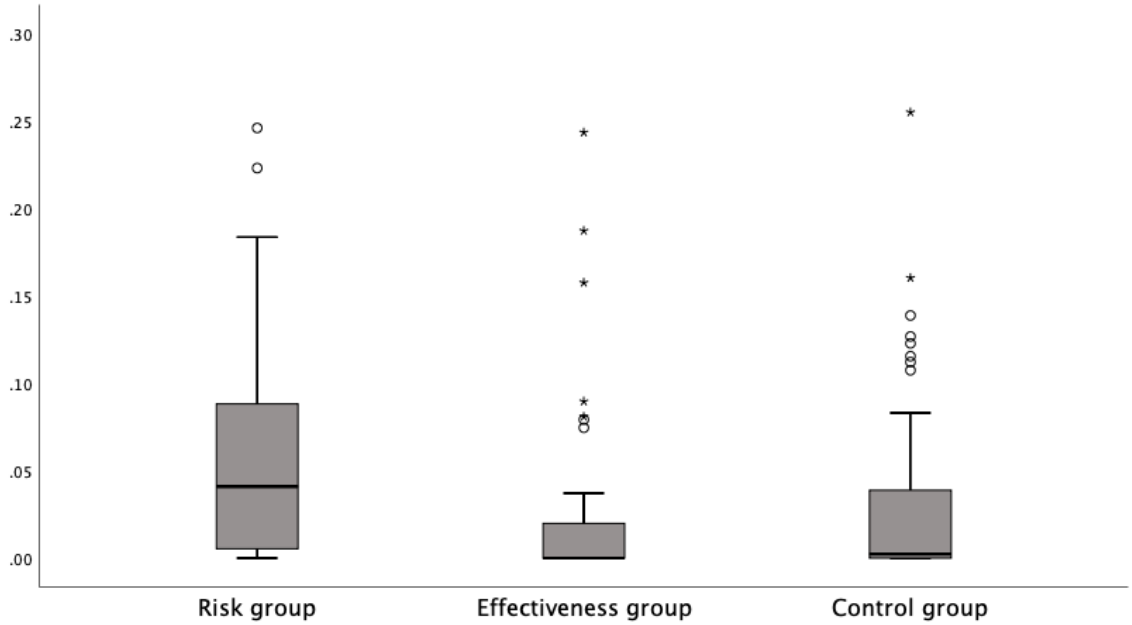
		Risk group	Effectiveness group	Control group
1	Engaged in comparative strategies	53.2% (n = 25)[a]	37.5% (n = 18)[a, b]	26.9% (n = 14)[b]
2	Did not engage in comparative strategies	46.8% (n = 22)[a]	62.5% (n = 30)[a, b]	73.1% (n = 38)[b]

Note. Each superscript letter denotes a subset of categories whose column proportions do not differ significantly from each other at the p = .05 level.

4.3.2 Relevant and Irrelevant Information for the Risk Assessment of Chemical Household Products

Next, we examined how much time the participants spent looking at relevant or irrelevant information with regard to the risk assessment of the products. To do so, we compared the relative fixation duration in relation to these areas (e.g. the fixation duration in relevant respectively irrelevant areas divided by the total duration). As relevant information, all the warning pictograms and hazard sentences (e.g. GHS and voluntary elements), composition information and instructions were regarded. All other aspects of the packaging were considered to be irrelevant (e.g. if the participants looked at affirmations on the label, 'has a nice smell', or the lid of the packaging, this was considered irrelevant information). The relative fixation duration in areas relevant to the risk assessment was significantly different for the different experimental groups, $F(2, 144) = 4.44$, p =.01 (cf. Figure 16). Post-hoc tests using the Tukey B correction showed that the relative fixation duration was longer for the risk group (M = 5.64%, SD = 6.08%) than for the effectiveness group (M = 2.42%, SD = 5.13%) and the control group (M = 3.09%, SD = 5.69), $p > .05$. No significant difference was found between the effectiveness group and the control group, $p > .05$.

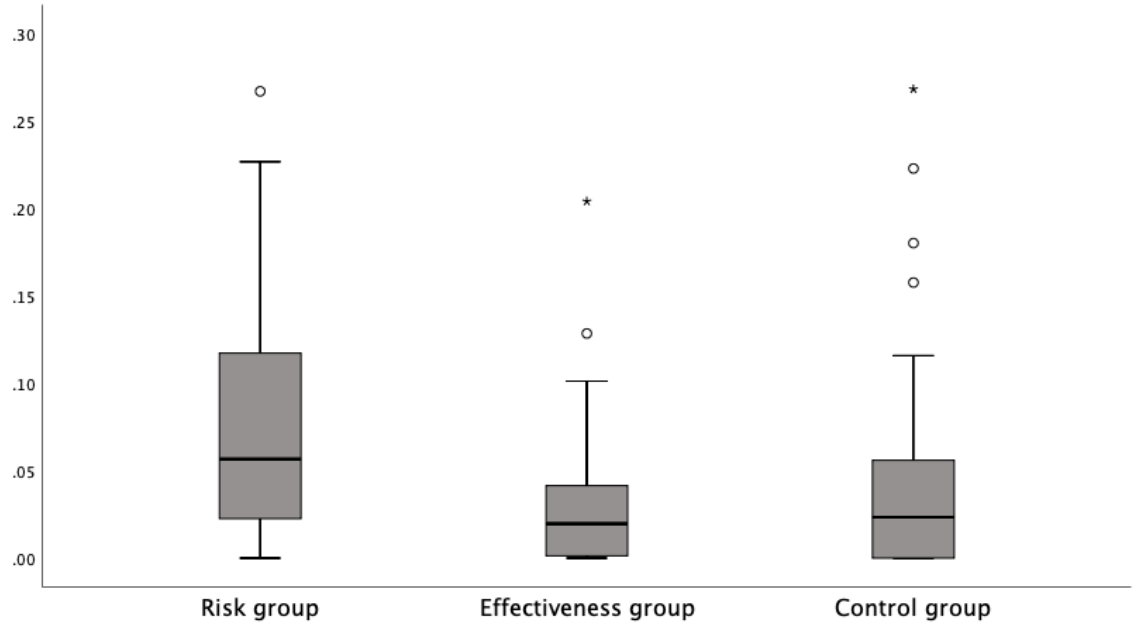
Figure 16. *Relative Duration in Areas with Information Relevant to the Risk Assessment (in Percentages): Boxplots (N = 147).*



Note. the box denotes the first and third quartile, the whiskers denote the minimum and maximum values, outliers are defined as being smaller respective larger than one and half times the interquartile range.

Equally, the relative fixation duration in areas irrelevant to the risk assessment differed significantly between the experimental groups, $F(2, 144) = 8.18$, $p < .001$ (cf. Figure 17). According to Post-hoc tests using the Tukey B correction, the risk group ($M = 7.84\%$, $SD = 6.88$) had a longer relative fixation duration than the effectiveness group ($M = 3.19\%$, $SD = 4.12\%$), and the control group ($M = 4.48\%$, $SD = 6.02\%$), $p < .05$. No significant difference was found between the effectiveness group and the control group, $p > .05$.

Figure 17. *Relative Duration in Areas with Information Irrelevant to the Risk Assessment (in Percentages): Boxplots (N = 147).*



Note. The box denotes the first and third quartile, the whiskers denote the minimum and maximum values, outliers are defined as being smaller respective larger than one and half times the interquartile range.

4.3.3 Outcome of the Decision-Making Process

Finally, we examined whether not only the participants' perception of the products differed, but also whether there were differences in terms of their choice when selecting a chemical household product. We were interested in determing whether those participants who chose a safer product had looked more thoroughly at the products when reaching their decision, especially with regard to information relevant to the risk assessment. We examined whether the participants who chose a safer product without any GHS warning pictograms, who choose a product with only the harmful pictogram (GHS07) or who choose a more dangerous product with other or multiple GHS pictograms (e.g. signalling a higher risk when compared with the products without any GHS pictograms or only the harmful pictogram) differed in terms of the number of products for which they looked at relevant information. We ran an ANOVA and found a significant overall difference depending on whether a product without GHS pictograms, with the harmful pictogram (GHS07) or with other or multiple GHS pictograms was chosen, $F(2, 144) = 10.42$, $p < .001$. Post-hoc tests using the Tukey B correction were run, which showed that those participants who chose a product without GHS

pictograms looked at information relevant to the risk assessment on significantly more products (M = 5.28, SD = 5.12) than those participants who chose a product with only the harmful pictogram (GHS07; M = 2.40, SD = 3.23), or who choose a product with another or multiple GHS pictograms (M = 1.91, SD = 3.10), $p < .05$. The difference between the latter two groups was not statistically significant, $p > .05$.

4.3.4 Influence of Psychological Factors on the Decision-Making Process

As a first step, we studied which characteristics were identified by the participants as reasons for their final product choice. A large number of participants indicated having chosen the product because they knew it or because they were used to choosing it. Other important reasons included the favourable risk profile of the product, the fact that the product was organic, sustainable or natural, the fact that the product was particularly suitable for a specific type of laundry (e.g. for sports clothes) and the size of the packaging or the number of laundry loads that could be done with the specific product. All of the reasons given are set out in Table 13.

In terms of their applied knowledge concerning the safe use of chemical household products, a huge lack of knowledge was found regarding the safety of products with organic active ingredients. A majority of participants erroneously believed such products to be safer. The other items were correctly answered by the majority of participants (cf. Figure 12).

Table 13. *Reasons Given by the Participants for Their Final Product Choice (N = 167).*

	Number of participants who gave this reason in %		
	Risk group (n = 57)	Effectiveness group (n = 55)	Control group (n = 55)
Usual product, knowing the product	36.8%	38.2%	38.2%
Risk profile of the product	28.1%	27.3%	32.7%
Organic, natural or sustainable product	26.3%	20.0%	36.4%
Suitability of the product for specific laundry type	17.5%	32.7%	23.6%
Size of the packaging, number of possible laundry loads	17.5%	25.5%	21.8%
Price	7.0%	16.4%	12.7%
Personal preference	7.0%	7.3%	9.1%
Quality	5.3%	7.3%	5.5%
Ease of use	3.5%	3.6%	7.3%
Advertisements	5.3%	5.5%	1.8%
Product at eye height, first product seen	1.8%	1.8%	3.6%

Table 14. *Linear Regression Analysis of the Number of Products for which Risk-Assessment-Relevant Information was Viewed at as the Dependent Variable (N = 147).*

	B *(SE)*	*ß*	*t*
Constant	3.47 *(.83)*		4.20
Risk group (0 = effectiveness group and control group, 1 = risk group)	4.61 *(.68)*	.53***	6.74
Effectiveness group (0 = risk group and control group, 1 = effectiveness group)	.02 *(.68)*	.00	.04
Chemophobia	-.70 *(.25)*	-.19**	-2.80

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

Finally, we ran a linear regression to determine the extent to which chemophobia influences the participants' decision-making process when choosing a laundry detergent. The model was found to be significant, $F(3, 143) = 22.50$, $p < .001$, and explained 32% of the variance with regard to the number of products for which the participants looked at information relevant to the risk assessment. Those participants who exhibited higher levels of chemophobia were less likely to study information relevant to the risk assessment found on the labels of the products when compared with participants who exhibited lower levels of chemophobia. Table 14 represents the results of the linear regression.

4.4 Discussion

4.4.1 Consumers' Decision-Making Strategies

As expected, the participants in the effectiveness and control groups did not look closely at the different products and showed little involvement with the products. However, the participants in the risk group, who were prompted with regard to the risks of laundry detergents, examined the products a lot more carefully than the other participants. As could be shown previously, consumers appear to only be aware of the risks of chemical household products when they are prompted about them (Buchmüller et al., 2020; Leonard & Wogalter, 2000).

Interestingly, the participants in the risk group not only more frequently looked at information relevant to the risk assessment, but also more frequently looked at information irrelevant to the risk assessment, such as the name of the product, packaging details (e.g. the product lid) or product affirmations (e.g. regarding the smell of the product, the sustainability of the product, etc.). The participants may not have been familiar with the warning labels and therefore needed to scan the products for any risk-related information.

The participants may have relied on objectively irrelevant information that was used in heuristic decision making. This notion is in line with prior risk research showing that lay people frequently use heuristics to determine risks in the absence of knowledge (Basso et al., 2014; Bearth et al., 2017; Rozin et al., 2004). Thus, we assume that the participants used erroneous heuristics for their risk assessment (e.g. 'organic products are always safer' or 'products similar to food are safer').

We were also interested in determining whether the different strategies consumers use to choose chemical household products influence their final product choice. Crucially, we found that the thoroughness with which the participants studied the products did have an impact. Those participants who looked at the risk-related information on a large number of products were more likely to select a product without any GHS pictograms (e.g. indicating a

smaller potential risk) than those participants who did not look at the products so thoroughly. This finding indicates that when warning labels are detected, they do indeed represent an effective way to guide consumers toward choosing a safer product. However, it remains unclear whether consumers can distinguish between different risks or if they are simply aware of a general potential risk and so try to avoid products featuring GHS or other warning pictograms without differentiating between different types of risks (e.g. corrosive, flammable, toxic) and their impacts on human health (e.g. toxic versus harmful versus environmental hazard). In line with the latter notion, no significant difference was found between those participants who selected a product featuring only the GHS07 (e.g. harmful) pictogram and the participants who chose products featuring specific (e.g. health hazard, corrosive) or multiple GHS pictograms. This is an important finding, as chemical regulation and enforcement relies on the idea that consumers can distinguish between various risks (United Nations Economic Commission for Europe, 2017). Yet, the findings of this study suggest that people exhibit a less differentiated understanding of the potential risks of everyday chemical household products.

Finally, people who exhibit high levels of chemophobia might generally expect that all chemical products are highly dangerous and, therefore, not see the point of checking whether a particular product is dangerous. Thus, we examined the effect of chemophobia on the participants' product choice strategies. As expected, the participants' level of chemophobia had an effect on the way they chose a chemical household product. In fact, consumers who exhibited higher levels of chemophobia looked at the products less thoroughly and also fixated on information relevant to the risk assessment on fewer products than consumers who exhibited lower levels of chemophobia. We assume that this occurred because consumers with high levels of chemophobia are less motivated to search for risk-related information because they perceive all products to be risky.

4.4.2 Implications for Manufacturers and Regulators

The results of this study indicate that the warnings currently found on the packaging of chemical household products do not represent an effective way to convey the risks of frequently used chemical household products such as laundry detergents to the consumers because they are usually not noticed. Therefore, it is not advisable to rely solely on such warnings, which means that other prevention measures should be considered.

However, the results also showed that when the GHS warnings were noticed by consumers, they did represent an effective way to convey the possible risks in a simplified and, therefore, more accessible manner for lay people. The placement of the warnings on the packaging (e.g. on the front of the packaging or directly before the instructions for use) can

influence their noticeability by consumers (Laughery et al., 1993; Wogalter et al., 1987). This suggests an approach that manufacturers could use to decrease the number of accidents involving their products. Contrary to what would intuitively be expected, prior research has shown that more noticeable warnings do not decrease the attractiveness of a product (Kovačević et al., 2018), which indicates that this should not be a handicap when competing for market shares with other brands. Furthermore, the risk of campaigns by consumer groups due to accidents believed to be caused to ambiguous packaging of chemical household products could be reduced in this way (e.g. the case of the Fabuloso cleaner: Miller et al., 2006; Perton, 2006).

Aside from the packaging, the use of other locations for warning labels might be effective. For example, if general warnings or prevention campaign messages were placed well visible at the point of sale (e.g. similar to those nowadays found widely on the shelves holding tobacco products), it might prove equally effective. An other possible approach would be the inclusion of protective equipment to the packaging, as sign of warning to the user (Hunn & Dingus, 1992). The main goal should be to activate consumers' knowledge regarding the risks so that they actively search for the risk-related information needed to reach an informed and safe purchase choice.

However, all prevention campaigns could be undermined by habituation effects. For instance, in the case of tobacco products, it has been shown that habituation has a significant influence on the effectiveness of warnings (Hammond et al., 2007; Rooke et al., 2012). Thus, warnings will prove more effective if they are changed regularly. Similar effects should be expected in relation to chemical household products. Indeed, what might be an effective measure for increasing the safe handling of such products today will likely not be as effective after having been widely implemented for a while.

4.4.3 Methodological Implications

The use of eye-tracking technology allowed us to measure whether the participants looked at the warnings provided. Although the participants in the risk group looked more frequently at the warnings than the participants in the effectiveness and control groups, they did not identify the risks as the reason for their product choice any more frequently than the other participants. This indicates that the participants in the risk group were not aware of their more frequent fixations on the warnings when compared with the participants in the effectiveness and control groups.

To increase the standardisation of the experimental setting and the reliability of the eye-tracking measures, we conducted the study in a virtual environment. In contrast to a traditional laboratory experiment, in a virtual environment the investigator is not in the same environment as the participant and, therefore, the participant is less aware of their presence during the completion of the experiment. Additionally, the use of a fully immersive virtual setting via a headset means that the environment is completely identical for all participants, which means that differences due to different light intensities (e.g. morning sun versus dusk in the evening) or the different placement of products can be excluded. Furthermore, more reliable eye-tracking measures are possible in a virtual setting when compared with a traditional mobile eye-tracking setup because the distance from the eye to the object is constant in a virtual situation while it differs in the latter situation. As a consequence, the calibration is more reliable in relation to a virtual setup.

4.4.4 Limitations

As for all studies, some limitations should be noted. The majority of participants will have wanted to make a reasonable choice. Therefore, it is likely that they looked more thoroughly at the products and the warning labels than they would usually have done in order to complete their task. Additionally, prior studies have shown that participants in virtual experiments generally need more time to complete a task. However, the results in this regard are comparable to those of experiments conducted in real-life settings (Siegrist et al., 2019; Xu, Demir-Kaymaz, et al., 2021; Xu, Siegrist, et al., 2021).

4.5 Conclusion

The results of the present study show that when consumers are not prompted regarding the risks of frequently used chemical household products such as laundry detergent, they rarely look at the warnings found on such products. Therefore, we conclude that the warnings do not serve as a reliable way to remind the consumers about risks, meaning that they cannot be particularly effective in terms of preventing accidents involving frequently used chemical household products. However, when consumers are prompted with regard to risks through warnings that are immediately visible to them (e.g. on the front of the packaging or on the display shelf), then such warnings prove effective in relation to guiding them to make a safer product choice. In conclusion, manufacturers and regulators should identify effective ways to prompt consumers regarding the risks of chemical household products and aim to increase the noticeability of warnings.

The Influence of Packaging on Consumers' Risk Perception of Chemical Household Products

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Abstract

Chemical household products are found in most households. If consumers are to safely handle such products, they need to be aware of the risks posed by the particular product they are using. Although most countries require that chemical household products feature warning labels (e.g. the Globally Harmonized System of Classification and Labelling of Chemicals), consumers appear to also use other cues to determine the risks associated with a specific product. Thus, we studied the influence of packaging on consumers' risk perception of chemical household products. More specifically, we examined the effect of the colour of the packaging (black or pink packaging versus the original packaging) as well as the presence of images of flowers or food-imitating elements on the packaging. Significant differences with regard to consumer's risk perception were found in terms of all four studied manipulations. Therefore, we conclude that consumers' risk perception can be influenced by the packaging design. In particular, if elements that lower consumer's risk perception (e.g. featuring flowers on the label and food-imitating elements on the packaging) are omitted from the packaging, consumers might be able to more accurately judge the risks associated with a product and so take appropriate safety precautions.

Keywords: Risk Perception, Chemical Household Products, Packaging Design

5.1 Introduction

Accidents involving chemical household products are a frequent occurrence and, in many cases, concern young children. For example, in the United States (US) around 45% of people affected by poisonings are under the age of six (Poison Control, 2018). In 2018 alone, the US poison control centres were contacted nearly 2.1 million times in relation to suspected human poisonings. In approximately 11% of cases, the poisonings were caused by household cleaning products (Poison Control, 2018). Such poisonings cause both personal distress to the person involved and their family, in addition to significant economic costs due to the required treatment and the associated loss of working hours (Benabdellah et al., 2020; Miller et al., 2000).

In a previous study (Buchmüller et al., 2020), we found that, while consumers prove to be aware of the risks associated with chemical household products when prompted (i.e. when asked to judge the severity of critical situations involving such products), they do not intuitively think of the potential risks (i.e. they prove unable to name any risks when asked about their spontaneous thoughts concerning specific chemical household products). This finding indicates that knowledge of the risk is present, although external cues are required to activate that knowledge (Buchmüller et al., 2020). The packaging of a chemical household product can serve as an external cue, as it has previously been shown that some specific products are more commonly involved in poisonings than others, for example, the cleaner “Fabuloso” in North America and laundry pods following their introduction to the European market (Basso, 2011; Basso et al., 2014; Miller et al., 2006). These products have specific packaging attributes, such as resembling food containers and not being clearly distinguishable from food products. Thus, their packaging might provoke a different subconscious reaction than the more traditional packaging of other products (Basso et al., 2014).

Taken together, these findings suggest that the packaging of a product might exert an important influence on the way in which it is perceived and therefore the extent to which the risks associated with the product are acknowledged by consumers. Hence, the packaging might function as a prompt for the consumer with regard to the risk posed by the product. This would have an influence on consumers’ product choice when purchasing chemical household products (e.g. buying products with a higher or lower risk level) and on the way they store these products in their household. In light of this, we sought to investigate whether the design elements of the packaging have a systematic influence on consumers’ risk perception of chemical household products.

5.2 Theoretical Background

5.2.1 Consumers' Knowledge of the Risks of Chemical Household Products

If consumers are to safely use chemical household products, they require applied knowledge of the risks and mitigating factors associated with such products (Laughery & Wogalter, 2014; Saleh et al., 2019; Siegrist & Árvai, 2020). This means, for example, that consumers do not need to know the chemical structures of the ingredients of a particular product, although they do need to know whether that product could potentially be corrosive in relation to the skin or surfaces. Previous research has shown that consumers are generally aware of the basic toxicological principles concerning the safe use of chemical household products (Buchmüller et al., 2020). However, there are some specific knowledge gaps, and consumers do not have the expert knowledge of, for example, a toxicologist. Therefore, it is important that consumers have access to additional sources of information.

5.2.2 Consumer's Perception of the Packaging of Chemical Household Products

Different factors could influence consumers' risk perception of chemical household products. Due to consumers' lack of expert knowledge regarding the toxic properties of chemical substances, they are reliant on easily understandable information concerning the potential risks posed by chemical household products. In the European Union, hazardous chemical household products need to be labelled with symbols and warning sentences within the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) (United Nations Economic Commission for Europe, 2017). However, prior studies suggest that there are some limitations in terms of the effectiveness of hazard labelling as a means of informing consumers about the risks of products (Boelhouwer & Davis, 2010; Hinks et al., 2009).

The objective information provided to consumers with the aid of warning symbols appears to be of only minor importance when compared with the cues provided through the design of a product, which might exert a stronger influence on consumers' risk perception. In fact, consumers seem to use potentially irrelevant signals derived from the packaging when judging the risks associated with a given product. This phenomenon has previously been described in relation to consumer products in general as the "halo effect" (Apaolaza et al., 2017; Boatwright et al., 2008; Iles et al., 2020; Westerman et al., 2013). When some attributes of a particular product are unknown, consumers tend to assume that the unknown attributes are similar to the product's known attributes. This allows consumers to reach a conclusion without the need of a lot of additional resources to gather the missing attributes (Boatwright et al., 2008). In the following, we will discuss some specific attributes that might be used by consumers as cues when determining the risks of chemical household products.

5.2.2.2.1 Food-Imitating Products and Flowers. In order to increase their attractiveness, some products are presented in packaging that has food attributes or that features pictures of flowers. For example, a product could be packaged in a type of bottle typically used for soft drinks, have pictures of food on its label or smell like food. Some consumer groups have expressed concern that chemical products resembling foods might be more commonly involved in poisonings than products without food attributes (Miller et al., 2006). In recent years, an increasing number of products have appeared with packaging and design features that resemble those of food (e.g. laundry pods that resemble sweets, dishwashing liquid that looks like syrup). While it seems obvious that illiterate people (especially young children) would experience problems distinguishing such products from food, prior studies have shown that the same might also be true for adults, even those who are able to read the labels (Basso, 2011; Basso et al., 2010; Basso et al., 2014). Similarly, it is possible that products with flowers on their packaging are perceived to be less dangerous than products that do not feature flowers, although this has not previously been investigated. In fact, flowers universally evoke positive emotions among consumers (Haviland-Jones et al., 2005), which means that their presence on packaging can render a product more attractive.

Prior studies have mostly investigated the effects of packaging on children's reactions to the products and their risk perception of those products (Schneider, 1977; Schwebel et al., 2014). Schwebel et al. (2014) examined children's risk perception of products packaged similarly to juice (i.e. the packaging featured pictures of fruit) and found that young children were less likely to recognise such products to be dangerous. Based on the findings of studies involving adults (Basso, 2011; Basso et al., 2010; Basso et al., 2014), we assume that the effects seen in relation to children might be equally relevant for adults, at least in particular situations (e.g. when inebriated, extremely tired, distracted). This might be especially true with regard to products that adults are unfamiliar with, as they cannot rely on their previous experiences or habits.

5.2.2.2.2 Colours. Some colours have distinct meanings. For example, the colours red, yellow, black and orange are commonly used to convey warnings (Smith-Jackson & Wogalter, 2000; Zielinska et al., 2017). While some minor cultural differences exist in terms of which of these colours indicates the highest level of risk, they are generally all linked to a sense of danger independent of people's cultural backgrounds (Smith-Jackson & Wogalter, 2000). Previous research concerning other consumer products has revealed that colours can have an influence on warnings. For example, in the context of tobacco products, it has been found that the choice

of colour of the warnings and the background colour have an influence on the level of attention consumers pay to the product in question (Lempert & Glantz, 2016).

Similar to what we expect with regard to food-imitating products, we expect that the effects found in relation to children regarding the impact of colours on warnings might also apply to adults. Schwebel et al. (2014) found that young children were more likely to recognise products with specific designs as being dangerous. In particular, products in opaque, squared (versus round), metal and black packaging were more often correctly identified as being dangerous. Contrary to this, Schneider (1977) did not find the colour of the packaging to effect whether children recognised a product as being dangerous or not. He measured this by observing whether the participating children opened a container or not. He did, however, only compare red, black and white containers. Both red and black are considered to be universal high-risk colours, which are commonly recognised as warning colours (Smith-Jackson & Wogalter, 2000). Schneider (1977) did not compare these high-risk colours to transparent containers or containers with less strong colours (e.g. pink, light blue), which are more commonly used for chemical household products.

5.2.3 Study Aims

Based on the above review of the literature concerning people's risk perception of chemical household products (Basso, 2011; Miller et al., 2006; Schneider, 1977; Schwebel et al., 2014), we suggest that packaging might exert a systematic effect on adult consumers' risk perception of chemical household products. Therefore, the present study sought to examine this issue in depth as well as to compare products with and without the attributes described above. In particular, we wished to examine the influence of both the colour of the packaging and the presence of flowers or food-imitating elements (e.g. pictures of fruit, claims that evoke expectations concerning the taste or smell of a product) on the packaging. A within-subject design was chosen to determine the effects of the different packaging design options. Within this study, the following four hypotheses were investigated:

- Products that are packaged in black containers will be perceived as more dangerous than products packaged in their original colour containers (e.g. the colour they are sold in at the moment).
- Products with food-imitating packaging will be perceived as less dangerous than products with packaging that is typical for chemical household products and that does not feature food-imitating elements.

- Products with flowers on their labels will be perceived as less dangerous than products without flowers on their labels.
- Products that are packaged in pink containers will be perceived as less dangerous than products packaged in their original colour containers (e.g. the colour they are being sold in at the moment).

5.3 Method

5.3.1 Study Participants

The participants in this study were recruited in Germany through a marketing research company (respondi) and invited to participate via e-mail. The sample contained N = 561 participants. The quota sampling method was used to obtain a representative sample. A total of n = 38 people were excluded from the study because they responded very quickly to the questionnaire (more than twice as fast as the median response time), meaning that there was doubt to as whether they had carefully read the questions. This led to a final sample size of N = 523, with approximately half of the participants being women (n = 269, 51.4%) and the median age being *Mdn* = 45 years (range: 18-70 years). All the participants participated online via their internet browser; the experiment was administered using the EFS Survey Tool (QuestBack). Participants were informed that they would remain anonymous and that their data would only be used for research and teaching purposes. After this and before beginning the experiment, they provided informed consent. They received a small incentive for their participation from the market research company.

5.3.2 Measures

5.3.2.1 Comparisons of Products with Changed Packaging. The participants were asked to compare two versions of the same chemical household product with and without experimental variation. The participants then had to rate which of the two versions was safer for their health ("Please indicate on the scale which product you consider to be safer health-wise"). The response scale ranged from *0 = Packaging A* over *50 = same safety* to *100 = Packaging B*. Participants were able to give their answer on a slider, the slider button only became visible once the participant activated the slider with the mouse (e.g. in order to avoid an effect by a default position of the slider button). For this within-subjects design, 12 products were used. The overall order of the products was randomized. All the 12 products were available for purchase at the time of testing and reflect the typical choice in grocery stores. Products with design features suspected to influence consumers' risk perception (e.g. organic

products, products in black containers, products with flowers) were not included (Bearth et al., 2017; Haviland-Jones et al., 2005; Schnabel & Asendorpf, 2013; Schwebel et al., 2014), except in the case that they were used for a specific manipulation (e.g. products with food-imitating elements). The participants were asked to compare the manipulated products to the same non-manipulated products. To assess their risk perception, the participants were asked to rate the safety of the products, rather than the risk of the products. Prior findings have shown that consumers are less aware of the risks of chemical household products when they are not explicitly reminded of those risks (Buchmüller et al., 2020). Therefore, asking consumers about their risk perception could potentially activate an increased risk perception and generate bias responses.

All the participants were shown the same images and manipulations. For the black bottle manipulation, three product packages were coloured in black and then compared to their original packaging (green, transparent or white). The same process was followed for the pink bottle manipulation, with three products being coloured in pink and then compared to their original packaging (white or red). For the flowers on packaging manipulation, flowers were added to three existing bottles, which were then compared to the original packaging (i.e. without flowers)[3]. Finally, for the manipulation of the products with food-imitating elements, three existing products with food-imitating elements were chosen and then compared to the same packaging with those elements removed[4]. All the manipulations can be found in Figure 18. For each manipulation, a scale was formed based on the mean of the three respective risk ratings for each product (black bottle manipulation: $\alpha = .82$, food-imitating elements on packaging manipulation: $\alpha = .73$, flowers on packaging manipulation: $\alpha = .70$, pink bottle manipulation: $\alpha = .65$). The order of presentation of the products was varied so as to avoid response effects (i.e. the manipulated product was sometimes product A and sometimes product B). Thus, where necessary, the products were recoded so that the product hypothesised to provoke the higher risk perception was always product B.

[3] In order to ensure, that flowers were the only factor manipulated in this condition, products without any ambiguous cues (e.g. no food-imitating elements) were chosen and flowers were added to their packaging.

[4] In order to ensure that the products had a realistic appearance, products with food-imitating elements were chosen, and all of those elements were removed for the control products.

Figure 18. The 12 Product Comparisons Used in the Experiment.

Black bottle manipulation:

1. 

2. 

3. 

Food-imitating elements manipulation:

4. 

5. 

6. 

Flowers on label manipulation:

7. 

8. 

9. 

Pink bottle manipulation:

10. 

11. 

12. 

5.3.2.2 Socio-Demographic Measures. The participants' gender, age and educational level, as well as whether they worked with chemicals, whether they were responsible for buying cleaning products for their household and whether any children below the age of 12 lived in their household, were all measured as additional variables. As the present study formed part of a larger project on chemical household products conducted in collaboration with an external partner, other experimental designs and scales were included in the questionnaire. However, they are not of relevance to the present research question and so will not be discussed in this paper.

5.4 Results

We conducted one-sample t-tests with a reference point of 50 (i.e. evaluating the risk of the products to be equal) to evaluate whether there was a significant difference in the ratings of the products. The possible differences in terms of the participant's risk perceptions were studied separately for each of the four manipulations.

A significant difference was found with regard to the products in black bottles when compared with the products in their original coloured bottles, $t(522) = -14.24$, $p < .01$, *Cohen's* $d = .62$. The participants considered the various coloured bottles to be safer than the black bottles (see all the means in Table 15). The same was true for the products in packaging with food-imitating elements when compared with products in packaging without those elements, $t(522) = 10.10$, $p < .01$, *Cohen's* $d = .44$. The participants judged the products with food-imitating elements to be safer than the products without such elements. A significant difference was also found between the products featuring flowers on their labels and the products with no flowers on their labels, $t(522) = -6.20$, $p < .01$, *Cohen's* $d = .27$. When flowers were added to the labels, the participants judged the products to be safer than when there were no flowers on the labels. Finally, a significant difference was found between the products in pink bottles and the products in more traditionally coloured bottles, $t(522) = 2.99$, $p < .01$, *Cohen's* $d = .13$. Contrary to our expectations, the participants judged the products in pink bottles to be less safe than the products in their original bottles. We repeated the t-tests for all four manipulations using bootstrapping with case resampling with replacement and using 1000 bootstrap samples. The results did not differ. Appendix A presents the means for each of the 12 product comparisons separately. In terms of the pink bottle manipulation, a significant difference was found for only one of the three products.

Table 15. Results of the Product Comparisons for Each Manipulation (Means (M), Standard Deviations (SD), and Confidence Intervals (CI), N = 523).

		M (SD)	*95 % CI*
1	Original bottle is safer (0) - Black bottle is safer (100)	38.72 (18.11)	[37.17, 40.27]
2	Original packaging with food-imitating elements is safer (0) - Packaging without food-imitating elements is safer (100)	42.53 (16.92)	[41.08, 43.98]
3	Packaging with flowers on label is safer (0) - Original packaging without flowers on label is safer (100)	45.45 (16.97)	[44.00, 46.90]
4	Pink bottle is safer (0) - Original bottle is safer (100)	52.14 (16.36)	[50.74, 53.54]

Note. 0: Packaging A – 100: Packaging B, participants were asked to choose the safer product (inverse measure), equal risk perception would be represented by M = 50.

5.5 Discussion

5.5.1 Influence of Packaging Elements on Risk Perception

The results of this study show that packaging can indeed exert an influence on consumers' risk perception. As expected, consumers considered the products in black bottles to be more dangerous. This finding is in accordance with the results found by Schwebel et al. (2014) with regard to children. It seems that children and adults use similar mental shortcuts when making a decision (e.g. heuristics) when they are uncertain about the risk of a given product. These heuristics allow the consumer to make a decision regarding the risks of a products without needing a large amount of resources when making such a decision is not possible with the information they already have at hand. While black bottles are already the norm for certain products in some regions (e.g. methylated spirits in Switzerland), switching to black bottles represents a very easy and cost-effective way of increasing consumers' risk perception of especially dangerous products. However, the possible habituation effects that might occur if all brands used the same bottles should be studied further.

Effects due to the presence of flowers and food-imitating elements were equally observed in this study. This was not surprising, as it has previously been observed that some of the products most frequently involved in poisonings have exactly those attributes (Basso et al., 2014; Miller et al., 2006). Interestingly, the effect of food-imitating elements on the packaging was stronger than the effect of flowers on the label. We hypothesise that this might be the case because food-imitating elements might raise different associations than flowers and, therefore, might have a stronger influence on the overall perception of a product compared to labels featuring images of flowers.

However, other factors could moderate the relationship. For example, an increase in risk judgements might only occur if the packaging of the chemical evokes associations with a specific food product on the part of the consumer. While there exist many products with flowers on their labels or food-imitating elements, to the best of our knowledge there have been no systematic studies of whether these factors consistently lead to more frequent poisonings (Angerer et al., 2011). In prior case reports, only selected products have been described as causing high numbers poisonings (Basso et al., 2014; Miller et al., 2006). Therefore, future studies should investigate whether all products with food-imitating elements are associated with an increased number of poisonings or whether this is only true for certain products and combinations of food-imitating elements (e.g. form of the packaging, colour of the product and pictures of food). If the packaging design is food-imitating but does not evoke associations to a specific food product it might result in less ambiguity. For example, it might prove unproblematic to have a picture of an orange on a cleaning agent, so long as that product is not also packaged in a container resembles a soft drink bottle. Additionally, accidents tend to have multiple causes, rather than being due to a single factor, such as the design of the packaging. For example, accidents are more likely to occur if the subjects are under the influence of alcohol or drugs or are very tired (Álvarez et al., 2010; Brismar & Bergman, 1998; Leger, 1994). Furthermore, the place in which the chemical household products are stored (e.g. in the kitchen with food or in a separate locked cabinet) might have an influence.

A possible alternative explanation for the above findings that should be mentioned at this point concerns the fact that the results could also be based on a demand effect (e.g. the participants had the feeling that they must decide between the two products and wanted to respond in the way they thought they were expected to) (Nichols & Maner, 2008). However, we found different effect sizes depending on the type of the manipulation. If the results were solely due to a demand effect, we would have expected similar effect sizes for all the manipulations. Additionally, we designed the questionnaire in such a way as to reduce the demand effect and explicitly gave our participants the possibility to indicate that both products were equally safe.

Finally, there are a wide variety of packaging designs for chemical household products on the market. Numerous factors can influence consumers' risk perception and consumers' behaviour toward the safe handling of such products. It remains unclear whether changing the design of a single product would have an impact on the overall number of poisonings. If not all product designs are changed so as to omit confusing cues (e.g. food-imitating elements, flowers on the label), consumers might simply buy those products that have the more attractive

designs (e.g. with flowers and food-imitating elements). They might then perceive those products to be safer and so neglect to uptake the necessary safety precautions when handling them (e.g. storage in a safe place, use of protective equipment). Thus, further research is required to provide a solid basis for legislators if confusing cues are to be banned based on scientific findings. While the manufacturers of laundry pods have demonstrated a desire for self-regulation and taken steps to render the packaging of their products safer (Day et al., 2017), it seems unlikely that the whole industry would be willing to change their packaging. This is especially true when it is recognised that the decision to use this type of problematic packaging is made in order to render the products in question more attractive and so to increase sales. It remains unclear whether the identified effect will be sustained over the years if all manufacturers choose similar packaging. For example, if all manufacturers opt to use black bottles, a habituation effect might develop (Wogalter et al., 2002) and new factors might instead mislead the consumer with regard to their risk judgements. Yet, the omitting of misleading attributes is not subject to a habituation effect. Thus, changes in packaging design should focus on products with elements that might mislead consumers into believing that they are safer than they really are (e.g. with food-imitating elements or flowers on the label).

5.5.2 Limitations and Implications for Future Research

The data for this study were collected online. Therefore, the participants were not in a realistic shop environment. They were directly asked to compare two types of packaging for the same product, whereas in a real-life setting, two different types of products would be compared. Nonetheless, the experimental design allowed us to check for the isolated effects of the four manipulated attributes. This would not have been possible if the participants had been asked to compare two different types of products that might vary in terms of numerous attributes (e.g. form and type of packaging, brand). Additionally, we used real products to increase the similarity to a real-life decision process. However, this means that not all design elements are as obvious as others (e.g. different sizes, contrast) which somewhat limits generalizability. Furthermore, this study relied on self-reported data. Consumers might choose a different product in their daily life or have other priorities concerning product attributes but prefer not to disclose as much. However, collecting data online through a relatively short questionnaire renders participation more accessible. Therefore, by conducting the study online, we believe that we have been able to reach a larger part of the German population. Although the data were collected completely anonymously, we cannot exclude effects due to demand, for example, the participants might have felt that a specific response would be most appropriate. Care was taken when designing the questionnaire to minimise such effects and not

favour a particular answer option. Finally, we cannot exclude that the results are due to the changes in design and not due to the design factors underlying the manipulations. However, this seems unlikely as the directionality of the found effect differed between the different manipulations.

The present study has shown that packaging can exert an influence on risk perception. In the future, it would be interesting to investigate whether this influence depends on specific situations, for example, if there is a difference between shop settings and the situation when the consumer uses the product at home. Moreover, it would be interesting to examine whether there are differences between different flowery labels or different food-imitating attributes. For example, it would be useful to study the effects of different flowers (e.g. whether roses on the label have the same effect as tulips).

5.6 Conclusion

Chemical household products are frequently used and so present in nearly every household (Bearth et al., 2020). As a result, even small effects rendering consumers' risk perception of such products more accurate are of great importance. Additionally, the consequences of accidents involving chemical household products can prove fatal, and such accidents often involve vulnerable young children (Miller et al., 2000; Poison Control, 2018). The factors presented in this study can be easily changed without incurring additional costs. Many manufacturers regularly update the design of their packaging. It should, therefore, be relatively easy to adapt the packaging during a scheduled design change in order to eliminate any elements that suggest a reduced risk (e.g. flowers or food-imitating elements) to the consumer. Further, changing the colour of the bottle of a chemical household product is an equally simple measure. Thus, the results of this study should be of interest to manufacturers and regulatory authorities alike. Manufacturers should be encouraged to rethink their packaging so as avoid any ambiguous attributes and reduce the number of poisonings due to their products. In addition, clear regulations regarding the packaging of chemical household products would be an asset and serve to guarantee that manufacturers that design safer packaging without any misleading attributes would not be penalised with lower sales.

General Discussion

6.1 Introduction

In this chapter, I will discuss the general conclusions of the four studies presented in this dissertation as well as their combined implications. The studies analysed different aspects of the safe handling of chemical household products. More specifically, the studies presented in Chapters Two and Three examined consumers' perception of chemical household products and related safety measures while the study presented in Chapter Four examined consumers' decision-making process when selecting chemical household products. Finally, the study presented in Chapter Five sought to reveal the differences in consumers' perception of chemical household products stemming from the by packaging attributes of such products.

First, I will discuss the findings concerning the different reasons behind consumers' biased risk perception and their problematic handling of chemical household products. Then, I will consider the implications of those findings for both regulators and the manufacturers of chemical household products. Subsequently, based on the findings and experiences derived from all four studies, I will discuss the methodological implications for future studies designed to examine risky behaviour in relation to chemical household products. Finally, I will provide an outlook on future research avenues.

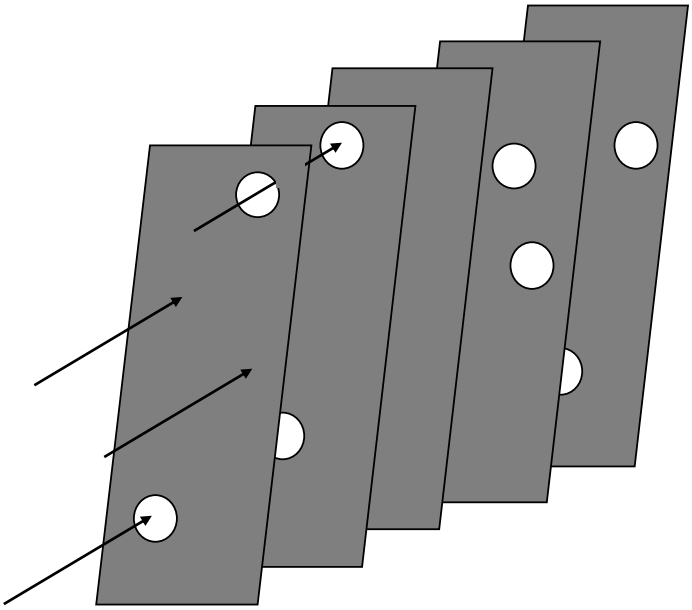
6.2 Reasons Behind Consumers' Biased Risk Perception and Problematic Handling of Chemical Household Products

In this dissertation, I have revealed various factors favouring a low or biased risk perception regarding chemical household products among consumers, which can lead to the problematic handling of such products. While each of these factors alone does not result in unsafe behaviour in relation to chemical household products, they are likely to prove problematic when appearing in combination.

In general, accidents typically result from the failure of multiple safety measures. This is also true for accidents involving chemical household products. Although the handling of such products is not a complex system, accident causes involving them can be explained by Reason's Swiss cheese model of accident causation (Reason et al., 2006) (see Figure 19). According to this model, the failure of a single safety measure will not lead to an accident because the other safety measures will prevent the initial failure from resulting in negative consequences. However, if there are holes in all of the safety nets and the holes overlaps then the hazard will be able to pass through safety nets and an accident can occur. For example, if consumers do not see the warnings on a bottle of toilet cleaner, the oversight will not generally lead to the problematic handling of the product if the consumers are aware that such products

are often corrosive and so adopt appropriate safety measures. Yet, if the consumers lack this knowledge and also fail to see the warnings, it is likely that they will not adopt appropriate safety measures and, consequently, may endanger themselves. In the following sections, I will discuss possible factors capable of leading to accidents involving chemical household products, as identified in the studies presented in this dissertation.

Figure 19. *Simplified Illustration of the Swiss Cheese Modell by Reason (Reason et al., 2006).*



Note. The arrows symbolise potential hazards, while the grey layers represent safety measures and the white holes represent safety failures.

6.2.1 Unawareness of the Risks in Everyday Life

The study presented in Chapter Two found that, while consumers were theoretically aware of the risks associated with chemical household products, they did not name them as free associations (Schnabel & Asendorpf, 2013) and, therefore, did not think about them intuitively during the course of their everyday lives. This finding suggests that consumers do not usually consider the risks when handling such products. Yet, being aware of a risk is a prerequisite for intentional safe behaviour. With regard to the Swiss Cheese Model (Reason et al., 2006), this means that the first layer does not prevent any hazards from passing and so does not reduce the number of possible accidents.

This finding has important implications for prevention campaigns. More specifically, it is insufficient to solely focus on increasing consumers' knowledge of risks; rather, consumers must also be capable of recalling such knowledge automatically at the appropriate moment (e.g. they must be intuitively aware of the risks they face at any moment). Moreover, this finding implies that consumers are unlikely to actively search for warnings and safety

instructions, suggesting that they will only notice them if they are clearly visible and, ideally, placed directly ahead of information perceived to be important by consumers (i.e. instructions for use) (Laughery et al., 1993; Wogalter et al., 1987).

6.2.2 Lack of Knowledge Regarding Toxicological Principles

Furthermore, the studies presented in Chapters Two and Three revealed that the participants not only experienced difficulties activating their toxicological knowledge regarding chemical household products but also held partially erroneous knowledge about such products. Similarly, a lack of knowledge concerning chemical household products was identified in previous studies investigating both general knowledge about chemicals (Kraus et al., 1992; Rozin et al., 2004; Slovic et al., 1995) and specific knowledge about household chemicals (Bearth et al., 2017). More concretely, the participants struggled to understand the dose-toxicity relationship. This lack of knowledge is problematic if consumers fail to realise that they should be more careful when handling highly concentrated products, such as dishwasher or laundry pods. In addition, the participants erroneously believed natural products to be safer than synthetic ones. This erroneous belief is problematic if consumers forego safety measures when handling natural products (e.g. by leaving natural yet toxic products within the reach of children) because they believe such products to be safe. Moreover, this lack of knowledge means that a further safety layer, which could potentially protect consumers from the hazards posed by chemical household products, is weakened.

6.2.3 Heuristics

Prior studies have reported that both food-imitating packaging and organic labelling affect consumers' risk perception (Basso et al., 2010; Basso et al., 2014; Bearth et al., 2017). More specifically, the two factors lead to products being perceived as safer than they actually are. However, the study presented in Chapter Five showed that these two packaging attributes are not the only ones capable of influencing consumers' risk perception. In addition to products with food-imitating packaging, products with packaging that featured flowers were also perceived to be less risky. Interestingly, the colour of the packaging equally influenced the participants' risk perception, especially if the packaging was black, which lead to it being perceived as more dangerous. This raises the question of whether it is these specific packaging attributes that cause a reduced risk perception or whether it is simply the unusual packaging that results in a reduced risk perception. It is possible that packaging featuring, for example, a picture of a skyscraper could lead to a higher risk perception, simply because it is something that consumers are not used to. In the case of tobacco products, it has previously been found that the effects of warnings wore off after some time (Hammond et al., 2007), and similar

effects can be expected for design elements intended to increase the risk perception of chemical household products. Future studies should seek to address these questions.

6.2.4 Effectiveness of Warnings

The three aforementioned factors (e.g. unawareness of the risks in everyday life, lack of knowledge regarding toxicological principles and use of heuristics) all concern aspects of consumers' decision-making process. Moreover, it would not prove easy for manufacturers and regulators to change these aspects.. However, they can be compensated for by means of effective warnings on products. But, as we have demonstrated, the existing warnings are not effective.

In fact, the study presented in Chapter Five showed that consumers not only rarely look at the warnings on the packaging and, even when they do so, exhibit only limited comprehension of them. While there are regulations in place regarding the minimum permitted size of warnings concerning chemical household products, no regulations prescribe where such warnings need to be positioned on the packaging, as is the case, for example, with tobacco products. This results in the warnings found on most products being hidden on the back of the packaging. However, prior studies have shown that the noticeability of warnings is crucial wuth regard to the efficacity of such warnings because consumers can only take action if they actually see the warnings (Laughery & Wogalter, 2014). Additionally, even when consumers do notice the warnings, they need to be able to understand their meaning (Laughery & Wogalter, 2014). While consumers' awareness of general risk is a good starting point, it does not enable them to take appropriate safety measures. For example, it makes a difference whether a given product is corrosive or flammable. In the former case, users should equip themselves with protective clothing (e.g. glasses, gloves), wheras in the latter case, users should keep away from any source of flame (e.g. cigarettes, candles, and heating starters and similar appliances). Therefore, consumers need to understand the meaning of the warnings if they are to implement the correct safety measures.

Taken together, these issues concerning the effectiveness of warnings again weaken one of the safety nets and so increase the probability of a hazard resulting in an accident. Each of these points is likely unproblematic when considered in isolation, although in combination they increase the probability of the unsafe handling of chemical household products and, therefore, the number of accidents involving such products (Reason et al., 2006). In the following section, I will discuss possible measures that could be adopted by both regulators and manufacturers to overcome the identified issues.

6.3 Implications for Regulators and Manufacturers of Chemical Household Products

The findings discussed above give rise to the question of what the practical implications of the four studies are and whether measures should be taken by regulators and manufacturers of chemical household products to address those implications. While measures adopted by regulators and manufacturers have only limited influence on the factors related to the individual consumer (e.g. lack of motivation to follow safety advice), we were able to show that the measures available to manufacturers and regulators, such as the use of unambiguous packaging, could have an influence on how products are perceived and, therefore, reduce the number of potential accidents involving them.

6.3.1 Information Campaigns

As previously discussed, consumers are unlikely to recall their knowledge of the risks related to chemical household products when actually using them. In addition, as shown in Chapters Two and Three, consumers exhibit specific knowledge gaps. Information campaigns can be an effective means of increasing consumers' knowledge (f. ex. Douglas et al., 1970; Salcedo et al., 1974). For example, following the implementation campaign by the Federal Office of Public Health, the Swiss population was able to recognise at least some of the GHS pictograms (econcept, 2015). However, due to the lack of risk awareness, information campaigns should pursue two goals. First, consumers should be sensitised to the risks when actually handling products. Second, a greater general awareness of risks should be fostered so that consumers would intuitively consider the risks without needing to be prompted to do so.

While it is difficult to envisage the implementation of information campaigns in consumers' homes, especially while they are actually using chemical household products, another possibility involves prevention campaigns at the point of sale. Similar to what is customary for tobacco products, consumers could be reminded of the risks via warning signs placed on the shelves in shops. However, it would be advisable to determine beforehand whether such a campaign would be supported by consumers, retailers and manufacturers.

As mentioned above, the second aim of information campaigns should be to increase consumers' knowledge of risks in a general way so that such knowledge is present without them having to be prompted. In Switzerland, information courses concerning the risks of chemical household products are available for primary and secondary school classes (Swiss Federal Office of Public Health, 2015). Yet, these courses are not compulsory, which means that their widespread implementations is doubtful. For this kind of intervention to be effective, it needs to become the norm for children to be educated regarding the risks of household chemical products.

6.3.2 Authorisation of Chemical Household Products

In terms of the implications of the findings of the present research for the authorisation of chemical household products, two key difficulties should be noted. First, very few aspects of the packaging of such products and its influence on consumers' risk perception have been studied. Second, in certain concrete cases, it can prove difficult to define whether a product meets the criteria for exhibiting a biasing characteristic. Often, the boundaries between traditional packaging and more innovative packaging featuring potentially misleading attributes are fluid. For example, how many food-imitating elements can a given product feature before it is mistaken for a food product? Does the inclusion of a picture of a lemon suffice, or is the product only mistaken for squash if other misleading design elements are present (e.g. statements about the smell)? Does this distinction depend on the packaging designs of available food products? These two points explain why, despite there being numerous regulations regarding chemical household products in place, they seem to lack effectiveness given the high number of accidents involving such products.

Interestingly, the study presented in Chapter Four showed that the way the participants choose a product influenced their product choice. Indeed, the participants who chose a safer product spent more time looking at the warnings. Therefore, encouraging consumers to study the warnings appears to be an effective approach. This finding also suggests that regulations regarding packaging and compulsory warnings can have a positive effect. However, they need be scientifically based, validated and precise. I will now present several possible points of action for regulators based on the findings of the studies included in this dissertation:

- The participants were not able to differentiate between the warning labels indicating different levels of risk (i.e. lower or higher risk). Additionally, the online surveys presented in Chapters Two and Three revealed that the participants were not aware of the meaning of the less commonly used GHS warning pictograms. Therefore, the use of one general warning pictogram is likely to prove more effective. While such an approach is not ideal because it does not provide information about the actual kind of risk (e.g. corrosive or flammable, as discussed above), it still provides particularly precautious users with the opportunity to inform themselves about the product and obtain additional information (and the chances are high that they already have done so). Moreover, the average user is more likely to understand the warning and, therefore, to intentionally implement safety measures. Ideally, this pictogram change should be coordinated at an international level so as to (i) facilitate the change for manufacturers and (ii) increase consumers' knowledge of the pictogram, including migrants, tourists

and people living in border regions. Prior to its implementation, the new warning pictogram should be scientifically validated with regard to its effectiveness.

- Packaging with design elements atypical of chemicals had an influence on consumers' risk perception. Thus, packaging featuring elements associated with positive emotions that are not typically associated with chemicals should be carefully evaluated, and the authorisation of such products should be restricted. Examples of relevant design elements include images of flowers and foods as well as text affirming a specific taste. In addition, legislation in this regard that is already in place (e.g. the prohibition of food-imitating products in EU countries; Council of the European Union, 1987) should be more stringently enforced.

6.3.3 Increasing Safety from the Manufacturers' Perspective

Increasing consumers' awareness of risks and necessary safety measures does not necessarily lead to negative consequences for manufacturers. In fact, prior research has shown that consumers do not rate packaging featuring warnings as less attractive than packaging without warnings (Kovačević et al., 2018). The voluntary measures undertaken by the International Association for Soaps, Detergents and Maintenance Products (A.I.S.E.) suggest that this is true in real life as well as in theoretical studies. Moreover, a large number of accidents involving its products can damage a manufacturer's reputation. A prominent case in this regard involves the cleaner *Fabuloso,* which was widely criticised by consumer groups due to its packaging resembling a soda bottle (Miller et al., 2006; Perton, 2006). Safety measures, including effective warnings and unambiguous packaging, may reduce the number of accidents and, therefore, the risk of reputational damage. Thus, similar recommendations can be made to manufacturers as suggested to regulators:

- Atypical packaging designs intended to provoke associations with products other than chemicals or non-related situations should be avoided because they foster ambiguity concerning the dangerousness of the products. If manufacturers are fearful of losing turnover, one possibility is to market their products as risky but especially effective.
- Ideally, there should be one clear warning that is easily noticeable. Prior studies have found that the warning should be either on the front of the packaging or directly before the instructions for use (Laughery et al., 1993; Wogalter et al., 1987). Although the GHS warnings are compulsory, manufacturers could use an additional warning and

omit the Safe Use Icons. Of course, the effectiveness of such a warning should be scientifically validated prior to its introduction.

6.4 Methodological Implications for Future Research

Different methodologies were combined in the studies presented in this dissertation, which allowed for the studies to make important methodological contributions to the research into behaviour on the part of lay people that might lead to potentially risky situations. Especially innovative is the use of eye tracking in a virtual environment. Thus, I will now briefly discuss the use of these two methodologies and explain how they can be used to tackle the problems that occur when measuring risky behaviour (as described in Chapter One).

6.4.1 Eye Tracking

The use of eye tracking enables the measurement of participants' eye movements, which are indicative of their attentional processes (Holmqvist et al., 2011). This technology is particularly suitable when answering research questions that address human behaviour participants either do not want to or cannot share. For example, in the fourth study presented in this dissertation, the participants were asked about the factors that influenced their choices of chemical household products. Many participants indicated that their choices were based on the potential risks of the products, although, very few participants actually looked at the warnings or other elements on the packaging (e.g. ingredients, instructions for use) that indicated the potential risks of the products. Therefore, it can be assumed that the participants were not consciously aware of the factors they relied on when choosing chemical products. In such situations, eye tracking can provide valuable information concerning human behaviour. Moreover, this methodology limits both recall bias and social desirability.

However, eye tracking involves certain methodological trade-offs, which are dependent on the model of eye tracker used. Here, I will discuss the problems associated with the Pupil Labs eye tracker when used with a HTC Vive VR headset. We used this setup for the study presented in Chapter Four. The Pupil Labs eye tracker algorithm is equipped with a slippage correction that performs less well than the corrections offered by other manufacturers (Niehorster et al., 2020). This means that when participants move their head and the headset only slightly slips (which happens somewhat frequently as the headset cannot be fixed firmly enough without causing discomfort to the individual participant), the position of the eye tracker camera and the world view are no longer aligned with the pupil. This results in uncertainty regarding whether the participant actually looked at a precise area of interest or at a neighbouring area (Niehorster et al., 2020). Furthermore, the Pupil Labs eye tracker uses an

operationalisation for fixations that is reported to measure fewer fixations than the eye trackers made by of other manufacturers (Ehinger et al., 2019). The data from the study presented in this dissertation as well as other data collected by our group, suggest that this inability to measure fixations is not evenly distributed along the total duration of measurement but is instead due to the total lack of measurements at certain moments. Additionally, due to the compact nature of VR headsets, the eye tracker cameras cannot be placed at an ideal angle, being positioned too low for optimal results. Due to this, the algorithm for this setup does not perform very well when used in a VR headset rather than a mobile eye tracker (Richter et al., 2019). Moreover, I can report frequent problems with the cameras fogging up, especially when medical face masks were worn (the data for the study presented in this dissertation were collected during the COVID-19 pandemic). Finally, for this methodology to be implemented, participants need to wear a headset, which is fairly heavy and can lead to the feeling of restricted breathing. This can prove problematic in terms of ecological validity, as this kind of setup constantly reminds participants that they are in a study setting.

Ultimately, the use of eye tracking can give rise to important additional insights, and many research questions could not be answered without the use of this methodology. Yet, the above-mentioned methodological constraints should be kept in mind when analysing the data and, as soon as available, eye trackers capable of overcoming the identified issues should be used.

6.4.2 Fully Immersive Virtual Reality

To reduce the risk of low ecological validity when using a mobile or stationary eye trackers, the devices can be fitted directly into a VR headset. This means that the eye tracker is not visible to the participant and its use does not lead to discomfort, for example, due to the a chin rest to immobilise the participant in the case of a stationary eye tracker. In addition, the use of VR facilitates the standardisation of laboratory studies because all visual factors, including *natural* illumination, can be controlled for. Furthermore, the risk of social desirability effects is reduced, as the presence of the experimenter is barely noticeable to the participant. However, it should be noted that, at the time of writing, no standard has yet been developed for research, meaning that all setups were originally developed for other tasks (e.g. gaming). This leads to cumbersome programming, so further developments in this area should be supported.

6.5 Limitations and Research Outlook

An important point that I have not discussed yet is the question of whether consumers are genuinely interested in reducing the number of accidents involving chemical household products. While it is socially expected that people claim to be willing to reduce the number of accidents related to such products, it remains unclear whether this is actually true and whether consumers are willing to make trade-offs in return for other benefits (e.g. higher attractiveness of the product, ease of use, etc.). This explains why warning labels are only rarely studied by consumers.

In future, it would be important to evaluate the effectiveness of various possible intervention measures, whether by manufacturers or regulators. While the studies presented in this dissertation have generated knowledge about the factors that can lead to unsafe behaviour, it has not been possible to determine how to ideally address these issues. For example, it would be interesting to study whether different placements of warning labels on product packaging affects the number of accidents involving chemical household products. The same is true for the omission of potentially problematic packaging features, including flowers, food-imitating elements and pictures of babies. It is necessary to study whether these features only influence risk perception or also influence the number of accidents. Furthermore, an evaluation of both existing prevention campaigns and possible optimised prevention campaigns is necessary. This would enable the more appropriate allocation of scarce resources to prevention measures and interventions that are known to be highly effective. However, it should be recognised that this evaluation process may not be final. Indeed, intervention campaigns concerning tobacco products have shown that the effectiveness of such campaigns tends to wear off over time and, further, that new measures are regularly needed (Hammond, 2011). Similar effects should be expected in relation to chemical household products.

6.6 Concluding Remarks

This dissertation sought to investigate consumers' perception of chemical household products and determine whether consumers handle such products in a safe way. First, we examined consumers' perception of chemical household products. Then, we examined the possible differences in these perceptions among European countries. Following these online surveys, we conducted a laboratory study in a virtual environment and used eye tracking to capture consumers' decision-making strategies when choosing a laundry detergent. Finally, we conducted an online experiment to examine the influence of different packaging design features on consumers' risk perception.

While there is still a lack of clear scientific evidence regarding consumers' handling of chemical household products, this dissertation has generated some important findings. The included studies showed that consumers (i) lack toxicological knowledge, (ii) do not usually intuitively think of risks and (iii) do not usually look at warnings on packaging. However, (iv) consumers' risk perception is affected by packaging design features.

In future, to determine the most problematic situations when handling chemical household products, data regarding the incidence of different types of products being involved in accidents, the ages of the victims and the situations in which the accidents occurred should be collected. Then, the factors that influenced consumers' perception and handling of the relevant products should be examined. Finally, the development and evaluation of interventions is necessary.

Due to suggesting possible intervention measures, the findings of this dissertation have multiple implications for both manufacturers and regulators. Although further research in this regard is necessary, manufacturers should keep in mind that packaging design can influence consumers' risk perception and, therefore, impact the number of poisonings related to chemical household products. Regulators should ensure that their prevention campaigns not only provide additional knowledge to consumers but also help consumers to activate this knowledge when necessary. Finally, a simplified warning system might prove more effective than the current labels.

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Appendix

Appendix A. *Perceptions and self-reported behaviour (M: Means, SD: Standard Deviations; 1: do not agree at all – 6: strongly agree).*

	AT N = 731		CH N = 698		DE N = 711		FR N = 708		IT N = 695		PL N = 693		SE N = 682		UK N = 713	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Self-reported behaviour (α = .60)	**5.28^{ab}**	**0.70**	**5.37^{a}**	**0.62**	**5.31^{ab}**	**0.70**	**5.19^{bc}**	**0.73**	**5.19^{bc}**	**0.82**	**5.00^{e}**	**0.84**	**5.01^{de}**	**0.78**	**5.13^{cd}**	**0.76**
F(7, 5623) = 23.10, p < .001, η2 = .03																
I keep chemical household products separate from food products.	5.78	0.74	5.80	0.65	5.71	0.87	5.74	0.80	5.59	0.91	5.56	1.09	5.66	0.85	5.72	0.79
I open a window, when a chemical household product has a strong smell.	5.43	1.04	5.43	0.92	5.43	1.00	5.40	1.06	5.33	1.03	5.22	1.18	5.13	1.19	5.24	1.09
I store chemical household products in a place that is inaccessible to children.	5.35	1.25	5.36	1.18	5.20	1.36	5.28	1.34	5.26	1.24	5.39	1.24	4.74	1.60	4.73	1.68
When disposing of chemical household products, I pay attention to the disposal instructions on the label.	4.91	1.41	5.11	1.26	4.92	1.43	4.65	1.65	5.10	1.19	4.78	1.50	4.75	1.49	4.81	1.44
In the past, I have transferred chemical household products into other containers. *	1.79	1.42	1.79	1.41	1.54	1.20	1.70	1.33	1.99	1.50	2.08	1.59	1.84	1.39	1.67	1.31
I also waterproof my textiles and shoes inside the house. *	2.01	1.49	1.67	1.26	1.86	1.39	2.21	1.63	2.15	1.55	2.93	1.67	2.33	1.64	2.09	1.45
Risk perception of chemical household products (α = .63)	**4.82^{ab}**	**0.90**	**4.77^{b}**	**0.88**	**4.93^{a}**	**0.87**	**5.16^{c}**	**0.84**	**4.83^{ab}**	**0.93**	**4.71^{b}**	**0.89**	**4.69^{b}**	**0.93**	**4.84^{ab}**	**0.85**

	AT N = 731		CH N = 698		DE N = 711		FR N = 708		IT N = 695		PL N = 693		SE N = 682		UK N = 713	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
F(7, 5623) = 19.54, p < .001, η2 = .02																
Misuse of chemical household products can have serious health consequences.	5.32	1.16	5.30	1.06	5.38	1.03	5.46	1.02	5.34	1.06	5.45	1.03	5.16	1.17	5.51	0.92
I feel that chemical household products can endanger my health	4.56	1.38	4.58	1.33	4.76	1.32	5.18	1.19	4.88	1.20	4.80	1.30	4.55	1.38	4.63	1.30
I assume that chemical household products that are available in retail are not particularly dangerous. *	2.48	1.39	2.70	1.41	2.46	1.36	2.16	1.31	2.73	1.53	2.97	1.57	2.79	1.49	2.42	1.43
Oftentimes, I find the hazard and precautionary information on the packaging of chemical household products exaggerated. *	2.12	1.31	2.09	1.29	1.97	1.16	1.85	1.32	2.16	1.47	2.44	1.54	2.14	1.27	2.35	1.38
Behavioural outcome expectancies (α = .76)	**5.08^{ab}**	**0.87**	**5.09^{ab}**	**0.83**	**5.12^{ab}**	**0.89**	**5.16^{b}**	**0.76**	**4.99^{ac}**	**0.94**	**5.07^{ab}**	**0.89**	**4.88^{c}**	**0.92**	**4.91^{c}**	**0.89**
F(7, 5623) = 9.37, p < .001, η2 = .01																
The consequences of a poisoning with chemical household products are serious and thus, it pays to be very careful with them.	5.27	1.07	5.30	1.07	5.26	1.15	5.54	0.96	5.44	0.97	5.44	1.05	5.06	1.22	5.36	1.07

	AT N = 731		CH N = 698		DE N = 711		FR N = 708		IT N = 695		PL N = 693		SE N = 682		UK N = 713	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
It is better to handle chemical household products with the utmost caution, as otherwise this is an unnecessary health risks to the self and others.	5.19	1.19	5.24	1.07	5.32	1.01	5.56	0.92	5.30	1.05	5.40	1.02	4.98	1.30	5.28	1.08
If I am not careful with chemical household products, I endanger my or others' health.	5.29	1.06	5.09	1.29	5.29	1.13	4.88	1.64	5.22	1.18	5.40	1.06	5.03	1.19	4.77	1.62
Most chemical household products are safe, so most of the time you do not have to take special precautions. *	2.31	1.29	2.26	1.29	2.23	1.31	1.80	1.16	2.31	1.46	2.65	1.53	2.34	1.32	2.52	1.40
It is too time consuming for me to read the hazard and precautionary statements on the packaging of chemical household products. *	2.15	1.42	2.01	1.3	2.12	1.42	2.15	1.44	2.59	1.68	2.16	1.48	2.43	1.50	2.07	1.38
Usually, it is unnecessary to read the hazard and precautionary statements on the packaging of chemical household products. *	1.80	1.22	1.80	1.22	1.78	1.24	2.08	1.55	2.12	1.63	2.00	1.45	2.03	1.36	2.35	1.66
Perceived behavioural control: Personal: It is my own responsibility to ensure that no accidents involving	**5.59[a]**	**0.81**	**5.53[a]**	**0.85**	**5.55[a]**	**0.78**	**5.27[b]**	**1.05**	**5.35[b]**	**1.00**	**5.34[b]**	**1.09**	**5.33[b]**	**1.06**	**5.52[a]**	**0.87**

	AT N = 731		CH N = 698		DE N = 711		FR N = 708		IT N = 695		PL N = 693		SE N = 682		UK N = 713	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
F(7, 5623) = 12.27, p < .001, η2 = .02																
Perceived behavioural control: External: Manufacturers and sellers are responsible for ensuring that no accidents involving chemical household products happen.	**2.65[a]**	**1.55**	**3.01[b]**	**1.66**	**3.04[b]**	**1.62**	**4.17[d]**	**1.72**	**4.11[d]**	**1.54**	**3.73[e]**	**1.69**	**3.41[c]**	**1.61**	**3.22[bc]**	**1.64**
F(7, 5623) = 79.99, p < .001, η2 = .09																
Product-related aspects (α = .74)	**4.13[ab]**	**1.00**	**4.08[bc]**	**0.98**	**4.11[bc]**	**1.03**	**3.96[bc]**	**1.10**	**4.03[c]**	**1.06**	**4.66[d]**	**0.88**	**3.85[c]**	**1.09**	**3.95[bc]**	**1.10**
F(7, 5623) = 39.87, p < .001, η2 = .05																
Previous experience with this or a similar product	4.66	1.31	4.62	1.22	4.68	1.25	4.36	1.34	4.67	1.18	5.09	1.05	4.28	1.32	4.60	1.30
Effectiveness	4.67	1.43	4.45	1.43	4.48	1.42	4.41	1.47	4.39	1.45	5.28	1.05	4.18	1.52	4.46	1.54
Biodegradable packaging	3.92	1.70	4.02	1.60	3.84	1.65	3.74	1.64	3.76	1.55	4.33	1.47	3.76	1.62	3.50	1.69
Odour	3.99	1.54	3.78	1.53	4.11	1.48	3.77	1.62	4.01	1.43	4.60	1.28	3.71	1.57	4.01	1.53

	AT N = 731		CH N = 698		DE N = 711		FR N = 708		IT N = 695		PL N = 693		SE N = 682		UK N = 713	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Size of the packaging (quantity)	3.38	1.67	3.51	1.59	3.43	1.64	3.53	1.66	3.31	1.55	4.02	1.54	3.31	1.56	3.20	1.69
Hazard-related aspects (α = .69)	**4.78^{abc}**	**1.13**	**4.83^{b}**	**0.96**	**4.79^{abc}**	**1.00**	**4.64^{cd}**	**1.06**	**4.79^{abc}**	**1.01**	**4.84^{b}**	**0.96**	**4.42^{e}**	**1.09**	**4.56^{de}**	**1.12**
F(7, 5623) = 14.57, p < .001, η2 = .02																
Danger warnings on packaging	5.22	1.25	5.30	1.03	5.30	1.05	5.13	1.22	5.05	1.20	5.14	1.13	4.91	1.26	5.22	1.18
Composition or ingredients	4.79	1.44	4.74	1.30	4.89	1.25	4.81	1.36	5.01	1.15	4.88	1.23	4.24	1.45	4.60	1.45
Information and advice from sales staff	4.33	1.55	4.44	1.42	4.18	1.5	3.98	1.46	4.33	1.36	4.50	1.29	4.11	1.45	3.86	1.63
Marketing-related aspects (α = .58)	**2.93^{a}**	**1.09**	**3.04^{ab}**	**1.04**	**3.07^{ab}**	**1.17**	**3.00^{ab}**	**1.17**	**3.33^{c}**	**1.24**	**3.62^{d}**	**1.17**	**3.18^{bc}**	**1.12**	**3.02^{ab}**	**1.24**
F(7, 5623) = 27.06, p < .001, η2 = .03																
Place of purchase (retail trade vs. special trade)	3.59	1.62	3.92	1.57	3.49	1.60	3.51	1.57	3.68	1.49	4.07	1.48	3.78	1.48	3.43	1.60
Packaging (colour, font)	3.00	1.56	3.21	1.65	3.23	1.61	3.09	1.64	3.34	1.54	3.38	1.52	3.35	1.64	2.90	1.61
Availability via online shipping	2.21	1.51	1.97	1.34	2.47	1.56	2.39	1.6	2.95	1.57	3.41	1.69	2.39	1.52	2.72	1.64

Appendix B. Results of the Product Comparisons for Each Product Separately (Means (M), Standard Deviations (SD), and Confidence Intervals (CI), N = 523)

			t	*Cohen's d*	*M (SD)*	*95 % CI*
1	Product 1 (black bottle manipulation)	Original bottle is safer (0) - Black bottle is safer (100)	-11.15***	.49	39.76 (21.02)	[37.96, 41.56]
2	Product 2 (black bottle manipulation)	Original bottle is safer (0) - Black bottle is safer (100)	-12.37***	.54	37.96 (22.52)	[36.03, 39.89]
3	Product 3 (black bottle manipulation)	Original bottle is safer (0) - Black bottle is safer (100)	-13.07***	.57	38.46 (20.20)	[36.73, 40.19]
4	Product 4 (food-imitating elements manipulation)	Original packaging with food-imitating elements is safer (0) - Packaging without food imitating elements is safer (100)	-6.53***	.29	43.42 (23.05)	[41.44, 45.40]
5	Product 5 (food-imitating elements manipulation)	Original packaging with food-imitating elements is safer (0) - Packaging without food imitating elements is safer (100)	-4.88***	.21	45.86(19.39)	[44.20, 47.52]
6	Product 6 (food-imitating elements manipulation)	Original packaging with food-imitating elements is safer (0) – Packaging without food imitating elements is safer (100)	-13.08***	.57	38.32 (20.43)	[36.57, 40.07]
7	Product 7 (flowers on label manipulation)	Packaging with flowers on label is safer (0) - Original packaging without flowers on label is safer (100)	-6.43***	.28	43.87 (21.79)	[42.00, 45.74]
8	Product 8 (flowers on label manipulation)	Packaging with flowers on label is safer (0) - Original packaging without flowers on label is safer (100)	-4.59***	.20	45.92 (20.31)	[44.18, 47.66]

9	Product 9 (flowers on label manipulation)	Packaging with flowers on label is safer (0) - Original packaging without flowers on label is safer (100)	-3.64***	.16	46.55 (21.68)	[44.69, 48.41]
10	Product 10 (pink bottle manipulation)	Pink bottle is safer (0) - Original bottle is safer (100)	4.37***	.19	54.11 (21.52)	[52.27, 55.95]
11	Product 11 (pink bottle manipulation)	Pink bottle is safer (0) - Original bottle is safer (100)	1.71	.07	51.60 (21.43)	[49.76, 53.44]
12	Product 12 (pink bottle manipulation)	Pink bottle is safer (0) - Original bottle is safer (100)	0.77	.03	50.70 (20.95)	[48.90, 52.50]

Note. 0: Packaging A – 100: Packaging B, participants were asked to choose the safer product (inverse measure), equal risk perception would be represented by $M = 50$; ***: $p < .001$.

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2008-2013	Bilingual Swiss Matura Kollegium Heillig Kreuz, Fribourg Matura thesis: Io in den Metamorphosen. Darstellung bei Ovid und Wickram

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