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Final report

Consumer Survey on Biocidal Products and Environmental Risks

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Abstract: Consumer Survey on Biocidal Products and Environmental Risks

Biocides are active substances and products that are used against various harmful organisms and can pose a risk to human and animal health, and the environment. Thus, biocides are regulated, and risk mitigation measures are implemented to minimise identified risks to an acceptable level. These risk mitigation measures may be the restriction of application and frequency or the user category, often accompanied by (use) instructions. Ideally, these instructions are easily comprehensible and practicable, and hence, elicit the appropriate response by the users (i.e., protection motivation). However, phrasing these instructions for non-professional users is not a straightforward task, as empirical data and explicit guidelines are missing. This project aimed at generating a first empirical basis within a representative online survey (N = 1000) in Germany. The online survey focused on three areas of interest: familiarity with biocidal products and their potential risks, evaluation of specific instructions and their variations, and the drivers of protection motivation. While consumers exhibited risk awareness for biocidal products, the results suggest several potential issues that might hinder the appropriate handling of biocidal products. The results also offer insights into the comprehensibility, practicability, difficulty, and protection motivation elicited by specific use instructions found on biocidal products today. This final report presents and discusses concrete and generalisable insights into how instructions for use on biocidal products should be phrased to maximise comprehensibility and which ambiguous terms should be avoided or explained.

Kurzbeschreibung: Befragung von Verbraucher*innen zu Biozid-Produkten und Umweltrisiken

Biozide sind Wirkstoffe und Produkte, die gegen verschiedene Schadorganismen eingesetzt werden und ein Risiko für die Gesundheit von Menschen und Tieren, sowie für die Umwelt darstellen können. Biozide sind daher reguliert, und es werden Maßnahmen zur Risikominimierung ergriffen, um unannehmbare Risiken auf ein akzeptables Maß zu reduzieren. Bei diesen Risikominimierungsmaßnahmen kann es sich um die Beschränkung der Anwendung und der Anwendungshäufigkeit oder um die Beschränkung der Kategorie von Anwender*innen handeln. Diese Beschränkungen werden häufig von Gebrauchsanweisungen begleitet, die im Idealfall leicht verständlich und praktikabel sind, so dass sie bei den Verbraucher*innen angemessenes Verhalten hervorrufen (d.h. eine Schutzmotivation). Die Formulierung dieser Gebrauchsanweisungen für nicht-professionelle Anwender*innen ist jedoch keine einfache Aufgabe, da empirische Daten und konkrete Empfehlungen fehlen. Ziel dieses Projekts war es, im Rahmen einer repräsentativen Online-Befragung (N = 1000) in Deutschland, eine erste empirische Grundlage zu schaffen. Die Online-Befragung konzentrierte sich auf drei Interessensbereiche: Vertrautheit mit Biozidprodukten und ihren potenziellen Risiken, Bewertung spezifischer Gebrauchsanweisungen und ihrer Variationen sowie die Treiber der Schutzmotivation. Während die Verbraucher*innen ein Risikobewusstsein für Biozidprodukte zeigten, deuten die Ergebnisse auf mehrere potenzielle Probleme hin, die den angemessenen Umgang mit Biozidprodukten behindern könnten. Die Ergebnisse bieten auch Einblicke in die Verständlichkeit, Praktikabilität, Schwierigkeit und Schutzmotivation, die durch spezifische Gebrauchsanweisungen auf Biozidprodukten hervorgerufen werden. Der vorliegende Abschlussbericht präsentiert und diskutiert konkrete und verallgemeinerbare Erkenntnisse darüber, wie Gebrauchsanweisungen auf Biozidprodukten formuliert werden sollten, um die Verständlichkeit zu maximieren und welche mehrdeutigen Begriffe vermieden oder erklärt werden sollten.

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BPR	Biocidal Products Regulation (EU) No 528/2012 concerning the making available on the market and use of biocidal products
CLP	CLP regulation ((EC) No 1272/2008 on the classification, labelling, and packaging of substances and mixtures)
EC	European Commission
ETH	Eidgenoessische Technische Hochschule Zürich
EU	European Union
PMT	Protection Motivation Theory
UBA	Umweltbundesamt

Summary

Background

Biocides are active substances and products that are used against various harmful organisms and can pose a risk to human and animal health, and the environment. Thus, biocides are regulated by the Biocidal Products Regulation (EU) No 528/2012 concerning the making available on the market and use of biocidal products (BPR). The BPR establishes an EU-wide harmonised authorisation procedure for biocidal products, including standardised principles to assess the potential risks that may arise due to their use. In case the risk assessment has identified unacceptable risks, the BPR foresees the possibility to allocate risk mitigation measures to minimise the risks to an acceptable level. Relevant risk mitigation measures may be the restriction of application and frequency or the user category, often accompanied by use instructions providing information on how to correctly use the product. Ideally, these use instructions are easily comprehensible and practicable, and hence, elicit the appropriate response by the users (i.e., protection motivation). However, phrasing these use instructions for non-professional users is not a straightforward task. During EU-wide authorisation processes of biocidal products, comprehensibility, and implementation of use instructions for the non-professional user are often a cause for dissent between member states. Among other reasons, the dissent occurs due to a lack of empirical evidence on the comprehensibility and practicability of instructions for consumers and only little is known concerning consumers' risk awareness for biocidal products.

Project aim and study design

Prior research has uncovered several individual barriers to safe use of household chemicals, such as a lack of perceived risk or evasion of responsibility to protect health and the environment (Bearth, Buchmuller, Burgy, & Siegrist, 2020; Bearth, Miesler, & Siegrist, 2017; Buchmuller, Bearth, & Siegrist, 2020). This project aimed at providing first insights into non-professional users' interactions with biocidal products, and the comprehensibility of specific instructions. The focus was on risk mitigation measures and use instructions (subsequently called "instructions") that provide information to the user on how to apply biocidal products in a safe way. Three areas of interest were defined in this study, namely the 1) familiarity of consumers with biocidal products and their potential risks, 2) the evaluation of specific instructions and possible improvements as well as 3) main drivers of protection motivation.

These areas of interest were investigated within an online survey in Germany. The participants were recruited with the support of a market research company (www.bilendi.de). Data collection took place in January 2022. The final sample comprises data from N = 1062.

First area of interest: Familiarity with biocidal products and their potential risks

- Goal 1: Uncover potentially relevant misconceptions and knowledge gaps about biocidal products among consumers.
- Research question 1: How familiar are consumers with biocidal products and their potential risks?

At the start of the questionnaire, the participants were asked to indicate at least one word, picture, or thought that came to their mind when they hear the term "biocidal product" in three open response fields (i.e., spontaneous associations). The goal of this was to access people's familiarity with biocidal products, their spontaneous and uninfluenced reactions, and to uncover whether people spontaneously think of risks regarding these products. The most frequent associations were "poison, death, or danger" and "agriculture (food, living beings)." Many

participants also mentioned a specific product or product category as their association to the term. This suggests a somewhat high (risk) awareness for biocidal products among many participants, although some also indicated that they did not know what "biocidal product" means.

Second area of interest: Evaluation of specific instructions and their variations

- Goal 2: Provide a scientific and empirical basis for optimal phrasing of instructions.
- Research question 2: How comprehensible are specific instructions for biocidal products and how practical and realistic is their implementation by consumers? Do variations improve comprehensibility?

In the questionnaire, a between-subjects scenario experiment was included to rate and compare a specific, basic instruction on a biocidal product with an experimental variation of this basic instruction. Participants were presented with 12 scenarios that included a problem in the household (e.g., an ant trail in the kitchen) and a fictitious biocidal product as a solution for this problem (e.g., product against ants). To test the effect of the variation in the instructions, the participants were randomly split into two separate groups and were presented with different instructions. Altogether, within the 12 scenarios, 12 basic instructions and 12 variations (total of 24 instructions), were investigated. For each instruction, the comprehensibility of the instruction, the perceived difficulty of adhering to the instruction, the protection motivation, and the elicited environmental risk perception were measured on five-point response scales from low to high.

The following four variations were investigated within the 12 scenarios:

a) Variation 1 "environmental risk": one group of participants received a basic instruction, while the other group received the same basic instruction with an environmental risk warning.

b) Variation 2 "positively charged animal": one group of participants received a basic instruction with a generic environmental warning (risk for the environment), while the other group received a variation of this environmental warning (risk for a positively charged animal, such as pets or bees).

c) Variation 3 "sentence phrasing": the basic instruction was passively phrased, while in the variation was actively phrased.

d) Variation "conciseness and examples": the basic instruction was presented in a concise way, while the variation included examples, clarifying the instructions.

The basic instructions were rated as rather or very comprehensible by a majority of participants. The least comprehensible basic instruction comprised technical phrases, such as "spot application" or "wind drift" that might have contributed to the comparably lower comprehensibility. The comprehensibility of the phrase "avoid transfer to other areas by wind drift" was significantly increased by adding the following example: "e.g., by not using the product when it is windy."

Basic instructions describing actions that are fully in consumers' control were perceived as easier to implement and therefore, elicited higher protection motivation than instructions that involve external factors or the behaviour of non-target organisms that are beyond the consumers' control (e.g., wind, rain, pollinators). It also becomes clear that perceived difficulty and protection motivation are linked: protection motivation is higher for actions that are perceived as easy (i.e., avoid a particular behaviour). A notable deviation from this association

between perceived difficulty and protection motivation was found for the instruction "Not more than one treatment per nest should be performed in a season." There, participants perceived a low difficulty, while reporting low protection motivation. Open responses at the end of the questionnaire support the plausible conclusion that consumers only limit the use of the product over time or according to dose, if the issue is solved (i.e., the wasp nest is gone), even though this is not perceived as difficult. If the issue persists (i.e., the wasp nest is still there), consumers will likely use more of the biocidal product or use it more frequently than indicated in the instruction. The instruction "do not wash treated blankets and textiles" was associated with particularly low protection motivation, as likely hygiene considerations might interfere with the motivation to adhere to this instruction. Perceived difficulty and protection motivation were impacted by variations: explicitly mentioning risks to the environment or positively-charged animals increased perceived difficulty and thus, reduced protection motivation significantly. However, adding examples had a positive impact on these two variables.

Third area of interest: Drivers of protection motivation

- Goal 3: Derive generalisable insights into which measures could be taken to increase protection motivation among the public.
- Research question 3: What drives and what complicates the adherence to instructions on biocidal products (e.g., practicability, product design, individual factors)?

To investigate the drivers of protection motivation an extended Protection Motivation Theory (PMT) served as a theoretical backdrop. The PMT assumes that the protection motivation, in this case the motivation to implement the safety measures on the label of a biocidal product, is determined by the perception of a threat and the estimation of the own ability to cope with it. Thus, it was hypothesised that threat appraisal and coping appraisal would be positively related to protection motivation. Additionally, locus of control – meaning, who is perceived to be responsible for the protection of health and the environment – was included to extend the model with a variable that had been shown to be relevant for chemical safety behaviour. It was hypothesised that protection motivation would be higher for participants that perceived more individual responsibility compared to participants that do not perceive a responsibility or perceive the government or industry to be responsible. Additionally, we hypothesised that cognitive processing of the instructions (e.g., evaluation of the instruction, time spent with the instruction) and socio-demographic variables might drive protection motivation.

The basis of this analysis was a hypothetical purchase scenario involving an insect spray against cockroaches. For this, the participants were asked to imagine that there are suddenly a lot of cockroaches in their house or apartment and that they purchased an insect spray to tackle this issue. They were presented with an insect spay and the full instructions on this insect spray. The time that participants spent with the instructions and their evaluation of these instructions were tracked as measures for cognitive processing. Afterwards, the variables of interest were measured with multi-item scales.

A large portion of variance in self-reported protection motivation could be explained by the extended PMT (48%). Some relationships between sociodemographic and household variables were observed: older and female participants reported higher protection motivation, while participants with small children (< 7 years of age), participants who would use an insect spray to get rid of cockroaches and participants that thought that biocidal products that are available in the supermarket would not harm health or the environment reported lower protection motivation. These findings should not be overestimated though, as some sociodemographic variables might be confounded (e.g., participants with small children are younger than

participants without small children) and effect sizes were small. The strongest relationship with protection motivation was found for coping appraisal. Participants that were confident that they can put the instruction into practice and expected positive outcomes of doing so reported higher protection motivation. When instructions were judged in a positive light (i.e., as clear and concrete, as uncomplicated, as concise), protection motivation was reported to be higher. Both findings stress the importance of comprehensible instructions that are easy to implement and do not require special skills or additional equipment. Perceived severity of negative outcomes was related to protection motivation, but not perceived likelihood of negative outcomes. The participants were more focused on risks to human and animal health, than environmental harm. It might therefore be advisable to strengthen consumers understanding of the potential severity of environmental harm caused by the unsafe handling of biocidal products. The findings also stress the importance of perceived personal responsibility (i.e., locus of control): Participants that perceived a high personal responsibility to protect human and animal health and the environment reported higher protection motivation. Thus, in addition to sensitising consumers to the severity of (environmental) harm, personal responsibility should be strengthened. Another issue arose regarding the neutral locus of control, which was negatively associated with protection motivation. That means if the consumers perceive all authorised biocidal products as safe, they exhibit lower protection motivation. This can be explained by the lack of awareness for the specificities of the authorisation procedure and that authorised products are not per se safe, but instructions need to be followed for a safe use of biocidal products.

Conclusion and recommendations for the instructions

This study stresses the importance of identifying ambiguous terms (e.g., spot application, regularly) in the instructions and removing or clarifying them for users. It is recommended to add examples for ambiguous terms, locations, or quantifications, even though this increases the length of the instruction. Subtle changes to the instructions' phrasing, however, do not seem to impact comprehensibility much. It should also be considered that instructions involving external factors (e.g., wind, rain, target and non-target animals), which are not under the users' control, are perceived as more difficult.

Zusammenfassung

Hintergrund

Biozide sind Wirkstoffe und Produkte, die gegen verschiedene Schadorganismen eingesetzt werden und ein Risiko für die Gesundheit von Menschen und Tieren, sowie für die Umwelt darstellen können. Biozide werden daher durch die Biozid-Verordnung (EU) Nr. 528/2012 (BPR) reguliert. Mit der BPR wurde ein EU-weit harmonisiertes Zulassungsverfahren für Biozidprodukte eingeführt sowie standardisierte Grundsätze zur Bewertung potenzieller Risiken durch deren Verwendung. Für den Fall, dass bei der Risikobewertung unannehmbare Risiken festgestellt werden, sieht die BPR die Möglichkeit vor, Risikominderungsmaßnahmen festzulegen, um die Risiken auf ein akzeptables Niveau zu minimieren. Bei diesen Risikominderungsmaßnahmen kann es sich um die Beschränkung der Anwendung und der Anwendungshäufigkeit oder um die Beschränkung der Kategorie von Anwender*innen handeln. Häufig sind diese Beschränkungen von Gebrauchsanweisungen begleitet, die im Idealfall leicht verständlich und praktikabel sind, so dass sie bei den Anwender*innen angemessenes Verhalten hervorrufen (d.h. eine Schutzmotivation). Die Formulierung dieser Gebrauchsanweisungen für nicht-professionelle Anwender*innen (Verbraucher*innen) ist jedoch keine einfache Aufgabe. Bei EU-weiten Zulassungsverfahren von Biozidprodukten sind die Verständlichkeit und die Formulierung von Anwendungshinweisen für Verbraucher*innen oft ein Grund für Diskussionen zwischen den Mitgliedsstaaten. Diese Diskussionen sind unter anderem darauf zurückzuführen, dass es an empirischen Erkenntnissen zur Verständlichkeit und Praktikabilität von Gebrauchsanweisungen für Verbraucher*innen fehlt und noch vergleichsweise wenig über das Risikobewusstsein von Verbraucher*innen für Biozidprodukte bekannt ist.

Projektziel und Studiendesign

Frühere Forschungsarbeiten haben mehrere individuelle Barrieren für eine sichere Verwendung von Haushaltschemikalien aufgedeckt, wie z.B. eine mangelnde Risikowahrnehmung oder die Vermeidung von Verantwortung für den Schutz von Gesundheit und Umwelt (Bearth, Buchmuller, Burgy, & Siegrist, 2020; Bearth, Miesler, & Siegrist, 2017; Buchmuller, Bearth, & Siegrist, 2020). Ziel dieses Projekts war es, erste Einblicke in die Interaktionen privater Anwender*innen mit Biozidprodukten und die Verständlichkeit spezifischer Anweisungen zu gewinnen. Der Schwerpunkt lag auf Risikominderungsmaßnahmen und Gebrauchsanweisungen (im Folgenden «Gebrauchsanweisungen» genannt), die dem Anwender oder der Anwenderin Informationen zur sicheren Handhabung von Biozidprodukten liefern. In dieser Studie wurden drei Interessensbereiche mit entsprechenden Zielen und Forschungsfragen definiert, nämlich die 1) Vertrautheit mit Biozidprodukten und ihren potenziellen Risiken, 2) die Bewertung spezifischer Gebrauchsanweisungen und ihrer Variationen und 3) die Treiber der Schutzmotivation.

Diese Interessenbereiche wurden im Rahmen einer Online-Umfrage in Deutschland untersucht. Die Teilnehmenden wurden mit Unterstützung eines Marktforschungsunternehmens (www.bilendi.de) rekrutiert. Die Datenerhebung fand im Januar 2022 statt. Die endgültige Stichprobe umfasst Daten von N = 1062 Teilnehmenden.

Erster Interessenbereich: Vertrautheit mit Biozidprodukten und ihren potenziellen Risiken

- Ziel 1: Identifizierung potenziell relevanter Missverständnisse und Wissenslücken über Biozidprodukte bei Verbraucher*innen.
- Forschungsfrage 1: Wie vertraut sind Verbraucher*innen mit Biozidprodukten und deren potenziellen Risiken?

Zu Beginn des Fragebogens wurden die Teilnehmenden gebeten, in drei offenen Antwortfeldern mindestens ein Wort, ein Bild oder einen Gedanken anzugeben, der ihnen einfällt, wenn sie den Begriff «Biozidprodukt» hören (d.h. ihre spontanen Assoziationen). Ziel war es, die Vertrautheit mit Biozidprodukten, spontane und unbeeinflusste Reaktionen zu erfassen und herauszufinden, ob die Teilnehmenden spontan an Risiken bei diesen Produkten denken. Die häufigsten Assoziationen waren «Gift, Tod oder Gefahr» und «Landwirtschaft (Lebensmittel, Lebewesen)». Viele Teilnehmenden nannten ein bestimmtes Produkt oder eine Produktkategorie als Assoziation zu dem Begriff. Dies deutet auf ein hohes (Risiko-)Bewusstsein für Biozidprodukte bei vielen Teilnehmenden hin, obwohl einige auch angaben, dass sie nicht wüssten, was "Biozidprodukt" bedeutet.

Zweiter Interessensbereich: Bewertung spezifischer Gebrauchsanweisungen und ihrer Variationen

- Ziel 2: Erstellen einer wissenschaftlichen und empirischen Grundlage für die optimale Formulierung von Gebrauchsanweisungen.
- Forschungsfrage 2: Wie verständlich sind spezifische Gebrauchsanweisungen für Biozid-Produkten und wie praktikabel und realistisch ist deren Umsetzung durch Verbraucher*innen? Verbessern Variationen die Verständlichkeit der Anweisungen?

Der Fragebogen enthielt ein Szenario-Experiment, in dem eine spezifische Basisanweisung zu einem Biozid-Produkt mit einer experimentellen Variation dieser Basisanweisung bewertet und verglichen werden sollte. Den Teilnehmenden wurden 12 Szenarien vorgelegt, die ein Problem im Haushalt (z.B. eine Ameisenstraße in der Küche) und ein fiktives Biozidprodukt als Lösung für dieses Problem (z.B. Produkt gegen Ameisen) beinhalteten. Um den Effekt der Variation der Gebrauchsanweisungen zu testen, wurden die Teilnehmenden nach dem Zufallsprinzip in zwei getrennte Gruppen aufgeteilt und bekamen in jedem der 12 Szenarien unterschiedliche Anweisungen präsentiert. Insgesamt wurden innerhalb der 12 Szenarien, 12 Basisanweisungen und 12 Variationen (insgesamt 24 Anweisungen) untersucht. Für jede Anweisung wurden die Verständlichkeit der Anweisung, die wahrgenommene Schwierigkeit, die Anweisung zu befolgen, die Schutzmotivation und die hervorgerufene Umweltrisikowahrnehmung auf fünfstufigen Antwortskalen von niedrig bis hoch gemessen.

Die folgenden vier Variationen wurden innerhalb der 12 Szenarien untersucht:

a) Variation 1 «Umweltrisiko»: eine Gruppe von Teilnehmenden (n = 529) erhielt eine Basisanweisung und die andere Gruppe von Teilnehmenden (n = 533) erhielt die gleiche Basisanweisung mit dem Hinweis auf ein Umweltrisiko.

b) Variation 2 «positiv-besetzte Tiere»: eine Gruppe von Teilnehmenden (n = 529) erhielt die Basisanweisung mit einem generischen Hinweis auf ein Umweltrisiko (Risiko für die Umwelt), während die andere Gruppe von Teilnehmenden (n = 533) eine konkretisierte Variation erhielt (Risiko für ein positiv-besetztes Tier, z.B. Haustier oder Bienen).

c) Variation 3 «Satzformulierung»: die Basisanweisung (n = 529) war passiv formuliert, während die Variation (n = 533) aktiv formuliert war.

d) Variation 4 “Prägnanz und Beispiele”: die Basisanweisung war kurz und prägnant (n = 529), während die Variation Beispiele enthielt und dadurch etwas länger war (n = 533).

Die Basisanweisungen wurden von der Mehrheit der Teilnehmenden als eher oder sehr verständlich eingestuft. Die am wenigsten verständliche Basisanweisung enthielt technische Formulierungen wie «punktuelle Anwendung» oder «Abdrift,» die zu der vergleichsweisen geringeren Verständlichkeit beigetragen haben könnten. Die Verständlichkeit des Satzes

«Abdrift durch Wind vermeiden» wurde durch folgende Konkretisierung signifikant erhöht: «z.B. das Produkt nicht verwenden, wenn es windig ist».

Basisanweisungen, welche Handlungen beschreiben, die vollständig in der Kontrolle der Verbraucher*innen liegen, wurden als leichter umsetzbar wahrgenommen und lösten daher eine höhere Schutzmotivation aus als Anweisungen, die externe Faktoren oder das Verhalten von Nicht-Zielorganismen betreffen, die sich der Kontrolle der Verbraucher*innen entziehen (z. B. Wind, Regen, Bienen). Es wird auch deutlich, dass zwischen der wahrgenommenen Schwierigkeit und der Schutzmotivation ein Zusammenhang besteht: Die Schutzmotivation ist höher für Handlungen, die als leicht empfunden werden (z.B. ein bestimmtes Verhalten vermeiden). Eine auffällige Ausnahme wurde jedoch bei der Anweisung «Nicht mehr als eine Behandlung pro Nest und Saison vornehmen.» festgestellt. Hier schätzten die Teilnehmenden die Schwierigkeit als gering ein, gaben aber eine geringe Schutzmotivation an. Die offenen Antworten am Ende des Fragebogens lassen den plausiblen Schluss zu, dass die Verbraucher*innen die Anwendung des Produkts nur dann zeitlich einschränken oder aussetzen, wenn das Problem gelöst ist (d.h. das Wespennest verschwunden ist), auch wenn dies nicht als schwierig empfunden wird. Bleibt das Problem bestehen (d.h. das Wespennest ist immer noch da), werden die Verbraucher*innen wahrscheinlich höhere Mengen verwenden oder es häufiger anwenden als in der Gebrauchsanweisung angegeben. Die Anweisung «Behandelte Decken und Textilien nicht waschen.» ergab eine besonders niedrige Schutzmotivation, da hygienische Erwägungen die Motivation, diese Anweisung zu befolgen, beeinträchtigen könnten. Die wahrgenommene Schwierigkeit und die Schutzmotivation wurden durch Variationen beeinflusst: Die explizite Erwähnung von Risiken für die Umwelt oder für positiv-besetzte Tiere erhöhte die wahrgenommene Schwierigkeit und verringerte somit die Schutzmotivation signifikant. Das Hinzufügen von Beispielen wirkte sich jedoch positiv auf diese beiden Variablen aus.

Dritter Interessensbereich: Treiber der Schutzmotivation

- Ziel 3: Ableitung von verallgemeinerbaren Erkenntnissen darüber, welche Maßnahmen ergriffen werden könnten, um die Schutzmotivation von privaten Anwender*innen zu erhöhen.
- Forschungsfrage 3: Was fördert und was erschwert die Einhaltung von Gebrauchsanweisungen für Biozidprodukte (z.B. Praktikabilität, Produktdesign, individuelle Faktoren)?

Die Treiber der Schutzmotivation wurden im Rahmen der erweiterten Protection Motivation Theory (PMT) untersucht. Die PMT geht davon aus, dass die Schutzmotivation, in diesem Fall die Motivation, die Anweisungen auf dem Etikett eines Biozidprodukts umzusetzen, durch die Bedrohungs- und Fähigkeitseinschätzung, bestimmt wird. Daher wurde die Hypothese aufgestellt, dass diese Variablen positiv mit der Schutzmotivation zusammenhängen. Zusätzlich wurde die Kontrollüberzeugung einbezogen, d.h. die Frage, wer für den Schutz der Gesundheit und der Umwelt verantwortlich gemacht wird. Es wurde die Hypothese aufgestellt, dass die Schutzmotivation bei Teilnehmenden, die mehr individuelle Verantwortung wahrnehmen, höher ist als bei Teilnehmenden, die keine Verantwortung wahrnehmen oder die Regierung oder Industrie als verantwortlich ansehen. Außerdem wurde die Hypothese untersucht, dass die kognitive Verarbeitung der Anweisungen (z. B. Bewertung der Anweisung, mit Lesen der Anweisung verbrachte Zeit) und soziodemografische Variablen mit der Schutzmotivation zusammenhängen.

Grundlage dieser Analyse war ein hypothetisches Kaufszenario für ein Insektenspray gegen Schaben (Kakerlaken). Dazu wurden die Teilnehmenden gebeten, sich vorzustellen, dass in ihrem Haus oder ihrer Wohnung plötzlich viele Schaben vorkommen und dass sie ein Insektenspray gekauft haben, um die Schaben zu bekämpfen. Anschliessend wurde den Teilnehmenden ein Insektenspray mit einer vollständigen Gebrauchsanweisung visuell vorgelegt. Die Zeit, welche die Teilnehmenden mit den Anweisungen verbrachten und deren Bewertung, wurden erfasst als Maße der kognitiven Verarbeitung. Anschließend wurden die interessierenden Variablen mit Multi-Item-Skalen gemessen.

Ein großer Teil der Varianz in der selbstberichteten Schutzmotivation konnte durch die erweiterte PMT erklärt werden (48%). Es wurden einige Zusammenhänge zwischen soziodemografischen und Haushaltsvariablen beobachtet: Ältere und weibliche Teilnehmenden gaben eine höhere Schutzmotivation an, während Teilnehmende mit kleinen Kindern (< 7 Jahre), Teilnehmende, die ein Insektenspray verwenden würden, um Schaben loszuwerden, und Teilnehmende, die der Meinung sind, dass im Supermarkt erhältliche Biozidprodukte der Gesundheit oder der Umwelt nicht schaden, eine geringere Schutzmotivation berichteten. Diese Ergebnisse sollten jedoch nicht überbewertet werden, da einige soziodemografische Variablen zusammenhängen (z.B. sind Teilnehmende mit kleinen Kindern im Durchschnitt jünger als Teilnehmende ohne kleine Kinder) und die Effektgrößen gering waren. Die Schutzmotivation hing am stärksten mit der Bewältigungseinschätzung zusammen. Teilnehmende, die zuversichtlich waren, dass sie die Anweisung in die Praxis umsetzen können, und positive Ergebnisse erwarteten, zeigten eine höhere Schutzmotivation. Wurden die Anweisungen positiv bewertet (d.h. klar und konkret, unkompliziert, prägnant), war die selbstberichtete Schutzmotivation höher. Beide Ergebnisse unterstreichen die Bedeutung verständlicher Anweisungen, die einfach umzusetzen sind und keine besonderen Fähigkeiten oder zusätzliche Ausrüstung erfordern. Der wahrgenommene Schweregrad negativer Folgen bei der einmalig unsachgemäßen Verwendung des Biozidproduktes hing mit der Schutzmotivation zusammen, nicht aber die wahrgenommene Wahrscheinlichkeit negativer Folgen. Die Teilnehmenden konzentrierten sich mehr auf die Risiken für die Gesundheit von Mensch und Tier als auf Risiken für die Umwelt. Es könnte daher ratsam sein, das Verständnis und Bewusstsein der Verbraucher*innen für das Vorhandensein potenzieller Umweltschäden zu stärken, die durch den nicht sachgemäßen Umgang mit Biozidprodukten verursacht werden können. Die Ergebnisse unterstreichen auch die Bedeutung der wahrgenommenen persönlichen Verantwortung (d.h. der Kontrollüberzeugung): Teilnehmende, die eine hohe persönliche Verantwortung für den Schutz der Gesundheit von Mensch und Tier sowie der Umwelt wahrnahmen, gaben eine höhere Schutzmotivation an. Neben der Sensibilisierung der Verbraucher*innen für potentiell entstehende (Umwelt-)Schäden sollte also auch die persönliche Verantwortung gestärkt werden. Ein weiteres Problem zeigte sich in Bezug auf die neutrale Kontrollüberzeugung, welche negativ mit der Schutzmotivation verbunden war. Das heißt, wenn die Verbraucher*innen zugelassenen Biozidprodukte als sicher wahrnehmen, weisen sie eine geringere Schutzmotivation auf. Dies lässt sich durch das fehlende Bewusstsein für die Besonderheiten des Zulassungsverfahrens erklären, da zugelassene Produkte nicht automatisch sicher sind, sondern Gebrauchsanweisungen befolgt werden müssen für eine sichere Nutzung von Biozidprodukten.

Schlussfolgerung und Empfehlungen für die Anweisungen

Diese Studie unterstreicht, wie wichtig es ist, technische oder mehrdeutige Begriffe (z. B. «punktuelle Anwendung», «regelmäßig») in den Gebrauchsanweisungen zu identifizieren und sie zu entfernen oder für die Verbraucher*innen zu erklären. Es wird empfohlen, Beispiele bei mehrdeutigen Begriffen, Orten oder Quantifizierungen hinzuzufügen, auch wenn dies die Länge

der Anweisung erhöht. Subtile Änderungen an den Formulierungen der Anweisungen scheinen jedoch die Verständlichkeit nicht wesentlich zu beeinflussen. Es sollte auch bedacht werden, dass Anweisungen, die externe Faktoren (z. B. Wind, Regen, Ziel- und Nicht-Zieltiere) einbeziehen, die nicht unter der Kontrolle der Verbraucher*innen stehen, als schwieriger empfunden werden.

1 Background and project aim

1.1 Background

Biocides are active substances and products that are used against various harmful organisms, such as insects, rodents, algae, fungi, and bacteria. They are applied with the intention to kill, destroy, harm, or deter organisms, and can pose a fundamental risk to human and animal health and the environment. Thus, they are regulated by the Biocidal Products Regulation (EU) No 528/2012 concerning the making available on the market and use of biocidal products (BPR).

The BPR establishes an EU-wide harmonised authorisation procedure for biocidal products, including standardised principles to assess the potential risks that may arise due to their use. In case the risk assessment has identified potential risks, the BPR foresees the possibility to allocate risk mitigation measures to minimise the risks to an acceptable level. Relevant risk mitigation measures may be the restriction of application (location and/or frequency) or the user category (general public versus professional users), often accompanied by use instructions providing information on how to correctly use the product. As the authorisation of biocidal products can be granted only if there is no unacceptable risk identified, risk mitigation measures are a legal binding part of the authorisation. Hence, risk mitigation measures provide necessary information on how to apply biocidal products in a safe way. In contrast, the labelling according to the criteria of the CLP regulation ((EC) No 1272/2008 on the classification, labelling, and packaging of substances and mixtures) provides hazard-based information on the safe storage and disposal as well as how to prevent or deal with accidental releases.

Risk mitigation measures, use instructions, and the labelling of biocidal products with CLP-hazard and safety statements are central parts of risk reduction in consumer households. As a correct and safe use of authorised products is assumed only when use instructions are followed, it is of utmost importance that they are easily understandable and can be implemented by users. However, prior research has shown that consumers might not be aware that a particular product is biocidal and thus, might lack the necessary risk awareness (Wieck, Olsson, & Kümmerer, 2018a, 2018b). Not being aware of the authorisation procedures, consumers might also falsely assume that authorised products are inherently safe, irrespective of the warnings or use instructions (Bearth, Buchmuller, et al., 2020). Furthermore, prior research has uncovered several individual barriers to safe use of household chemicals, such as a lack of perceived risk or evasion of responsibility to protect health and the environment (Bearth, Buchmuller, et al., 2020; Bearth et al., 2017; Buchmuller et al., 2020).

During EU-wide authorisation processes of biocidal products, comprehensibility, and wording of use instructions for the non-professional user are often a cause for dissent between member states. Among other reasons, the dissent occurs due to a lack of empirical evidence on consumers' risk awareness, perceptions of risk mitigation measures, and use instructions. This project aimed at providing first insights into these issues within an online survey in Germany. The focus was on risk mitigation measures and use instructions (subsequently called "instructions") that provide information to the user on how to apply biocidal products in a safe way, but not on the hazard information according to the CLP Regulation.

1.2 Project aim

Three areas of interest and matching goals and research questions were defined in this study:

Area of interest: Familiarity with biocidal products and their potential risks

- Goal 1: Uncover potentially relevant misconceptions and knowledge gaps about biocidal products among consumers.
- Research question 1: How familiar are consumers with biocidal products and their potential risks?

Area of interest: Evaluation of specific instructions and their variations

- Goal 2: Provide a scientific and empirical basis for optimal phrasing of instructions.
- Research question 2: How comprehensible are specific instructions on biocidal products variations and how easy and realistic is the implementation by consumers in their household? Do variations improve these instructions?

Area of interest: Drivers of protection motivation

- Goal 3: Derive generalisable insights into which measures could be taken to increase protection motivation among the public.
- Research question 3: What drives and what complicates the adherence to instructions on biocidal products (e.g., practicability, product design, individual factors)?

This report presents the method and result of the online survey and supplements these novel insights with the available scientific literature. This report summarises key insights for regulation, and risk communication, and it provides specific recommendations for risk mitigation measures and instructions allocated to minimise potential environmental risks.

2 Theoretical background

2.1 Chemical risks: challenges for policy and regulation

The term Intuitive Toxicology was coined in an article on the public perception of toxicological principles (e.g., dose-effect relationships, risk analysis) (Kraus, Malmfors, & Slovic, 1992). The term expresses the fact that laypeople are guided by different factors than experts when assessing the risk of chemical substances and products. While experts (e.g., toxicologists, risk assessors) rely on risk assessments and exposure modelling, laypeople are guided by other aspects, such as the packaging or previous experiences (Bearth, Buchmuller, et al., 2020; Bearth & Siegrist, 2019; Jansen, Claassen, van Kamp, & Timmermans, 2020; Siegrist & Bearth, 2019). These intuitive strategies of risk judgment can lead to situations that pose a risk to humans, animals and/or the environment, especially in private households (Beirens, van Beeck, Dekker, Brug, & Raat, 2006). To overcome knowledge gaps, chemical risks are explicitly communicated to consumers, either on product packages or via other means of communication (e.g., information material on websites, flyers, or recommendations by sales personnel). The aim of this risk communication is the prevention of environmental or health risks. In cases where it is unlikely that consumers will adhere to instructions, the more prudent regulatory approach could be to restrict the use of this biocidal product to professional users or not authorise the product at all. This regulatory decision, however, poses a considerable challenge, as it requires insights regarding consumers' perception and behaviour elicited by these risk communication measures. Table 1 presents a definition of the instruction-specific terminology used within this report. Protection motivation is the core variable of interest and denotes the likelihood that consumers will implement a specific instruction on a biocidal product. It is assumed that protection motivation is influenced by the four perception variables shown in Table 1. It is assumed that high comprehensibility, high practicability, low difficulty, and high risk perception of a specific instruction lead to higher protection motivation.

Table 1: Definition of the instruction-specific terminology for the components of consumers' perceptions and behaviour.

Term	Definition
Behaviour	
Protection motivation elicited by a specific instruction	How likely will the task in the instruction be fulfilled by consumers (motivation to implement safety measure)
Perception	
Comprehensibility of a specific instruction	How well the instruction is understood by consumers (e.g., regarding used terminology and sentence structure)
Practicability of a specific instruction	What is expected of consumers to fulfil the task in the instruction (e.g., regarding previous knowledge, abilities, or equipment)
Difficulty of adhering to a specific instruction	How easy or difficult is the task in the instruction (e.g., as perceived by consumers)
Risk perception elicited by a specific instruction	Perception elicited by the instruction that the product could harm human health, animal health or the environment

Warnings, instructions, and product design of chemical household products (including biocidal products, cleaning agents and detergents) are of central importance for consumers' perceptions and behaviour (e.g., Basso, Bouille, Le Goff, Robert-Demontrond, & Oullier, 2016; Bearth et al.,

2017; Schwebel et al., 2017; Wogalter, Conzola, & Smith-Jackson, 2002). Subsequently, the relevant literature on this is summarised.

2.2 Consumer exposure and attention to objective risk messages

To consider consumers' interactions with risk communication, instructions, or warnings, it has proven helpful to think of the various stages that might lead to protection motivation (Wogalter et al., 2002; Wogalter et al., 1987). A warning will not automatically lead to protection motivation, but rather require exposure (i.e., potential that the targeted consumers are in the physical presence of the warning), attention (i.e., consumers direct their attention to the warning), salience and understanding (i.e., consumers realise the personal relevance of the warning and understand it), and motivation (i.e., consumers are motivated to protect themselves). Subsequently, the warning literature on these steps is summarised.

Generally, it can be stated that consumers know that there are instructions and warning labels on household chemicals, but sometimes consumers are unaware of behavioural implications and only pay attention to them in specific situations or for specific products (Boelhouwer, Davis, Franco-Watkins, Dorris, & Lungu, 2013; Buchmuller et al., 2020; Buchmuller, Xu, Bearth, & Siegrist, 2022; Nieuwenhuijsen, Grey, Golding, & Grp, 2005). An example for such a specific situation is, when explicit attention is called to a potential risk of a product (e.g., by a retailer before purchase; Buchmuller et al., 2020; Buchmuller, Xu, et al., 2022) or when a product is linked to a strong initial risk perception, such as a "strong" product (e.g., drain cleaner or descaler; Bearth et al., 2017). Geuens, Byrne, Boeije, Peeters, and Vandecasteele (2021) found that even though consumers were asked to carefully read all information on a warning label for a cleaning product, the average time of reading the instruction was only 30 seconds. Moreover, consumers did not spend more time with complex labels containing more text, and the recall of the information was poor. Generally, the consumers preferred a simple warning label (with less text and more pictures) over a complex warning label (more text, smaller pictures) to avoid informational overload (Geuens et al., 2021). Furthermore, colourful warnings (red, orange, yellow, green, or red) were rated as more understandable and the associated product as more dangerous than warnings in black and white (Braun, Mine, & Clayton Silver, 1995; Chen, Liu, & Huang, 2015). According to Boelhouwer and Davis (2010), the presence of a signal word ("danger" or "warning") impacted consumers' perceptions of the risk of a product. Various studies investigated the understanding of pictograms and their meaning, showing that some pictograms (e.g., GHS pictogram for flammable) were better known or understood than others (e.g., GHS pictogram for health or environmental hazard) (Bearth, Buchmuller, et al., 2020; Boelhouwer et al., 2013; Chen et al., 2015; Dalvie, Rother, & London, 2014; Hinks et al., 2009; Su & Hsu, 2008). Only a few studies focused more explicitly on the interactions of users with warnings and instructions on product labels, with a focus on farmers and plant protection products in Iran and Pakistan (Bagheri, Emami, & Damalas, 2021; Damalas & Khan, 2016; Damalas, Theodorou, & Georgiou, 2006) or with a more general focus on user interactions (Dugger-Webster & LePrevost, 2018). These studies also showed a lack of in-depth interaction with the labels due to technical language or small and unreadable writing on the label. While it can be expected that this is partly transferrable to other products, such as biocides, or the European context, these findings should not be overestimated due to their specificity in context. Specifically for biocidal products, it has been shown that consumers do not know what biocidal products are and which products fall into this category (Wieck et al., 2018a, 2018b). Therefore, consumers might not initiate a search for warnings or specific protection measures, as they might be unaware that they are using a biocidal product that might harm them or their surroundings. In a study with parents of young children (Grey, Nieuwenhuijsen, Golding, &

Team, 2005), most respondents were concerned about the safety of biocidal products. Nevertheless, about one third said they did not heed the safety warnings on the packaging.

Barriers to preventive behaviour when storing, using, or disposing of household chemicals include lack of awareness of personal risk and responsibility, habit, and previous experience (Bearth, Buchmuller, et al., 2020; Bearth & Siegrist, 2019; Nieuwenhuijsen et al., 2005). Product warnings that explicitly point out the consequences of injury are more likely to make product users exercise caution when using them compared to product warnings without this information (Laughery & Wogalter, 2014). According to Edworthy et al. (2004), instructions that use the personal pronoun (i.e., "you should…") and are in the "instructions for use" section of the label are most likely to be followed. A literature review by Dugger-Webster and LePrevost (2018) offers an overview of the factors that impact consumers' willingness to follow the instructions or warning labels. The authors conclude that country-specific regulatory systems, label characteristics (e.g., complexity, language, consistency), demographics (e.g., literacy, experience, beliefs, and culture), and other factors (e.g., place of purchase of the plant protection product, type of plant protection product) are relevant.

Extensive research (Bearth, Buchmuller, et al., 2020; Bearth et al., 2017; Bearth & Siegrist, 2019; Buchmuller et al., 2020; Riley, 2014; Rozin, 2006) shows that consumers sometimes fail to recognise the personal relevance of a warning, as they underestimate the risk of a particular product (e.g., product perceived as natural or "weak"). Thus, an important barrier to protection motivation is the consideration of product attributes that are not or only marginally informative about the actual risk potential of a product. For example, the risks of "ecological" household chemicals (e.g., drain cleaner in a biodegradable packaging) are underestimated compared to conventional household products (Bearth et al., 2017; Bearth & Siegrist, 2019). This can be explained by the fact that consumers, unlike experts, differentiate between products that they perceive as natural and products that they perceive as artificial, rating the former as less dangerous (Bearth, Cousin, & Siegrist, 2014; Bearth, Kwon, & Siegrist, 2020; Bearth, Saleh, & Siegrist, 2019; Saleh, Bearth, & Siegrist, 2019; Siegrist & Bearth, 2019). The shape and colour of the packaging and the presentation of the label can also directly influence the perception of risks (Basso et al., 2016).

2.3 Adhering to the warnings on the product label: The Protection Motivation Theory

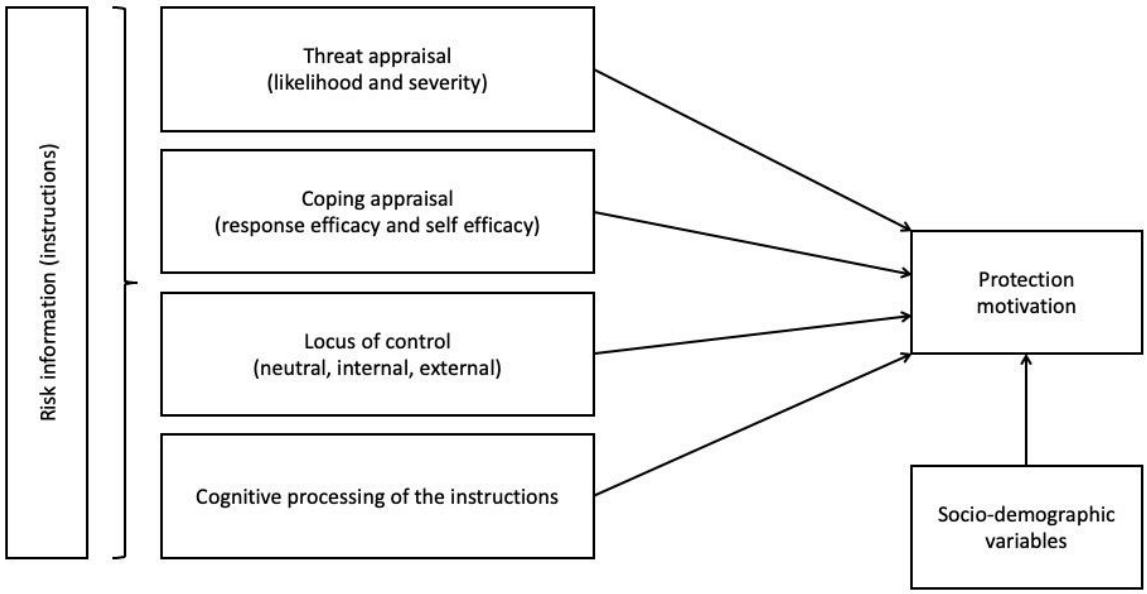
Despite the barriers identified in the prior literature, consumers' attention can be drawn to instructions if they are comprehensible, easy to implement, and practical (Bearth, Buchmuller, et al., 2020; Boelhouwer et al., 2013; Fransson, Brunklaus, & Molander, 2013). For the optimised design of such warnings and instructions, it is therefore important to gather generalisable and theory-driven insights into consumers' perceptions and behaviour regarding biocidal products that do not relate to specific instructions. The Protection Motivation Theory (PMT) (Maddux & Rogers, 1983; Prentice-Dunn & Rogers, 1986; Rogers, 1975), was chosen in this study as a theoretical backdrop for these generalisable insights. The PMT aims at explaining people's protective behaviour by measuring their subjective threat and coping appraisals. It is assumed that people that perceive a health or environmental threat and perceive a need and the ability to respond to this threat, are more willing to protect themselves than people that do not.

Originally, the PMT was developed to investigate the impact of risk communication (e.g., health warnings and deterrent pictures on cigarette packs) on health behaviour (e.g., quit smoking). Over the years, the PMT has been applied to a variety of health behaviours (Milne, Sheeran, & Orbell, 2000). Due to its origin in risk communication literature, it offers a good theoretical

framework for the context of adhering to instructions on biocidal products. Based on prior literature (Bearth, Buchmuller, et al., 2020), the PMT was supplemented with an additional variable, namely locus of control. Locus of control can be defined as an individual's perception of the degree of responsibility of a specific entity in a specific situation. Put simply, it determines to what degree consumers perceive no responsibility (neutral locus of control), perceive someone else responsible (e.g., government, regulatory offices; external locus of control) or themselves responsible to protect health and the environment from biocidal products (internal locus of control) (Bearth, Buchmuller, et al., 2020). Locus of control was added in this study because prior literature suggested it as a relevant predictor for user interactions with chemical household products (Bearth, Bosshart, Wermelinger, Daum, & Siegrist, 2022; Bearth, Buchmuller, et al., 2020; Bearth & Siegrist, 2019).

Figure 1 presents this study's working model and Table 2 provides definitions of the relevant terminology from the extended PMT.

Figure 1: The theoretical framework of the study: Extended PMT.



Source: own illustration, ETH Zurich, based on PMT (Rogers, 1975).

Table 2: Definition of terminology from the extended PMT for the context of instructions on biocidal products (Prentice-Dunn & Rogers, 1986).

Term	Definition
Protection motivation	General likelihood of adhering to the tasks in the instructions on biocidal products
Subjective threat appraisal	
Likelihood	Perceived likelihood of consequences of non-adherence to instructions
Severity	Perceived severity of consequences of non-adherence to instructions
Subjective coping appraisal	
Response efficacy	Expectations regarding the adherence to instructions
Self-efficacy	Expectations regarding the own abilities to adhere to instructions
Subjective locus of control	
neutral	Neutral allocation of responsibility (biocidal products are safe)
internal	Personal allocation of responsibility (I am responsible for safety)
external	Allocation of responsibility to other person or institution (other people are responsible for safety)
Cognitive processing of instructions	Comprehensibility of instructions, effort and time spent with the instruction, evaluation of instruction, immersion
Sociodemographic variables	Gender, age, education, residence, presence of children or a pet, job in chemical industry

3 Overall study design and procedure

3.1 Study design

The data for this study was collected within an online survey. The questionnaire was developed in close collaboration with the German Environment Agency (cf. Appendix A1 for the full questionnaire in German). The questionnaire of this online survey was pretested with a convenience sample to ensure comprehensibility and appropriateness of questions (N = 28). The project was approved by the Swiss Federal Institute of Technology's ethics board prior to data collection. At the start of the questionnaire, the participants were asked to provide the following three pieces of information that were used in the quota design: their gender (male, female, other), age (open question) and state of residency (list of 17 states and "outside of Germany" response option to exclude people that do not live in Germany). Also, several socio-demographic variables were assessed at the end of the questionnaire. The participants highest education level was measured, the participants were asked who else lived in their household and whether they worked in the chemical industry. Further, they were asked whether they lived in the city or countryside, whether they had a cellar or outdoor space (e.g., balcony, terrace, garden) and whether they had any pets. At the very end of the questionnaire, the participants were also asked whether there was anything that they would like to add.

Aside from these quota and socio-demographic variables, the questionnaire comprised the following three sections that correspond to the above-introduced areas of interest:

- **Familiarity with biocidal products and their potential risks**: spontaneous associations with the term "biocidal product," recall and use of specific biocidal products
- **Evaluation of specific instructions and their variations:** Scenario experiment on the comprehensibility, difficulty of adhering to the instructions, practicability, protection motivation, and environmental risk perception of specific instructions (cf. Table 1 for definitions)
- **Drivers of protection motivation:** Section assessing the variables from the extended PMT within a hypothetical purchase scenario (cf. Table 2 for definitions)

3.2 Participants and recruitment

Target participants for this study were people living in Germany. A quota design with gender, age, and state of residency was applied to ensure a heterogeneous sample and representativeness of the collected data for the German resident population. Data collection took place in January 2022. The participants were recruited with the support of a market research company (www.bilendi.de) and provided informed consent prior to participating in the study. The data set was cleaned prior to data analysis by removing speeders (n = 20; taking less than 5 minutes for the questionnaire) and participants exhibiting doubtful response patterns (n = 6).

The final sample comprises data from N = 1062 participants (female: n = 534, 50%; male: n = 525, 49%; other: n = 3, 1%). The mean age of the participants was M = 45 (SD = 16, range: 18 to 85 years of age). The distribution of participants according to state corresponds to the national distribution, with more participants from populous states (e.g., North Rhine-Westphalia, Bavaria, and Baden-Wuerttemberg) than from less populous states (e.g., Bremen, Saarland, Hamburg). Overall, more participants indicated to live in a city (n = 652, 61%), rather than in the countryside (n = 410, 39%). The participants differed according to their educational background, with n = 468 (44%) indicating a low (primary and secondary school diploma,

vocational training) and n = 594 (56%) indicating a higher education (e.g., “Abitur” or academic degree). A minority of n = 74 (7%) indicated to work in an industry that produces, transports, trades, or uses chemical products. The participants were also asked about the circumstances in their homes that might be related to the use of biocidal products. Most participants indicated to have a cellar in their home (n = 875, 82%). Similarly, most participants indicated to have an outside space (n = 974, 92%; i.e., balcony, terrace, garden, lawn, allotment garden). Lastly, n = 457 of the participants owned a pet (43%; e.g., cat, dog, rabbit, bird, guinea pig, hamster).

4 Methods and results

The following section of the report is structured according to the areas of interest and associated research questions. For reader-friendliness, the methods and results are presented together. Section 4.1 presents the methods and results regarding the consumers' familiarity with biocidal products and their potential risks. Section 4.2 first, explains the design of the between-subjects scenario experiment and second, presents the results of how specific instructions and variations of these instructions were rated by the consumers. Section 4.3 presents the materials used to investigate the drivers of protection motivation within the PMT.

4.1 Research question 1: How familiar are consumers with biocidal products and their potential risks?

4.1.1 Method

At the start of the questionnaire, the participants were asked to indicate at least one word, picture, or thought that came to their mind when they hear the term "biocidal product" in three open response fields (i.e., their spontaneous associations).

To investigate participants' familiarity with biocidal products, two approaches were taken. Participants were presented with five open response fields and were asked to provide names of specific biocidal products. Responses to these fields were optional to avoid a large drop-out of participants at this stage of the questionnaire. The responses to the open questions were subsequently coded according to a flexible coding scheme by one researcher. Another researcher checked the codes and resolved uncertainties in coding. Also, the participants were questioned about their use of biocidal products in their own household. For this, they were asked to indicate how frequently they used various types of biocidal products (e.g., disinfectants, products against or to deter insects and other animals, detergents). The response scale comprised the following options: daily or several times per week, several times per month, several times per year, less frequently, never, I do not know this product.

4.1.2 Results

Table 3 presents the coded responses to the three open response fields. Over all encodable terms combined (2269 terms), the most frequent associations were "poison, death, or danger" and "agriculture (food, living beings)." Also, a large portion of participants indicated that they did not know what "biocidal product" means. Moreover, the analysis of the associations exhibited that some participants mistakenly associated the term "biocidal product" with "organic products or quality," "not chemical / natural" or "environmentally friendly." Many participants also mentioned a specific product or product category as their association to the term.

When asked about specific biocidal products, the participants mostly mentioned generic product categories instead of specific products or brands. In the five optional response fields, the participants indicated 829 specific biocidal products. Most frequently, products for combating pests were mentioned (291, 35%), followed by disinfectants (154, 19%), products to protect (82, 10%) and cleaning products (60, 7%). Also, food products (82, 10%) and medicine (31, 4%) were mentioned erroneously as biocidal products. Other product categories that were mentioned less frequently were alcohol and fertiliser.

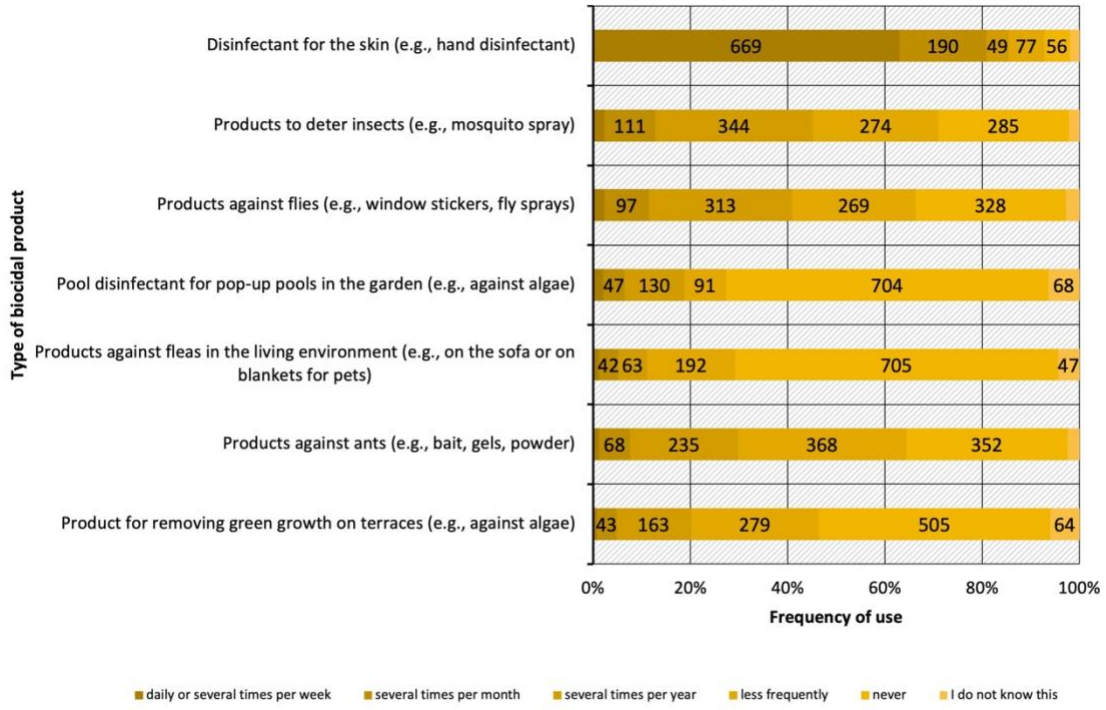
Figure 2 shows the frequency of use for the seven types of biocidal product. The most frequently used biocidal product is the disinfectant for the skin, as most participants use it daily or several

times per week. Products against insects were used several times per month or year by most participants, except for products against fleas, which were never used by most participants. The detergent for removing green growth was used more frequently by the participants than the pool disinfectant.

Table 3: Spontaneous associations regarding the term "biocidal product."

	Total	1st association	2nd association	3rd association
Poison, death, or danger	377 (17%)	183	123	71
Agriculture (food, living beings)	327 (14%)	113	108	106
I do not know	253 (11%)	182	35	36
Organic product or quality	204 (9%)	141	45	18
Specific product	188 (8%)	106	49	33
Medicine or health	162 (7%)	47	52	63
Pest control or treatment	158 (7%)	67	62	29
Harmful to the environment	141 (6%)	31	63	47
Chemical	110 (5%)	57	26	27
Environmentally friendly	71 (3%)	14	26	31
Not chemical / natural	58 (3%)	26	24	8
Research (tested, laboratory)	58 (3%)	13	23	22
Household (cleaning)	41 (2%)	11	16	14
Analysis of "bio" and "zid"	30 (1%)	11	11	8
Other	91 (4%)	24	24	43
Total	2269 (100%)	1026	687	556

Figure 2: Use of biocidal products in the own household (*N* = 1062)



Source: own illustration, ETH Zurich

4.2 Research question 2: How comprehensible are specific instructions on biocidal products and how easy and realistic is their implementation? Do variations improve comprehensibility?

4.2.1 Method

4.2.1.1 Between-subjects scenario experiment

In the questionnaire, a between-subjects scenario experiment was included to rate and compare a specific, basic instruction on a biocidal product with an experimental variation of this basic instruction. Participants were presented with 12 scenarios that included a problem in the household (e.g., an ant trail in the kitchen) and a fictitious biocidal product as a solution for this problem (e.g., product against ants). With each biocidal product, a one-sentence instruction was presented within a visualisation (cf. Figure 3). To test the effect of the variation, the participants were randomly split into two separate groups and were presented with different instructions in each of the 12 scenarios. One group of participants (n = 529) received the basic instruction, while the other group of participants (n = 533) received the variation. The following four variations were investigated within the 12 scenarios:

a) Variation 1 “environmental risk”: one group of participants (n = 529) received a basic instruction, while the other group of participants (n = 533) received the same basic instruction with an environmental risk warning (instructions 1.1 to 1.3).

b) Variation 2 “positively charged animal”: one group of participants (n = 529) received a basic instruction with a generic environmental warning (risk for the environment), while the other group of participants (n = 533) received a variation of this environmental warning (risk for a positively charged animal, such as pets or bees) (instructions 2.1 to 2.3).

c) Variation 3 “sentence phrasing”: the basic instruction (n = 529) was passively phrased, while in the variation the instruction was actively phrased (n = 533) (instructions 3.1 to 3.3).

d) Variation “conciseness and examples”: the basic instruction was presented in a concise way (n = 529), while the variation included examples, clarifying the instructions (n = 533) (instructions 4.1 to 4.3).

Altogether, within the 12 scenarios, 12 basic instructions and 12 variations (total of 24 instructions), were investigated. Table 4 presents the 12 basic instructions and their corresponding variations in English. The numbering of the instructions introduced above (1.1 to 4.3) will be used subsequently to denote instructions to improve reader friendliness.

The participants were asked to rate the comprehensibility of each of the instructions, the perceived difficulty of adhering to the instruction, their elicited protection motivation and environmental risk perception (dependent variables). Perceived comprehensibility of instruction was measured by asking the following question: “How comprehensible do you find the instruction on the product?” and providing five response options (1: very incomprehensible, 2: rather incomprehensible, 3: neither, 4: rather comprehensible, 5: very comprehensible). Perceived difficulty of adhering to the instruction was measured with this question: “How difficult is it to follow the instructions on the product?” and five response options (1: very difficult, 2: rather difficult, 3: neither, 4: rather simple, 5: very simple). Protection motivation was measured with this question: “How likely would you follow the instructions on the product exactly?” and five response options (1: definitely not, 2: rather not, 3: maybe, 4: probably, 5: definitely). Lastly, environmental risk perception was measured with the question: “Based on the instruction, how high do you consider the risk to the environment due to improper use of this product?” with five response options (1: no risk at all, 2: low risk, 3: medium risk, 4: high risk, 5: very high risk). The 12 scenarios were shown in a randomised order to control for ordering effects.

Figure 3: Example of the visualisation of biocidal products and instruction.

Source: own illustration, ETH Zurich.

Table 4: Overview of all scenarios, basic instructions, and variations in English (note: .

	Scenario	Basic instruction	Variation
Variation 1 "environmental risk"			
1.1	You discover an ant trail in your living area and suspect that you have an ant nest in your kitchen. You buy the pictured product against ants.	Not more than one treatment per nest should be performed in a season.	Not more than one treatment per nest should be performed in a season to avoid negative effects on the environment.
1.2	You are bothered by cockroaches on your balcony or terrace. You buy the pictured product against cockroaches.	Apply only in areas that are not liable to flooding or becoming wet, i.e., protected from rain, floods and cleaning water.	Apply only in areas that are not liable to flooding or becoming wet, i.e., protected from rain, floods and cleaning water, to avoid harm to the environment.
1.3	You have a flea infestation in your living area. You buy the product shown to control fleas on your sofa or on blankets.	Do not wash treated blankets or textiles.	Do not wash treated blankets or textiles to avoid environmental harm by discharges into the sewage system.
Variation 2 "positively charged animal"			
2.1	You are bothered by the many flies on your balcony or terrace. You buy the pictured product to fight the flies.	Only for spot application outdoor to avoid harm to the environment.	Only for spot application outdoor to avoid harm to pets (e.g., dogs and cats).
2.2	You are bothered by the many ants on your balcony or terrace and buy the product shown.	To protect the environment, cover the product (e.g., with a flowerpot or tile).	To protect bees and other pollinators, cover the product (e.g., with a flowerpot or tile).
2.3	You discover cockroaches on your terrace. You buy the pictured product to fight the cockroaches.	To protect the environment, apply only outdoors in locations protected from rain.	To protect organisms living in the soil (e.g., worms), apply only outdoors in locations protected from rain.
Variation 3 "sentence phrasing"			
3.1	You are bothered by the many cockroaches in your living area. You buy the pictured product to fight the cockroaches.	Only for crack and crevice treatment indoors.	Only use this product for crack and crevice treatment indoors.
3.2	You bought the pictured disinfectant for disinfecting surfaces.	Product residues must not be discharged into the sewage system or the environment.	Do not allow product residues to enter the sewage system or the environment.

	Scenario	Basic instruction	Variation
3.3	You buy the product shown because you want to control the many flies in your living area. Note: A fly bait is a motif sticker that is stuck to the window to control flies.	Avoid cleaning of the stickers. If this occurs, immediately dispose cleaning cloth to domestic waste.	Do not clean the sticker. If this still occurs, immediately dispose cleaning cloth to domestic waste.
Variation 4 „conciseness and examples“			
4.1	You discover a wasp nest near your bedroom window. You buy the product shown to combat the wasp nest.	Avoid transfer to other areas by wind drift.	Avoid transfer to other areas, e.g., by not using the product when its windy.
4.2	You discover cockroaches in your bathroom. You buy the product shown in the picture.	Only use the bait boxes in hidden, hard-to-reach areas.	Only use the bait boxes in hidden, hard-to-reach areas, such as under the sink, behind the toilet, near drains, etc.
4.3	You bought the product shown because you have discovered an ant trail on your terrace and want to control the ants.	Do not use on unpaved ground.	Do not use on unpaved ground, that means only on paved paths around the house, balconies and terraces.

4.2.1.2 Additional insights into the comprehension and practicability of specific instructions

To add insights on participants' self-reported comprehension, three specific instructions were investigated further at the end of the questionnaire: "do not wet clean regularly," "only for spot application" and "avoid introduction to the municipal sewage treatment plant." This section was introduced with the explicit disclaimer that we were interested in the participants' understanding of these instructions and that they should report as honestly as possible whether they thought the instruction was comprehensible or not. If the participants indicated to know what it means, they were subsequently asked to provide a definition in their own words in an open response field. This was coded into "correct," "incorrect" and "does not know" (empty response fields and incomprehensible responses were coded as missing values and not considered for the analyses).

To add insights on self-reported practicability, meaning the role of additional equipment for people's protection motivation, the following set of instructions: "to ensure correct dosage, use a normal teaspoon. Do not rinse used teaspoon with water. Reuse or dispose of in a safe manner" were investigated further. The participants were asked to read this instruction and to decide what they would do in this situation. For this, a combination of close- and open-ended questions at the end of the questionnaire was chosen. First, participants had to indicated whether they would use a teaspoon, a plastic teaspoon or dose by eye measure (without a teaspoon). Additionally, they could provide alternatives to these options in an open response field. The participants that chose the first option, using a teaspoon, were then asked what they would do with it after using the biocidal product. The response options to this question were as follows: throw it in the bin, clean it by hand or in the dishwasher with water, clean it without water or

label the teaspoon and use it for similar tasks. Additionally, the participants could provide alternatives to these options in an open response field.

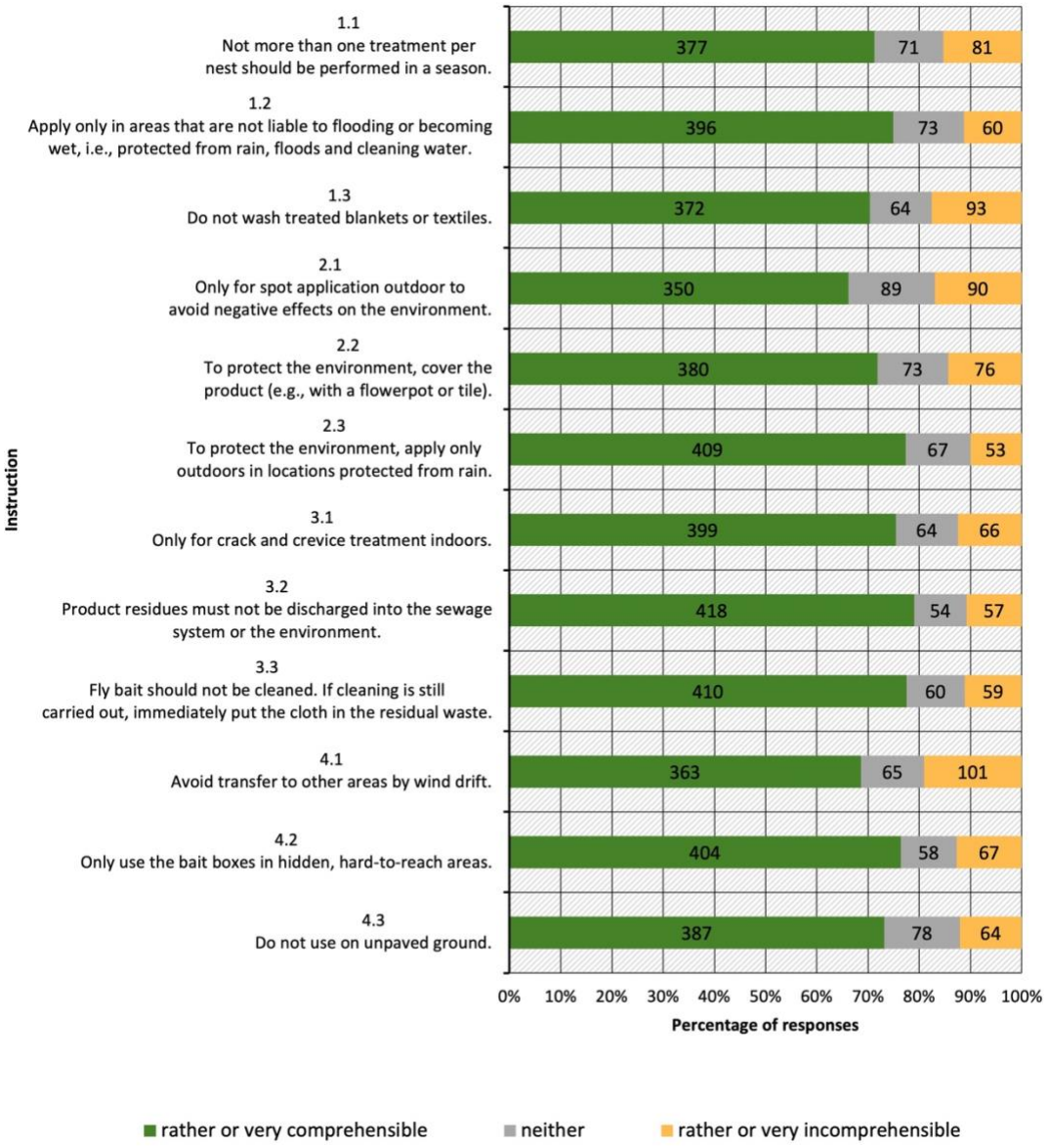
4.2.2 Results

This section reports on the participants' judgments of the specific instructions. First, the responses to the 12 basic instructions are presented descriptively. Second, the effects of the experimental variations are presented. This was analysed separately for each variable of interest, i.e., comprehensibility, difficulty of adhering, protection motivation, and environmental risk perception. For statistical reasons and for ease of interpretation, the response options were recoded (e.g., "rather comprehensible" and "very comprehensible" were combined into one response option "rather or very comprehensible").

4.2.2.1 Comprehensibility of the specific instructions

Figure 4 presents the comprehensibility of the 12 basic instructions. The majority of participants (for all instructions > 60%) indicated that the basic instructions were rather or very comprehensible. The number of participants that perceived the basic instructions as rather or very incomprehensible varied between 10 and 20%. Around 10% of participants responded that the instructions were neither comprehensible nor incomprehensible. The least comprehensible basic instruction comprised very specific phrases, such as "spot application" or "wind drift" that might have contributed to the comparably lower comprehensibility.

Figure 4: Comprehensibility of the basic instructions (*n* = 529)

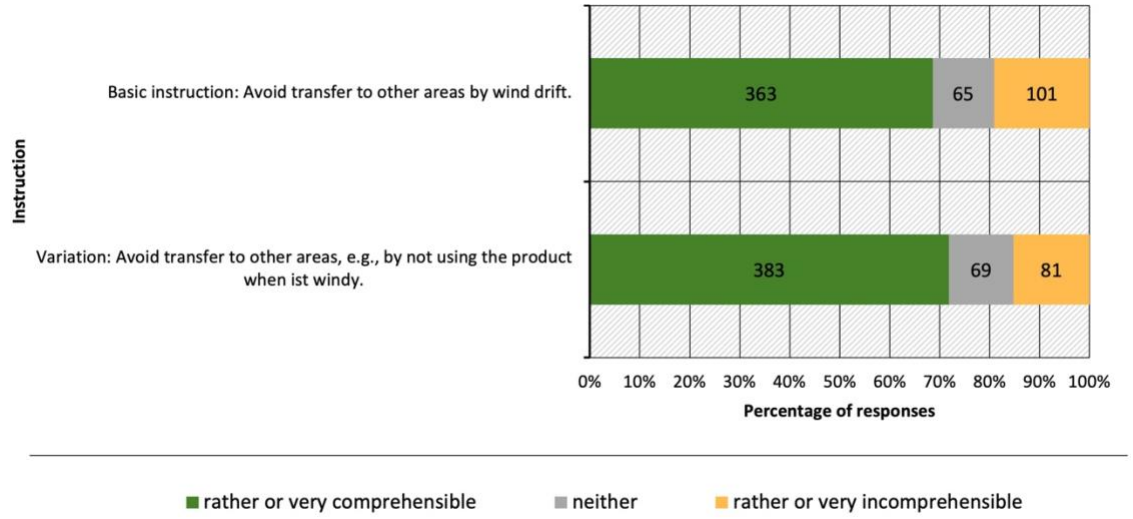


Source: own illustration, ETH Zurich

Subsequently and in Figure 5, the results are presented on whether the variations improved comprehensibility compared to the basic instructions.

- For instruction 4.1 ("avoid transfer to other areas by wind drift"), the comprehensibility was significantly improved by providing examples (Mann-Whitney U = 131351, n1 = 529, n2 = 533, p = .043). In the variation of the instruction with added examples significantly more participants (72%) indicated that the instruction was rather or very comprehensible compared to the instruction with the ambiguous term "wind drift" (69%; cf. Figure 5).
- The comprehensibility of the other instructions was not affected by any of the four variations (Mann-Whitney U > 132963, n1 = 529, n2 = 533, p > .089).

Figure 5: Comprehensibility of the basic instruction (*n* = 529) and its variation (*n* = 533) (only significant differences in comprehensibility are presented).

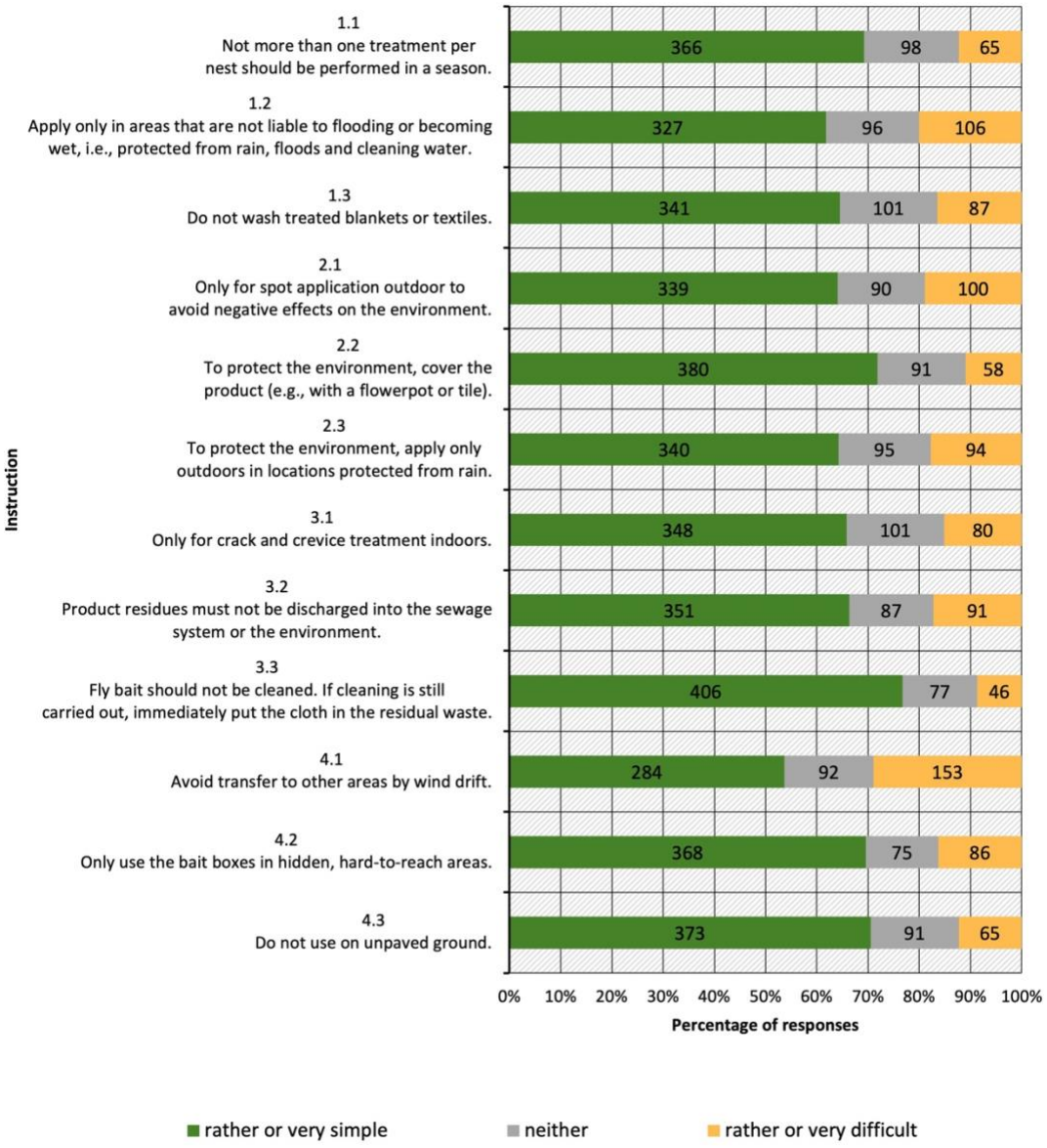


Source: own illustration, ETH Zurich

4.2.2.2 Difficulty of adhering to the specific instructions

Figure 6 presents the difficulty of adhering to the 12 basic instructions. Generally, perceived difficulty varied somewhat, with lower perceived difficulty for instructions that are in the users' control (e.g., place of use, avoidance of a particular behaviour). The most difficult instructions were set outdoors or involved external factors, such as wind or rain.

Figure 6: Difficulty of adhering to the basic instructions (*N* = 529)



Source: own illustration, ETH Zurich

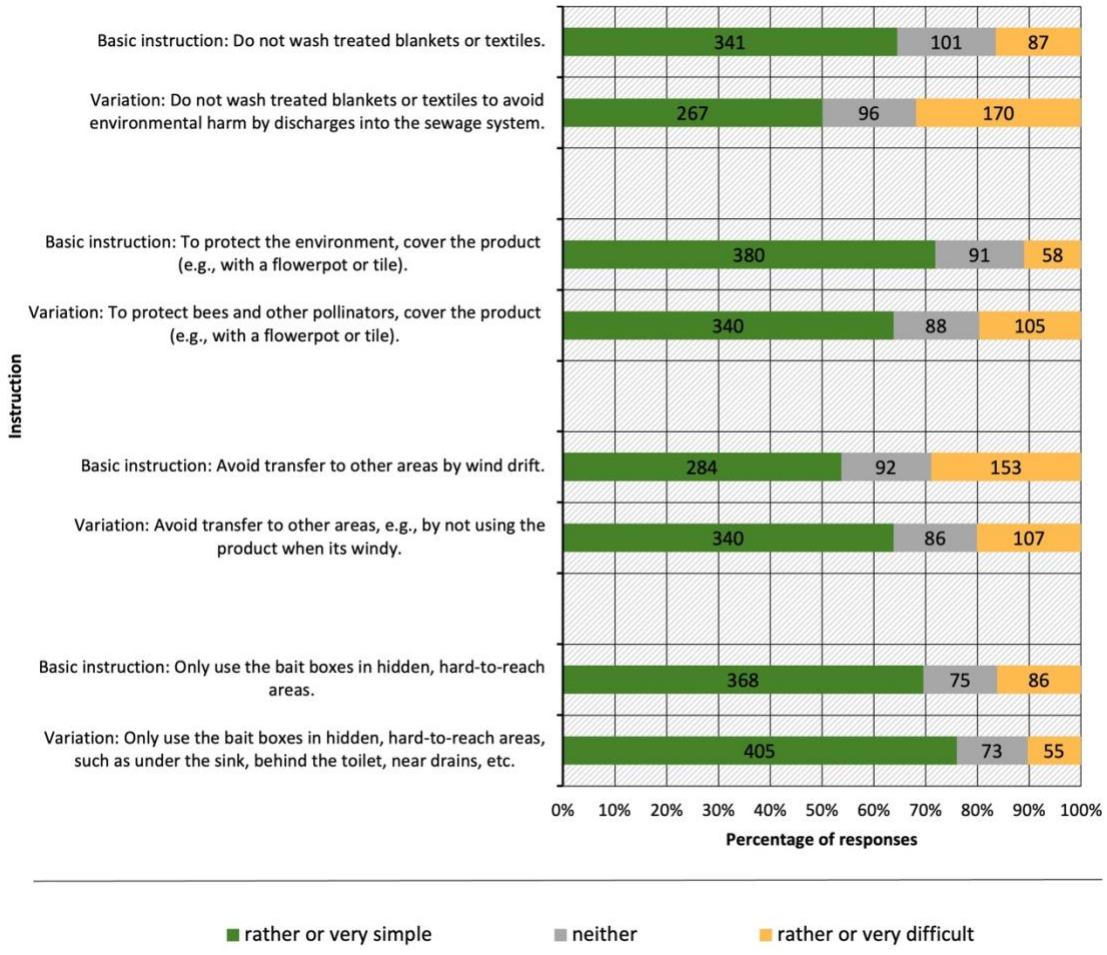
The results on whether the variations reduced perceived difficulty compared to the basic instructions are presented below and in Figure 7.

- Including environmental risk warnings in the instructions increased the perceived difficulty of adhering to the instruction 1.3 ("Do not wash treated blankets or textiles;" Mann-Whitney U = 114888, n1 = 529, n2 = 533, p < .001). This means that, in the condition with the environmental risk warning, more participants indicated that not washing their blankets or textiles would be rather or very difficult (32%) than in the condition without the environmental risk warning (16%, cf. Figure 7).
- Similarly, mentioning "pollinators" in instruction 2.2 ("To protect the environment, cover the product (e.g., with a flowerpot or tile)") compared to "the environment" also increased perceived difficulty of covering a product with a flowerpot or tile (Mann-Whitney U = 127261, n1 = 529, n2 = 533, p = .004). In the positively charged animal condition, 20%

indicated a rather or very high perceived difficulty compared to 11% in the generic environment condition (cf. Figure 7).

- The experimental results also show that providing examples – while sacrificing conciseness – reduced perceived difficulty for instruction 4.1 ("Avoid transfer to other areas by wind drift;" Mann-Whitney U = 123885, n1 = 529, n2 = 533, p < .001) and instruction 4.2 ("Only use the bait boxes in hidden, hard-to-reach areas;" Mann-Whitney U = 127372, n1 = 529, n2 = 533, p = .004; cf. Figure 7).
- The other variations did not have a significant impact on perceived difficulty of adhering to the instructions (Mann-Whitney U > 133622, n1 = 529, n2 = 533, p > .127).

Figure 7: Difficulty of adhering to the basic instructions (*n* = 529) and their variations (*n* = 533) (only significant differences in difficulty are presented).

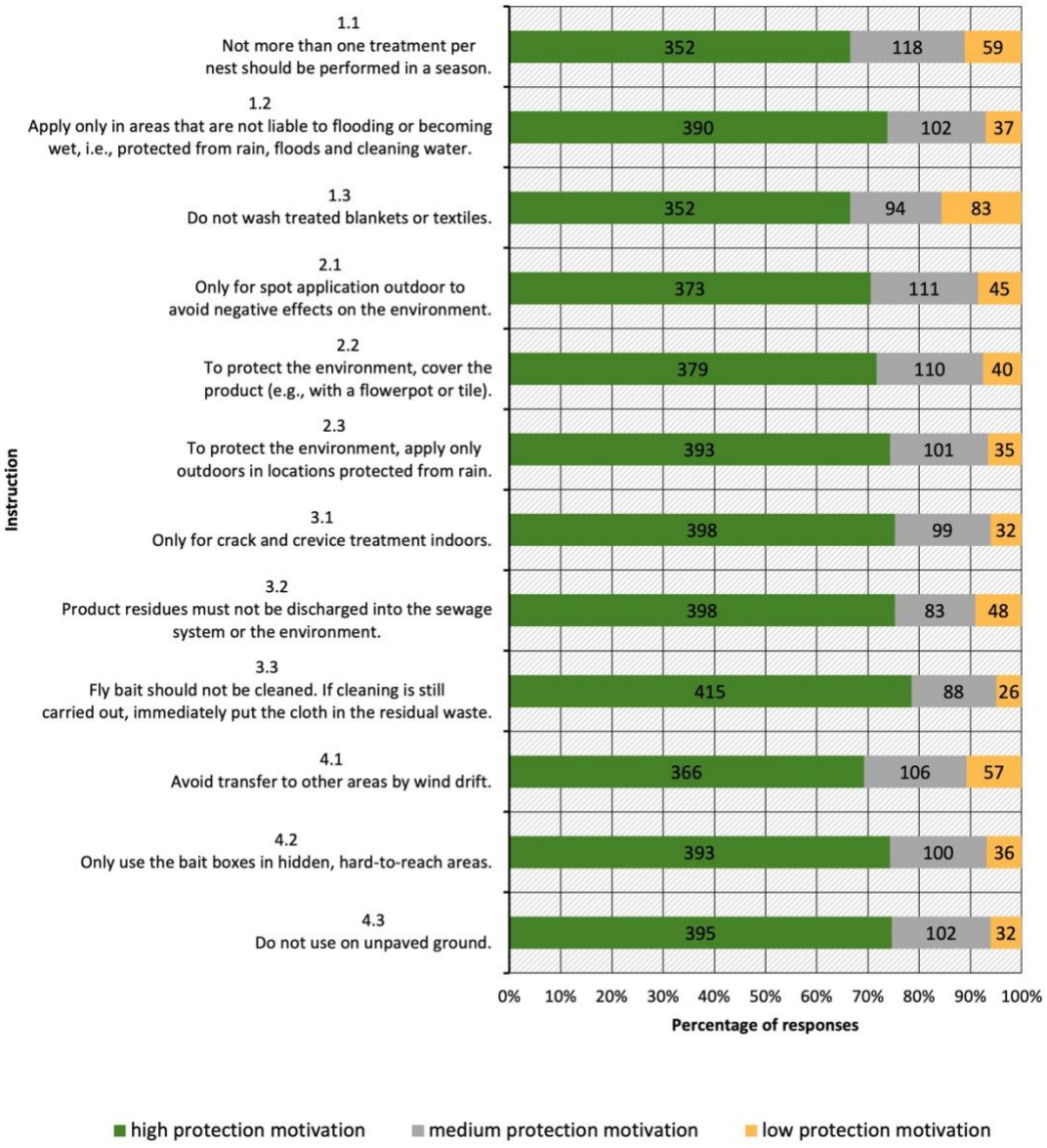


Source: own illustration, ETH Zurich

4.2.2.3 Protection motivation elicited by the specific instructions

Figure 8 presents the protection motivation associated with the 12 basic instructions. More than 70% of participants indicated to definitely or probably adhere to the indicated basic instructions for 9 out of the 12 basic instructions. However, instructions asking to not wash treated blankets, to reduce the number of treatments, and to avoid transfer to other areas by wind drift were associated with slightly lower protection motivation (< 70% of participants indicated a high protection motivation), likely associated with hygiene considerations, the expected effectiveness of the treatment, and the external factor wind.

Figure 8: Protection motivation elicited by the basic instructions (*N* = 529)



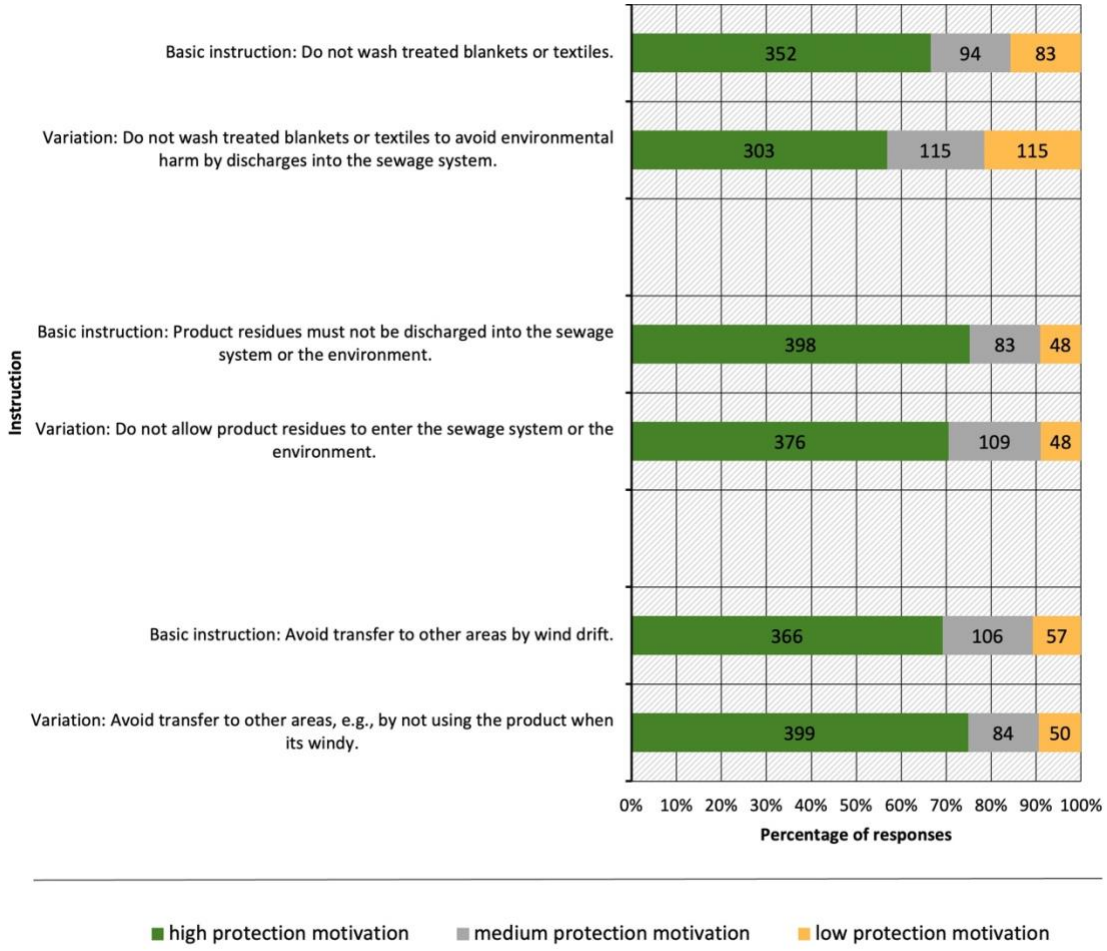
Source: own illustration, ETH Zurich

The results on whether the variations increased protection motivation compared to the basic instructions are presented below and in Figure 9.

- Mentioning an environmental risk had a negative impact on protection motivation for instruction 1.3 ("Do not wash treated blankets or textiles;" Mann-Whitney U = 126512, n1 = 529, n2 = 533, p = .003). More participants reported a low protection motivation in the instruction with the environmental risk (22%) compared to the instruction without (16%, cf. Figure 9).
- In instruction 3.2 ("Product residues must not be discharged into the sewage system or the environment"), the variation impacted the self-reported protection motivation negatively (Mann-Whitney U = 131224, n1 = 529, n2 = 533, p = .038). The passive phrasing elicited high protection motivation in slightly more participants (75%) than the active phrasing (70%, cf. Figure 9).

- For instruction 4.1 ("Avoid transfer to other areas by wind drift"), protection motivation was positively impacted by the variation (Mann-Whitney U = 128523, n1 = 529, n2 = 533, p = .008). In the variation with examples more participants indicated high protection motivation (75%), compared to the basic instruction (69%, cf. Figure 9).
- No other variations had a significant impact on protection motivation (Mann-Whitney U > 140308, n1 = 529, n2 = 533, p > .068).

Figure 9: Protection motivation elicited by the basic instructions (*n* = 529) and their variations (*n* = 533) (only significant differences in protection motivation are presented).

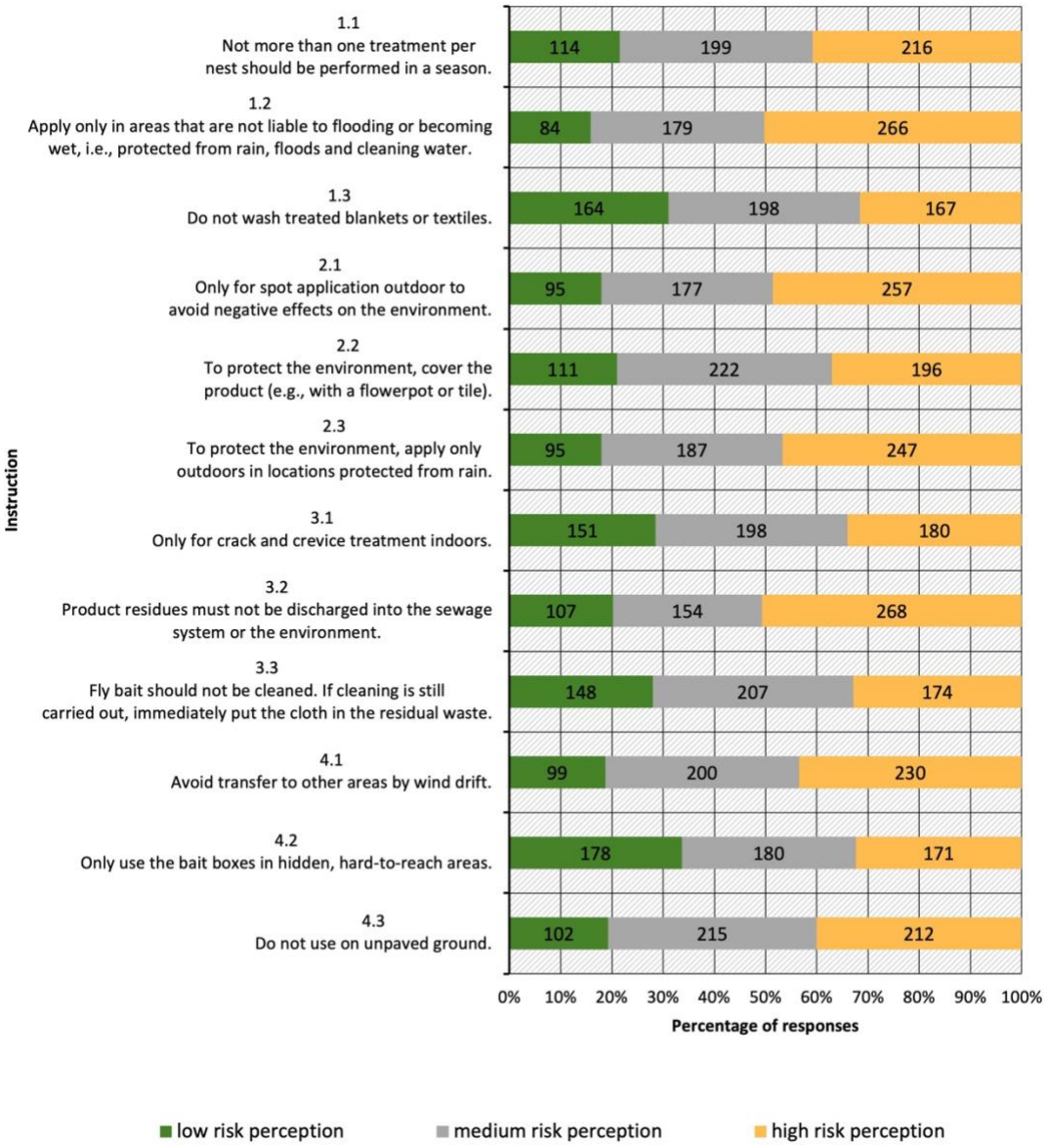


Source: own illustration, ETH Zurich

4.2.2.4 Environmental risk perception elicited by the specific instructions

Figure 10 presents the environmental risk perception elicited by the 12 basic instructions. The environmental risk perception varied substantially. Environmental risk perception was lower for basic instructions involving the indoors, while it was higher for outdoor instructions, involving wind, rain, or the sewer system.

Figure 10: Environmental risk perception elicited by the basic instructions (*N* = 529)

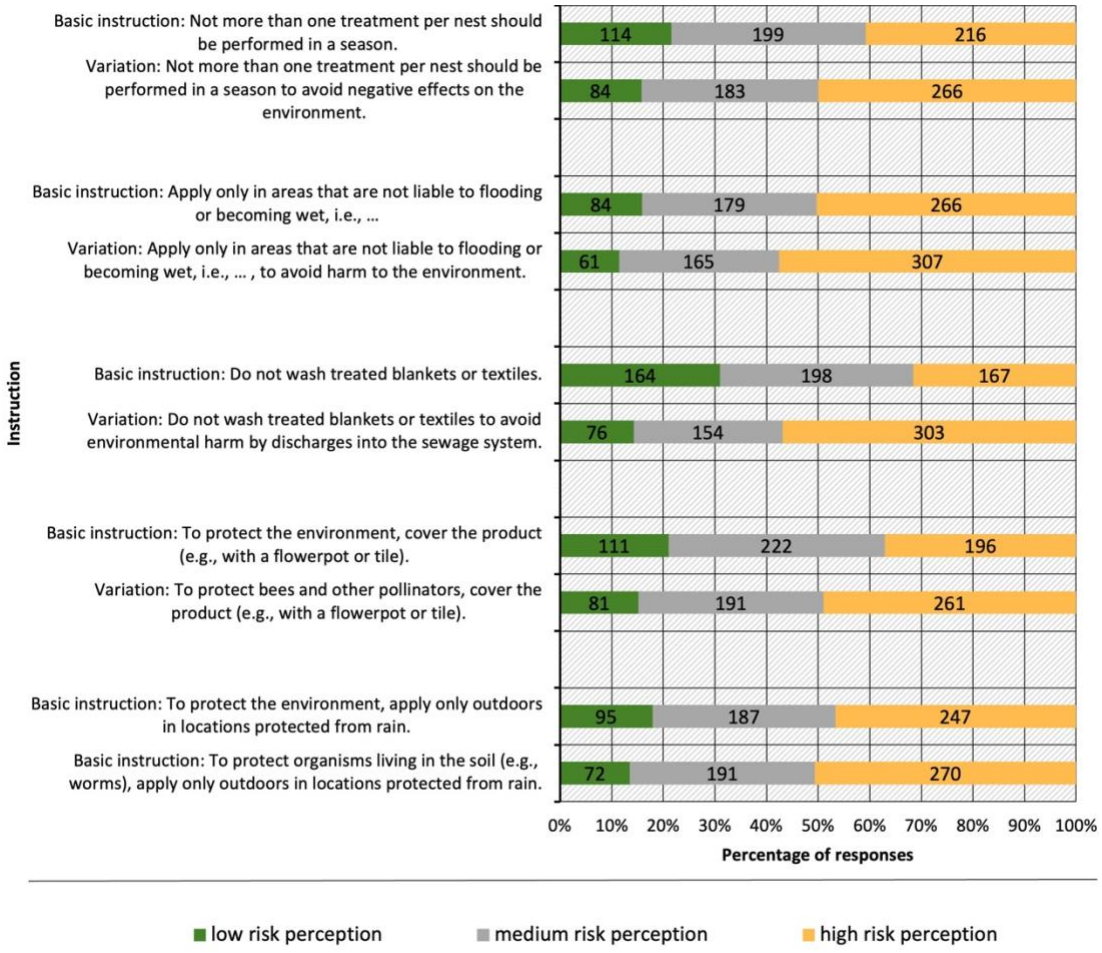


Source: own illustration, ETH Zurich

Following and in Figure 11, the results regarding the variations in the instructions are presented.

- As expected, mentioning an environmental risk and a risk to positively charged animals increased environmental risk perception for almost all relevant instructions, namely instruction 1.1 (Mann-Whitney U = 123955, n1 = 529, n2 = 533, p < .001), instruction 1.2 (Mann-Whitney U = 123942, n1 = 529, n2 = 533, p < .001), instruction 1.3 (Mann-Whitney U = 95551, n1 = 529, n2 = 533, p < .001), instruction 2.2 (Mann-Whitney U = 119762, n1 = 529, n2 = 533, p < .001), and instruction 2.3 (Mann-Whitney U = 130736, n1 = 529, n2 = 533, p = .033).
- The other variations did not influence environmental risk perception (Mann-Whitney U > 135079, n1 = 529, n2 = 533, p > .216).

Figure 11: Environmental risk perception elicited by the basic instructions (*n* = 529) and their variations (*n* = 533) (only significant differences in environmental risk perception are presented).



Source: own illustration, ETH Zurich

4.2.2.5 Additional insights: Self-reported comprehensibility of specific instructions

Instruction "do not wet clean regularly": In total, n = 795 participants (75%) indicated to know what "do not wet clean regularly" means. Analysing their (795 = 100%) subsequent responses in the open response field, showed that n = 355 provided a correct response. Despite initially indicating to know the meaning, roughly half of the participants provided an incorrect definition of the instruction (n = 374, 51%). A total of n = 9 (1%) participants indicated to not know the answer after all. The remaining participants did not provide a response (n = 41) or an incomprehensible or unclear response (n = 16). The response was considered correct, if the participants indicated that the product should only be used on surfaces that are not wet cleaned (e.g., under cupboards, in the bathroom under or behind the bathtub). It is assumed that under these circumstances no releases into the environment are to be expected due to wet cleaning and subsequent transfer to the sewer systems. Frequently, "not regularly" was quantified. The quantifications varied substantially across participants: not daily, not weekly, or no more than once per month. Moreover, the following false responses were recorded: thinking that the biocidal product should not be used regularly, misunderstanding the purpose of this measure (for effectiveness of biocidal product) or assuming that the product should only be used outside (in the garden or on the terrace). It was also considered incorrect, if a participant did not

provide a coherent sentence and just one word (sporadically) or if they repeated the verbatim instruction.

Instruction "only for spot application": A total of n = 912 (86%) indicated to know the meaning of "only for spot application." Their detailed responses (912 = 100%) showed that n = 744 (87%) provided a correct definition, while n = 93 (11%) provided an incorrect definition and n = 17 (2%) said that they did not know. The response was considered correct if the participant indicated that the biocidal product should not be dispersed, but rather applied locally restricted on specific spots. It was considered incorrect if the participants understood spot application in a temporal sense (not regularly, not at regular intervals) or as quantity (use only very little of the product everywhere), reported specific areas in and around the house, or repeated the original instruction. The responses coded as missing values were n = 21 incomprehensible and n = 37 no response.

Instruction "avoid introduction to the municipal sewage treatment plant": The participants were also asked whether they knew where a biocidal product should not be used to avoid releases to the municipal sewage treatment plant. A total of n = 725 (68%) indicated to know this, while n = 337 (32%) said that they did not know. Checking the responses indicating to know (725 = 100%) revealed that n = 570 (87%) knew where not to use biocidal products, while n = 63 (10%) did not and n = 20 (3%) indicated to not know after all. Correct responses were defined rather generously, e.g. an application not around drains (e.g., in the bathroom or kitchen, toilet) or not outside on grass or unpaved paths. It was considered incorrect if the participant indicated that this was only valid for cities or close to a sewage treatment plant or outside, or if they repeated the wording. A few participants indicated that the product could not be used anywhere, which was also coded as incorrect. The responses coded as missing values were: n = 38 incomprehensible and n = 34 no response.

4.2.2.6 Additional insights: Role of required equipment

The following list presents the results regarding the role of additional equipment for protection motivation (practicability, i.e., a teaspoon to measure dosage that should not come into contact with water; N = 1062). Incorrect behaviour denotes first, if the dosage is not determined with a teaspoon, and second, if the teaspoon is washed after using it to determine the dosage.

A total of n = 258 admitted that they would dose by eye measure (without a teaspoon). The detailed responses to the first question are presented below.

- I would use a teaspoon: n = 224 (21%)
- I would get and use a plastic teaspoon: n = 513 (48%)
- I would dose by eye measure (without a teaspoon): n = 258 (24%)
- Other: n = 67 (7%)
  - Would not use the product at all (n = 31)
  - Would use another utensil that they will throw away afterwards (n = 10)
  - Would use another utensil only for this purpose (n = 9)
  - Would use the utensil that is provided with the product (n = 6)

The participants that had chosen to use a teaspoon (n = 224), but not those that had chosen any of the other options (i.e., plastic teaspoon, eye measure, other) were afterwards asked what they

would do with it after using the biocidal product, as it was assumed that they might be tempted to clean the teaspoon and use it for food and drinks again. A total of n = 45 (20% of the n = 224 that would use a teaspoon) admitted that they would clean the teaspoon with water. The following list presents the response options, open responses, and distributions.

- I would throw the teaspoon in the bin: n = 55 (25%)
- I would clean the teaspoon by hand or in the dishwasher with water and re-use it: n = 45 (20%)
- I would clean the teaspoon without water (e.g., with a dry towel) and re-use it: n = 18 (8%)
- I would label the teaspoon and use it only for similar tasks: n = 102 (45%)
- Other: n = 4 (2%, combination of strategies, such as dry cleaning and then in the dishwasher, disinfecting the teaspoon)

4.3 Research question 3: What drives and what complicates the adherence to instructions on biocidal products?

4.3.1 Method

The PMT assumes that the protection motivation, in this case the motivation to implement the instructions on the label of a biocidal product, is determined by the perception of a threat and the estimation of the own ability to cope with it. Thus, it was hypothesised that threat appraisal and coping appraisal would be positively related to protection motivation. Locus of control – meaning, who is perceived to be responsible for the protection of health and the environment – was included. It was hypothesised that protection motivation would be higher for participants that perceived more individual responsibility compared to participants that do not perceive a responsibility or perceive the government or industry to be responsible. Additionally, we hypothesised that cognitive processing of the instructions and socio-demographic variables would relate to protection motivation.

The basis of this analysis was a hypothetical purchase scenario involving an insect spray against cockroaches. For this, the participants were asked to imagine that there are suddenly a lot of cockroaches in their house or apartment and that they purchased an insect spray to tackle this issue. They were presented with a stylised picture of this insect spray (like the ones used in the scenario experiment, cf. Figure 2) and with the following instructions:

The application of the insect spray is limited to areas that are not wet cleaned or fully protected from water, such as garages, cellars, attics, cavities, warehouses, electrical service rooms, boiler rooms. The product is applied selectively in cracks and crevices that are present on porous / non-porous surfaces and may provide shelter for crawling insects (cockroaches, ants, silverfish, earwigs) and spiders. On porous surfaces, the effectiveness may be lower. Apply directly into the cracks/crevices. Minimum distance between two pump strokes: 20cm. Application rate: 36 pump blasts/m2 (corresponds to 50 ml product/m2). Max. 72 pump strokes/house and application. Max. 2 applications/year. Wait 4 weeks before the second application. Do not use in areas that are wet cleaned. Do not use in kitchens or bathrooms.

Two checks were included to test whether the participants had read the instructions. First, they were asked explicitly whether they had read the instruction (yes, no) and second, the time spent on the page was tracked in the online questionnaire. Additionally, the participants were asked to evaluate the text with four items (length, complexity, necessity to read twice, clarity and

specificity). Next, their protection motivation, threat and coping appraisal, and locus of control were assessed. Threat appraisal was measured by asking the participants about the likelihood and severity of harm to human health, to own or other people's pets and wild animals, and the environment if the insect spray would not be used correctly once. Coping appraisal was measured with two variables: response efficacy and self-efficacy.

Additionally, after the scenario, the participants were asked whether they were able to immerse themselves into the thought of purchasing an insect spray (response options: not at all, rather badly, rather well, very well) and whether they would in fact purchase an insect spray (yes, no) to tackle this issue. The participants that indicated that they would not were further asked in an open question what they would do instead.

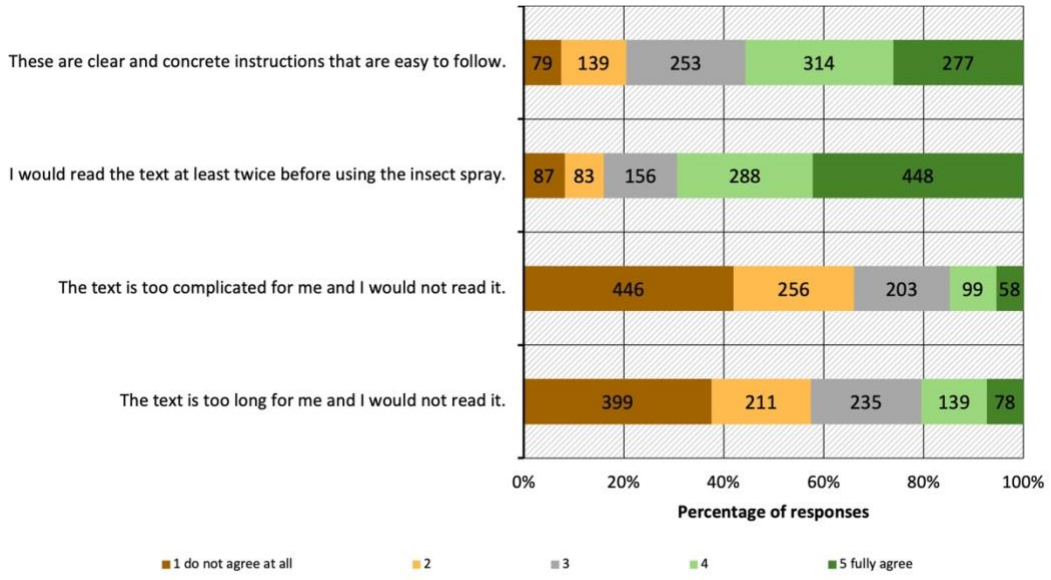
4.3.2 Results

In this section, the results regarding the included theoretical model are presented. In a first step, the results regarding the cognitive processing of instructions are presented. In a second step, the theoretical model is tested and the impact of the included independent variables on protection motivation is compared.

4.3.3 Cognitive processing of instructions

Figure 12 presents the results of the evaluation of the presented instruction. Roughly half of the participants rated the instructions as clear and concrete, even more participants agreed that they would read the instructions at least twice before using the product. Roughly 60% of the participants disagreed that the instruction was too complicated or too long.

Figure 12: Evaluation of instructions (*N* = 1062)



Source: own illustration, ETH Zurich

The majority of the 1062 participants, namely 982 (93%) indicated to having read the whole instruction text. Checking the time spent on this page shows that the participants spent on average about a minute on this page with a standard deviation of 3.4 minutes. Overall, there were large variations in the time spent on this page (between 2 seconds and 67 minutes). Comparing these two measures of compliance shows that the participants that indicated that they read the entire instruction spent more time on the page (M = 57 seconds, SD = 211 seconds)

than the participants that indicated that they had not (M = 25 seconds, SD = 52 seconds). It is likely that some participants responded in a socially desirable way to the question of whether they had read the text. This can be substantiated by the fact that some participants that had indicated to having read the entire instruction also spent very little time on the page (39% less than 30 seconds).

Most participants indicated that they could rather (n = 572, 54%) or very well (n = 321, 30%) empathise with this scenario. Oppositely, n = 150 (14%) had some and n = 19 (2%) had a lot of difficulties to empathise with the scenario. Further, most of the participants (n = 774, 73%) indicated that they would use an insect spray against cockroaches, while n = 288 (27%) would not. The participants that indicated that they would not use an insect spray were asked what else they would do in case of a cockroach infestation in their house or apartment. A total of n = 246 provided valid responses to this question. Most frequently, these participants indicated that they would call a specialist (exterminator, pest control) for aid (n = 86, 35%) or use more natural or gentler means to get rid of the cockroaches (n = 77, 31%). Other strategies that were mentioned were using cockroach traps (n = 34, 14%), killing the cockroaches manually (n = 11, 5%), combating the causes of the infestation (n = 10, 4%), cleaning (n = 9, 4%) or other strategies (n = 19, 7%).

4.3.4 Locus of control and perception of commercially available biocides

Table 5 presents the absolute and relative distributions of the responses regarding the internal, neutral, and external locus of control. A majority of participants rather or fully agreed that it is their responsibility not to harm the environment or damage their health with the insect spray. Similarly, a majority of participants rather or fully agreed that manufacturers are responsible. Mixed responses were observed regarding neutral locus of control. Roughly 20% of the participants rather or fully agreed that commercially available insect sprays are safe for the environment and health, whereas roughly a third was undecided and 40% of the participants did not agree.

Table 5: Absolute and relative distribution of responses regarding the internal, neutral, and external locus of control (*N* = 1062)

	1 do not agree at all	2	3	4	5 fully agree
It is my responsibility not to harm the environment with the insect spray.	28 (3%)	54 (5%)	198 (18%)	318 (30%)	464 (44%)
It is my responsibility not to damage my health with the insect spray.	15 (1%)	49 (5%)	178 (17%)	299 (28%)	521 (49%)
Commercially available insect sprays have been tested by the authorities and are therefore safe for the environment.	272 (26%)	230 (22%)	350 (33%)	143 (13%)	67 (6%)
Commercially available insect sprays have been tested by the authorities and are therefore safe for health.	263 (25%)	232 (22%)	340 (32%)	164 (15%)	63 (6%)
It is the responsibility of the manufacturer of insect sprays to produce them in a way that does not harm the environment.	39 (4%)	90 (8%)	270 (25%)	303 (29%)	360 (34%)
It is the responsibility of the manufacturer of insect sprays to produce them in such a way that they do not harm health.	48 (4%)	91 (9%)	255 (24%)	293 (28%)	375 (35%)

4.3.5 Determining factors for protection motivation

Table 6 presents the Pearson bivariate correlations between protection motivation and the included independent variables. All independent variables, aside from neutral and external locus of control were positively associated with protection motivation. This suggests that participants with higher threat and with higher coping appraisal reported a higher motivation to protect the environment by adhering to the instructions on the insect spray. Particularly, self-efficacy was most strongly associated to protection motivation, followed by internal locus of control. To compare the impact of the included variables and other variables of interest (e.g., socio-demographics, control variables), a hierarchical linear regression analysis was conducted with protection motivation as a dependent variable (cf. Tables 6 to 8).

Table 6: Bivariate correlations between protection motivation and the included independent variables (*N* = 1062).

	Protection motivation	Threat appraisal: Likelihood	Threat appraisal: Severity	Response efficacy	Self-efficacy	Internal locus of control	Neutral locus of control	External locus of control
Protection motivation	-							
Threat appraisal: Likelihood	.25***	-						
Threat appraisal: Severity	.24***	.68***	-					
Coping appraisal: Response efficacy	.27***	.02	-.01	-				
Coping appraisal: Self-efficacy	.58***	.22***	.17***	.35***	-			
Internal locus of control	.37***	.24***	.20***	.32***	.38***	-		
Neutral locus of control	-.18***	-.18***	-.11***	.29***	-.03	-.14***	-	
External locus of control	.04	.07*	.11***	.03	.10**	.11***	.13***	-

Asterisks represent levels of significance for the Pearson correlation coefficients (*: $p < .05$, **: $p < .01$, ***: $p < .001$).

In the first step (cf. Table 7), socio-demographic variables were included. Older and female participants reported higher protection motivation, while participants with small children in the household reported lower protection motivation. Education, place of residence, the presence of pets in the house or a job in the chemical industry were not related to protection motivation. In a preliminary analysis, it was found that the region (South, North, North-East, East, or Rhineland) was not related to protection motivation.

Table 7: Linear regression analysis with protection motivation (N = 1047)

Step 1: Socio-demographic variables (R2 = .07, F(7, 1039) = 11.9, p < .001)

	B [95%CI]	β	*t*	*p*
Constant	3.4 [3.2, 3.6]		30.1	< .001
Age	**0.0 [0.0, 0.0]**	**.17**	**5.1**	**< .001**
Gender (1: male)	**-0.3 [-0.4, -0.2]**	**-.18**	**-5.9**	**< .001**
Education (1: high)	**0.0 [-0.2, 0.1]**	**-.03**	**-0.8**	**.429**
Residence (1: countryside)	**-0.1 [-0.2, 0.0]**	**-.04**	**-1.3**	**.189**
Small children (1: children < 7)	**-0.2 [-0.4, -0.1]**	**-.08**	**-2.6**	**.010**
Pets (1: pets)	**0.0 [-0.1, 0.1]**	**.01**	**0.4**	**.703**
Job (1: job)	**0.0 [-0.2, 0.2]**	**.01**	**0.2**	**.819**

B: Unstandardised coefficient, β: Standardised coefficient, *t*: t-value, *p*: p-value (level of significance)

In the second step (cf. Table 8), two cognitive processing variables xxx and xxx were included. Time spent on the page with the instruction was not significantly related to higher protection motivation. A more positive evaluation of the instruction was related to higher protection motivation. The relationships between the socio-demographic variables and protection motivation remained the same.

Table 8: Linear regression analysis with protection motivation (N = 1047)

Step 2: Socio-demographic and cognitive processing variables (R2 = .28, F(9, 1037) = 44.8, p < .001)

	***B* [95%CI]**	**β**	***t***	***p***
Constant	1.7 [1.4, 2.0]		12.2	< .001
Age	0.0 [0.0, 0.0]	.10	3.4	<.001
Gender (1: male)	-0.2 [-0.3, -0.1]	-.12	-4.3	< .001
Education (1: high)	0.0 [-0.1, 0.1]	-.02	-0.9	.389
Residence (1: countryside)	-0.1 [-0.2, 0.0]	-.04	-1.3	.181
Small children (1: children < 7)	-0.2 [-0.4, -0.1]	-.08	-2.8	.005
Pets (1: pets)	0.0 [-0.1, 0.1]	.00	0.1	.919
Job (1: job)	0.1 [-0.1, 0.2]	.02	0.6	.581
Time spent with instruction	**0.0 [0.0, 0.0]**	**-.01**	**-0.3**	**.763**
Evaluation of instruction	**0.5 [0.4, 0.5]**	**.46**	**17.2**	**< .001**

B: Unstandardised coefficient, β: Standardised coefficient, *t*: t-value, *p*: p-value (level of significance)

In the third step (cf. Table 9), the psychological PMT variables were added. Participants that reported more positive expectations regarding their own ability to implement and the outcomes of implementing the instructions reported higher protection motivation. Of the two threat appraisal variables, only perceived severity was significantly related to protection motivation. Participants that thought that not following the instructions once was associated with more severe outcomes for health, animals, and the environment reported higher protection motivation. Internal locus of control was positively related to protection motivation, while a neutral locus of control was negatively related to it and external locus of control was not related to protection motivation at all. Thus, participants that perceived themselves as primarily responsible reported higher protection motivation and participants that thought that commercially available products would not be harmful reported lower protection motivation.

Table 9: Linear regression analysis with protection motivation (*N* = 1047)

Step 3: Socio-demographic, cognitive processing variables, and psychological variables (R2 = .46, F(16, 1030) = 55.3, p < .001)

	***B* [95%CI]**	**β**	***t***	***p***
Constant	0.7 [0.3, 1.0]		3.7	< .001
Age	0.0 [0.0, 0.0]	.07	2.6	.008
Gender (1: male)	-0.2 [-0.3, -0.1]	-.10	-4.4	< .001
Education (1: high)	0.0 [-0.1, 0.1]	-.01	-0.2	.835
Residence (1: countryside)	-0.1 [-0.1, 0.0]	-.03	-1.2	.221
Small children (1: children < 7)	-0.2 [-0.3, 0.0]	-.07	-2.7	.007
Pets (1: pets)	0.0 [-0.1, 0.0]	-.02	-0.9	.383
Job (1: job)	0.0 [-0.2, 0.2]	.00	0.0	.989
Time spent with instruction	0.0 [0.0, 0.0]	-.02	-0.8	.447
Evaluation of instruction	0.2 [0.2, 0.3]	.21	7.6	< .001
Threat appraisal: Likelihood	**0.0 [-0.1, 0.1]**	**.01**	**0.3**	**.733**
Threat appraisal: Severity	**0.2 [0.1, 0.2]**	**.12**	**3.7**	**<.001**
Coping appraisal: Response efficacy	**0.1 [0.1, 0.2]**	**.12**	**4.2**	**< .001**
Coping appraisal: Self-efficacy	**0.3 [0.3, 0.4]**	**.35**	**12.0**	**< .001**
Internal locus of control	**0.1 [0.0, 0.1]**	**.07**	**2.8**	**.006**
Neutral locus of control	**-0.1 [-0.2, -0.1]**	**-.15**	**-5.7**	**< .001**
External locus of control	**0.0 [-0.1, 0.0]**	**-.04**	**-1.5**	**.130**

B: Unstandardised coefficient, β: Standardised coefficient, *t*: t-value, *p*: p-value (level of significance)

5 Discussion of results, limitations, and implications

5.1 Spontaneous associations raised by the term "biocidal product"

At the start of the online questionnaire, people were asked to report their associations regarding the term "biocidal product." Asking about associations allows to access people's spontaneous and uninfluenced reactions and to uncover whether people spontaneously think of risks regarding this product or concept. Several conclusions can be drawn from the associations elicited by the term "biocidal product," as outlines subsequently.

A central finding from previous studies that was replicated within this study: the participants exhibited knowledge gaps regarding what the term "biocidal products" denotes (Wieck et al., 2018a, 2018b). Also, the participants revealed some misconceptions about the term. A prevalent misconception was the association with organic or naturalness based on the root word "bio" (in German, the term for organic products is "Bio-Produkte"). However, despite this misconception concerning the theoretical definition of a "biocidal product", it is not to be expected that this will impact people's interactions with real biocidal products. In every-day situations, rather the product type (e.g., rodenticides vs. antibacterial soap), the product design, and the information provided on the label will inform the consumers' risk perception than the term "biocidal product" on its own (Bearth et al., 2017; Buchmuller, Bearth, & Siegrist, 2022). Prior research had shown that consumers tend to underestimate the risks of organic products or products they perceive as natural (Bearth et al., 2017; Rozin, 2006; Scott, Rozin, & Small, 2020). It has also been suggested that consumers link risk to perceived effectiveness of the product and might perceive "natural" products as less risky and less effective (Bearth et al., 2017; Dugger-Webster & LePrevost, 2018). This might have negative implications for health and the environment, as consumers might handle these products less safe (i.e., stored in low-level cabinets, neglecting protective measures during the use) or use them excessively due to the perceived low effectiveness. Thus, it is important to keep in mind that – despite the warnings and instructions on a biocidal product – the product packaging and labelling will impact consumers' risk perception, which in turn might determine the willingness to implement protective measures and instructions. For the term "biocidal product," associations with risks to health, animals or the environment were made by a large portion of participants. This suggests a somewhat high general risk awareness for biocidal products, compared to other household chemicals. In another study on associations raised by various chemical household products (e.g., descaler, laundry detergent), this spontaneous link to risks was not found (Buchmuller et al., 2020). It is however to be expected that depending on the specific product that the consumers thought about, risk perception will be lower (i.e., disinfectants, preservatives) or higher (i.e., products for pest control).

5.2 Insights regarding the instructions on biocidal products

5.2.1 The comprehensibility of specific instructions on biocidal products

The comprehensibility of all included instructions, basic and variation, was rather high. However, some ambiguous or technical terms that reduce comprehensibility were identified, namely "spot application" and "wind drift." The results also suggest that comprehensibility is negatively linked to perceived difficulty (comprehensible instructions are perceived as easier to adhere to) and protection motivation (comprehensible instruction elicit higher protection motivation). The instruction "do not wet clean regularly" was associated with particularly low comprehensibility. Most confusion seemed to originate from the part of the instruction "not regularly," which resulted in varying quantifications. It is therefore, strongly recommended to

adjust the wording of this sentence to avoid ambiguity and confusion among consumers. Providing specific examples of places and quantifying the subjective term "not regularly" should mitigate the ambiguity and result in a higher comprehensibility. Should it not be possible to agree on a quantification, it might be more advisable to remove the ambiguous quantification from the instruction entirely. Another consumer knowledge gap was observed regarding what to avoid to not introduce a biocidal product to the municipal sewage treatment plant. It might also make sense to provide some guidance to consumers regarding instructions that involve the municipal sewage treatment plant, as many participants were unsure about this.

An important conclusion of this study is that subtle variations in the phrasing of the instructions do not substantially increase or decrease comprehensibility. Particularly, active vs. passive phrasing did not impact comprehensibility. Both versions are similarly comprehensible. However, based on the study's results, it is recommended to provide specific examples, while sacrificing conciseness. This is particularly important, if ambiguous locations (e.g., hard-to-reach areas) or external factors (e.g., wind drift) are included in the instructions.

5.2.2 Perceived difficulty of adhering and protection motivation of specific instructions on biocidal products

Instructions describing actions that are fully in consumers' control were perceived as easier to implement and therefore, more realistic than instructions that involve external factors or the behaviour of non-target organisms that are beyond the consumers' control (e.g., wind, rain, bees). It also becomes clear that perceived difficulty and protection motivation are linked: protection motivation is higher for actions that are perceived as easy (i.e., avoid a particular behaviour). A notable deviation from this association between perceived difficulty and protection motivation was found for instruction 1.1 "Not more than one treatment per nest should be performed in a season." There, participants perceived a low difficulty, while reporting low protection motivation. Open responses at the end of the questionnaire support the plausible conclusion that consumers only limit the use of the product over time or according to dose, if the problem is solved (i.e., the wasp nest is gone), even though this is not perceived as difficult. If the issue persists (i.e., the wasp nest is still there), consumers will likely use more of the biocidal product or use it more frequently than indicated in the instruction. Instruction 1.3 "do not wash treated blankets and textiles" was associated with particularly low protection motivation, as likely hygiene considerations might interfere with the motivation to adhere to this instruction.

Based on this study's findings, it is not recommended to hint at the environmental risk in the instruction. It increased perceived difficulty and more importantly, reduced protection motivation in this study. The findings contradict our initial assumption that providing a reason for a specific action might make it more relevant for consumers, which would increase protection motivation (Laughery & Wogalter, 2014; Wieck et al., 2018a; Wogalter et al., 2002). Instructions that are already perceived as rather difficult (e.g., involving external factors) might even be perceived as more difficult when presented together with environmental risk. Similarly, alluding to specific, positively charged animals did not positively impact perceived difficulty or protection motivation, even though this increased the environmental risk perception. It is possible that explicitly mentioning the environmental risk, made the consequences of the own action seem more uncontrollable. For example, for instruction 2.2 ("To protect the environment, cover the product (e.g., with a flowerpot or tile") mentioning "bees and other pollinators" might have made it more salient to the participants that while they can easily cover the product, they cannot control the behaviour of pollinators and thus, also not the success of the measure. It can therefore be relevant to consider such unexpected and unwanted effects in the instructions. However, it should also be mentioned that the effects of these variations were rather small and

should not be overstated. As mentioned above for comprehensibility, it appears that subtle variations in the instructions do not substantially change perceived difficulty or protection motivation.

5.2.3 Practicability of specific instructions and the impact of additional materials

Several conclusions can be drawn from this study regarding the practicability of instructions involving additional materials. When asked to use a teaspoon to measure dosage of the biocidal product, a quarter of participants admitted that they would simply dose by eye measure. This might lead to overdosing, which might have negative implications for the environment, or to underdosing, which might have negative implications for the effectiveness of the product. This in turn might lead to unnecessary repeated uses of the biocidal product. Based on this study's results, it seems likely that a substantial part of users will not adhere to the instruction to use a measuring tool if it is not included in the package of the product. It seems plausible that the additional effort or cost to organise the needed equipment may hinder the full implementation of this instruction. Three quarters of participants indicated that they would get and use a teaspoon or a plastic teaspoon to determine dosage, as was suggested in the instruction. However, due to socially desirable response tendencies, it is possible that this number is an overestimation, and even more participants would dose by eye measure if equipment were unavailable. The socially desirable response (i.e., what the participants think would be more socially accepted as a response) was quite transparent in this question (i.e., use a measuring tool). Using a teaspoon, which afterwards cannot be cleaned with water and re-used for food and drink, might represent a hidden cost to the user and thus, might not be adhered to. This hidden cost generally makes the instruction "to not clean used equipment" difficult to adhere to and unlikely to be followed by users. This is supported by the fact that 48% indicated to get and use a plastic spoon that is more likely to be thrown away after use. However, this cannot be confirmed with absolute certainty within this survey, as it was based on self-report alone. Future studies could strengthen these insights by making use of observational methods.

Of the participants that would use a teaspoon, 20% indicated that they would disregard the second part of the instruction to not clean the teaspoon with water. This might introduce the product into the sewage system, what should have been prevented with this instruction. Unfortunately, the questionnaire did not investigate further what the participants would do with the plastic teaspoon. It is plausible that consumers would be more willing to throw away a plastic spoon after use than a regular teaspoon. However, it is unlikely that plastic teaspoons are present in every household all the time and it is not guaranteed that consumer would not also clean a plastic teaspoon with water. Future studies should investigate this aspect in more depth.

Two recommendations can be determined from these findings. First, it might make sense to adjust the wording of the instruction and to encourage consumers to use a measuring tool other than a regular teaspoon. While likely present in most user households, consumers might be hesitant to use a teaspoon as a measuring tool if they afterwards cannot re-use it for food and drinks. This might contribute to over- or underdosing of the biocidal product. The instruction could instead recommend using a plastic teaspoon or some other disposable measuring tool. Second, it might be more advisable to offer additional equipment (i.e., dosing aid) to the consumers along with the purchase of the biocidal product. This could be achieved by prominently stating the need for this additional material on the packaging and placing the additional material alongside the biocidal product in the place of sale or including the additional material in the product package. An alternative solution without the need for additional material might be that the product cap or lid doubles as a measuring device.

5.2.4 Overview of recommendations for specific instructions

In Table 10, the recommendations for specific instructions are listed and extended to other frequently used and similar instructions. However, it should be kept in mind that only the 12 instructions listed in the left-most column were empirically investigated.

5.3 The drivers and barriers of protection motivation

A large portion of variance in self-reported protection motivation could be explained by the extended PMT (48%). Some relationships between sociodemographic and household variables were observed: older and female participants reported higher protection motivation, while participants with small children (< 7 years of age), participants who would use an insect spray to get rid of cockroaches and participants that thought that biocidal products that are available in the supermarket would not harm health or the environment reported lower protection motivation. These findings should not be overestimated though, as some sociodemographic variables might be confounded (e.g., participants with small children are younger than participants without small children) and effect sizes were small.

The strongest relationship with protection motivation was found for coping appraisal. Participants that were confident that they can put the instruction into practice and expected positive outcomes of doing so reported higher protection motivation. When instructions were judged in a positive light (i.e., as clear and concrete, as uncomplicated, as concise), protection motivation was reported to be higher. Both findings stress the importance of comprehensible instructions that are easy to implement and do not require special skills or additional equipment.

Another psychological factor that – according to this study's findings – might impact protection motivation is risk perception. However, only perceived severity of negative outcomes was related to protection motivation, not perceived likelihood of negative outcomes. The participants perceived risks to human and animal health more likely and severe than environmental harm (cf. Table B.3 in Appendix B). It might therefore be advisable to strengthen consumers understanding of the potential severity of environmental harm caused by the incorrect handling of biocidal products. It might also be relevant to address the issue of individual vs. collective risk perception. Consumers might think that their own individual unsafe handling of biocidal product will not negatively impact the environment, while neglecting that other consumers might think the same way and thus, environmental harm adds up. This phenomenon has previously been linked to other environmental issues, such as water, air or land pollution (Schultz et al., 2012). Further, consumers are aware that biocidal products may pose an environmental risk, but this risk awareness might not automatically lead to an adjustment of behaviour (Lecomte, Moreau, & Auburtin, 2006). In an as of yet unpublished study on perceptions of plant protection products in agriculture, consumers were found to rate pesticide use as more dangerous and unacceptable when health risks were involved compared to environmental risks (Contzen, Bearth, Aicher, & Wilks, in prep.). This could also have implications for the use of biocidal products in one's own household. It would be possible, that perceived environmental risks trigger less protection motivation than perceived health risks. The findings also stress the importance of perceived personal responsibility or internal locus of control: Participants that perceived a high personal responsibility to protect human and animal health and the environment reported higher protection motivation. Thus, in addition to sensitising consumers to the severity of (environmental) harm, personal responsibility should be strengthened. Another issue arose regarding the neutral locus of control, which was negatively associated with protection motivation. That means if the consumers perceive all authorised biocidal products as safe, they

exhibit lower protection motivation. This can be explained by the lack of awareness for the specificities of the authorisation procedure.

Potential information channels to reach consumers could be flyers at the point of sale, inputs by sales staff or national informational campaigns. Laughery and Wogalter (2014) also concluded that product warnings that explicitly point out the consequences of injury are more likely to make product users exercise caution when using them compared to product warnings without this information. It remains unclear though whether this also transfers from a perceived health risk to the perceived environmental risk, as consumers might be more driven to adhere to instructions if they are thinking of harm to themselves or other human's health than when thinking about harm to the environment. Generally, it is also important to mention that due to informational overload, lack of resources (i.e., time, motivation, attention) and insufficient motivation to protect the environment, it might be difficult to get this message to the consumers.

Table 10: Recommendations regarding specific instructions on biocidal products

Instruction included in the study	Instructions[1]	Recommendation
1.1: not more than one treatment per nest in a season	N46, N57, N117, N165, N189, N217	It is to be expected that instruction will not be followed if the problem persists after initial use of biocidal product
1.2: apply only in areas that are not liable to flooding or becoming wet	N21, N28, N110, N119, N131, N172, N191	Keep as is or consider adding examples of locations
1.3: do not wash treated blankets or textiles	-	Unlikely to be followed by consumers, as linked to hygiene concerns Avoid including environmental risk in instruction
2.1: only for spot application outdoors	N5	Improve comprehensibility by adding examples Clarify the term “spot application” by using consumers’ language (e.g., do not disperse, rather use it in specific spots)
2.2: cover the product (e.g., with a flowerpot or tile)	N93	Avoid making external factors (i.e., pollinators, insects) salient, as this increases perceived difficulty
2.3: apply only outdoors in locations protected from rain	N21, N28, N106, N110, N119, N131, N142, N172, N191	Avoid making external factors (i.e., organisms in the soil) salient, as this increases perceived difficulty Consider adding examples
3.1: only for crack and crevice treatment indoors	N4, N178	Keep as is or consider adding examples of locations
3.2: residue containing the product cannot enter the sewer	N11, N54, N106, N110, N128, N141, N142	Use passive phrasing Add examples to avoid ambiguity in location
3.3: sticker must not be cleaned. If this occurs, the cleaning cloth need to immediately be disposed to domestic waste	N14	Keep as is
4.1: avoid transfer to other areas by wind drift	N21, N28, N110, N119, N131, N172, N191	Perceived as more difficulty to adhere to due to external factor wind Improve comprehensibility by adding examples or clarifying term “wind drift”
4.2: only use the bait boxes in hidden, hard-to-reach areas	N172	Add examples of locations
4.3: do not use on unpaved ground	-	Keep as is or consider adding examples of locations
Additional: Do not wet clean regularly	N1, N275	Add examples of ambiguous locations Quantify or remove subjective term “regularly”

1 Numbering according to the list of frequently used sentences SPC (European Chemicals Agency ECHA).

5.4 Limitations

The most important limitation of this study is the use of self-report. It is to be expected that some of the participants responses were biased due to social desirability (i.e., responding in a way that participants think is expected of them), the hypothetical nature of the scenarios or recall bias (i.e., not remembering how participants acted in specific situations). It is to be expected that self-reported protection motivation is more impacted by these biases (Grimmer & Miles, 2017; Sheeran & Webb, 2016) than self-reported comprehensibility and difficulty. It is therefore possible that the conclusions drawn about protection motivation might overestimate the protection motivation in a real interaction with biocidal products. Nonetheless, the experimental design allows to make some inferences about the impact of systematic variations on the variables of interest. In the future, the findings from this study could be strengthened by either applying qualitative approaches (e.g., discussing these studies' conclusions in interviews or focus groups with consumers) or observatory experimental approaches (e.g., observing consumers while they are interacting with biocidal products). As mentioned above, the scenario design required the participants to imagine a hypothetical situation. Some participants reported that it was easy to get immersed into the scenarios, while others struggled with it, either due to the hypothetical nature of scenarios or their personal preferences of not using biocidal products. This might explain the 10-20% of people responding "neither" to the questions about comprehensibility and difficulty. It should also be noted that only a selection of instructions and variations in German could be tested, which is why general statements about the design of other instructions in other languages should be interpreted with care. The robustness of some of the findings uncovered in this study and its links to prior literature, however, allows to reasonably assume that similar findings would have been uncovered for similar instructions. Lastly, the selection of the sample should be discussed. Care was taken to recruit a heterogeneous sample and to avoid providing too much information on the content of the survey to avoid a systematic early dropout of participants (i.e., those uninterested in the topic or having extreme feelings about the topic). Nonetheless, this sample represents a somewhat selected section of the population, as it did not reach consumers that do not fill out online surveys. This should be taken into consideration when making inferences about this sample to the German population.

5.5 Conclusion and summary of recommendations

Recommendations regarding the design of instructions

- Avoid ambiguous terms (i.e., spot application, wind drift, regularly, introduction to municipal sewage system), as these can lower comprehensibility and thus, protection motivation.
- It is recommended to add examples for ambiguous terms, locations, or quantifications, even though this increases the length of the instruction.
- Subtle changes in the instructions phrasing (i.e., active vs. passive phrasing) do not increase or decrease comprehensibility, which should be considered during the authorisation.
- It should be considered that instructions involving external factors (e.g., wind, rain, target and non-target animals) that are not under the consumers' control are perceived as more difficult. Therefore, it is not recommended to explicitly add environmental risks to the instructions.
- The adherence to instructions regarding the frequency and extent of use might be linked to the biocidal products' initial success in solving the problem, as consumers might use it again should a problem persist. This needs to be considered during the authorisation.
- Provide additional equipment (i.e., dosing aids, protective coverings) with the biocidal product to increase protection motivation and avoid overdosing or non-adherence.
- Keep in mind that – aside from warnings and instructions – consumers consider product type, design and labelling to inform initial risk assessment of the product (e.g., the risk and effectiveness of biocidal products perceived as natural may be underestimated).

Recommendations regarding consumers' protection motivation and risk communication

- Improve instructions, as comprehensive instructions were perceived as easier to adhere to and elicited higher protection motivation.
- Strengthen consumers' coping appraisal by making information available to them (e.g., about the consequences of individual vs. collective non-adherence to instructions) and by providing consumers with the skills and tools to adhere to the instructions (e.g., education, add equipment).
- Emphasise severity of negative outcomes over likelihood of negative outcomes. It is however yet unclear whether similar effects are to be expected for environmental risks compared to health risks.
- Increase perceived individual responsibility of consumers to protect human health, animal health and the environment. Make sure that consumers know that products are not inherently safe due to their availability on the market.
- Older and female participants reported higher protection motivation. This shows that risk awareness raising communication might be more successful if targeted on specific groups in the population.

6 List of references

Articles taken from journals

Bagheri, A., Emami, N., & Damalas, C. A. (2021): Farmers' behavior in reading and using risk information displayed on pesticide labels: a test with the theory of planned behavior. In: Pest Management Science, 2021, 77, John Wiley & Sons, Hoboken NJ, p. 2903-2913.

Basso, F., Bouille, J., Le Goff, K., Robert-Demontrond, P., & Ouiller, O. (2016): Assessing the role of shape and label in the misleading packaging of food imitating products - from empirical evidence to policy recommendation. In: Frontiers in Psychology, 2016, 7, Frontiers Media, Lausanne.

Bearth, A., Bosshart, N., Wermelinger, S., Daum, M., & Siegrist, M. (2022): Household chemicals and pre-schoolers - Caretakers' beliefs and perspectives on risks and responsibilities. In: Safety Science, 2022, 154, Elsevier, Amsterdam, p. 105864.

Bearth, A., Buchmuller, K., Burgy, H., & Siegrist, M. (2020): Barriers to the safe use of chemical household products - a comparison across European countries. In: Environmental Research, 2020, 180, Elsevier, Amsterdam.

Bearth, A., Cousin, M. E., & Siegrist, M. (2014): The consumer's perception of artificial food additives: Influences on acceptance, risk and benefit perceptions. In: Food Quality and Preference, 2014, 38, Elsevier, Amsterdam, p. 14-23.

Bearth, A., Kwon, S., & Siegrist, M. (2020): Chemophobia and knowledge of toxicological principles in South-Korea: perceptions of trace chemicals in consumer products. In: Journal of Toxicology and Environmental Health, 2020, 89, Taylor & Francis, Abingdon-on-Thames, p. 104144.

Bearth, A., Miesler, L., & Siegrist, M. (2017): Consumers' risk perception of household cleaning and washing products. In: Risk Analysis, 2017, 37, John Wiley & Sons, Hoboken NJ, p. 647-660.

Bearth, A., Saleh, R., & Siegrist, M. (2019): Lay-people's knowledge about toxicology and its principles in eight European countries. In: Food and Chemical Toxicology, 2019, 131, Elsevier, Amsterdam, p. 110560.

Bearth, A., & Siegrist, M. (2019): Situative and product-specific factors influencing consumers' risk perception of household cleaning products. In: Safety Science, 2019, 113, Elsevier, Amsterdam, p. 126-133.

Beirens, T. M. J., van Beeck, E. F., Dekker, R., Brug, J., & Raat, H. (2006): Unsafe storage of poisons in homes with toddlers. In: Accident Analysis and Prevention, 2006, 38, Elsevier, Amsterdam, p. 772-776.

Boelhouwer, E. J., & Davis, J. (2010): Effects of ghs hazard category, signal words, and pictograms on an individual's assessment of perceived risk. In: Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 2010, 54, SAGE Publishing, New York NY, p. 1851-1855.

Boelhouwer, E. J., Davis, J., Franco-Watkins, A., Dorris, N., & Lungu, C. (2013): Comprehension of hazard communication - effects of pictograms on safety data sheets and labels. In: Journal of Safety Research, 2013, 46, Elsevier, Amsterdam, p. 145-155.

Braun, C. C., Mine, P. B., & Clayton Silver, N. (1995): The influence of color on warning label perceptions. In: International Journal of Industrial Ergonomics, 1995, 15, Elsevier, Amsterdam, p. 179-187.

Buchmuller, K., Bearth, A., & Siegrist, M. (2020): Consumers' perceptions of chemical household products and the associated risks. In: Food and Chemical Toxicology, 2020, 143, Elsevier, Amsterdam, p. 111511.

Buchmuller, K., Bearth, A., Siegrist, M. (2022): The Influence of Packaging on Consumers' Risk Perception of Chemical Household Products. In: Applied Ergonomics, 2022, 100, Elsevier, Amsterdam, p. 103676.

Buchmuller, K., Xu, C., Bearth, A., & Siegrist, M. (2022): Consumers' decision-making process when choosing potentially risky chemical household products - the case of laundry detergents. In: Environmental Research, 2022, 209, Elsevier, Amsterdam, p. 112894.

Chen, C.-F., Liu, T., & Huang, K.-C. (2015): Characteristics of warning labels for drug containers and their effects on perceived hazardousness. In: Safety Science, 2015, 78, Elsevier, Amsterdam, p. 149-154.

Contzen, N., Bearth, A., Aicher, L., & Wilks, M. F. (in prep.): Concern for the environment or human health? The influence of risk information and personal values on the acceptance of the use of plant protection products.

Dalvie, M. A., Rother, H.-A., & London, L. (2014): Chemical hazard communication comprehensibility in South Africa - safety implications for the adoption of the globally harmonised system of classification and labelling of chemicals. In: Safety Science, 2014, 61, Elsevier, Amsterdam, p. 51-58.

Damalas, C. A., & Khan, M. (2016): Farmers' attitudes towards pesticide labels: implications for personal and environmental safety. In: International Journal of Pest Management, 2016, 62, Taylor & Francis, Abingdon-on-Thames, p. 319-325.

Damalas, C. A., Theodorou, M. G., & Georgiou, E. B. (2006): Attitudes towards pesticide labelling among Greek tobacco farmers. In: International Journal of Pest Management, 2006, 52, Taylor & Francis, Abingdon-on-Thames, p. 269-274.

Dugger-Webster, A., & LePrevost, C. E. (2018): Following pesticide labels - a continued journey toward user comprehension and safe use. In: Current Opinion in Environmental Science & Health, 2018, 4, Elsevier, Amsterdam, p. 19-26.

Edworthy, J., Hellier, E., Morley, N., Grey, C., Aldrich, K., & Lee, A. (2004): Linguistic and Location Effects in Compliance with Pesticide Warning Labels for Amateur and Professional Users. In: Human Factors, 2004, 46, SAGE Publishing, New York NY, p. 11-31.

Fransson, K., Brunklaus, B., & Molander, S. (2013): Flows of chemical risk information in the consumer paint product chain. In: Journal of Industrial Ecology, 2013, 17, John Wiley & Sons, Hoboken NJ, p. 310-320.

Geuens, M., Byrne, D., Boeije, G., Peeters, V., & Vandecasteele, B. (2021): Investigating the effectiveness of simplified labels for safe use communication - the case of household detergents. In: International Journal of Consumer Studies, 2021, 45, John Wiley & Sons, Hoboken NJ, p. 1410-1424.

Grey, C. N. B., Nieuwenhuijsen, M. J., Golding, J., & Team, A. (2005): The use and disposal of household pesticides. In: Environmental Research, 2005, 97, Elsevier, Amsterdam, p. 109-115.

Grimmer, M., & Miles, M. P. (2017): With the best of intentions - a large sample test of the intention-behaviour gap in pro-environmental consumer behaviour. In: International Journal of Consumer Studies, 2017, 41, John Wiley & Sons, Hoboken NJ, p. 2-10.

Hinks, J., Bush, J., Andras, P., Garratt, J., Pigott, G., Kennedy, A., & Pless-Mulloli, T. (2009): Views on chemical safety information and influences on chemical disposal behaviour in the UK. In: Science of The Total Environment, 2009, 407, Elsevier, Amsterdam, p. 1299-1306.

Jansen, T., Claassen, L., van Kamp, I., & Timmermans, D. R. M. (2020): 'All chemical substances are harmful' - Public appraisal of uncertain risks of food additives and contaminants. In: Food and Chemical Toxicology, 2020, 136, Elsevier, Amsterdam, p. 110959.

Kraus, N., Malmfors, T., & Slovic, P. (1992): Intuitive toxicology- expert and lay judgments of chemical risks. In: Risk Analysis, 1992, 12, John Wiley & Sons, Hoboken NJ, p. 215-232.

Laughery, K. R., & Wogalter, M. S. (2014): A three-stage model summarizes product warning and environmental sign research. In: Safety Science, 2014, 61, Elsevier, Amsterdam, p. 3-10.

Lecomte, J., Moreau, J., & Auburtin, G. (2006): Health/environmental risks perception and attitude towards households pesticides products. In: Epidemiology, 2006, 17, Taylor & Francis, Abingdon-on-Thames, p. 382-382.

Maddux, J. E., & Rogers, R. W. (1983): Protection motivation and self-efficacy - a revised theory of fear appeals and attitude change. In: Journal of Experimental Social Psychology, 1983, 19, Elsevier, Amsterdam, p. 469-479.

Milne, S., Sheeran, P., & Orbell, S. (2000): Prediction and intervention in health-related behavior - a meta-analytic review of protection motivation theory. Journal of Applied Social Psychology, 2000, 30, Wiley & Sons, Hoboken NJ, p. 106-143.

Nieuwenhuijsen, M. J., Grey, C. N. B., Golding, J., & Grp, A. (2005): Exposure misclassification of household pesticides and risk perception and behaviour. In: Annals of Occupational Hygiene, 2005, 49, Oxford University Press, Oxford, p. 703-709.

Prentice-Dunn, S., & Rogers, R. W. (1986): Protection motivation theory and preventive health - beyond the health belief model. In: Health Education Research, 1986, 1, Oxford University Press, Oxford, p. 153-161.

Riley, D. (2014): Mental models in warnings message design - a review and two case studies. In: Safety Science, 2014, 61, Elsevier, Amsterdam, p. 11-20.

Rogers, R. W. (1975): A protection motivation theory of fear appeals and attitude change. In: The Journal of Psychology, 1975, 91, Taylor & Francis, Abingdon-on-Thames, p. 93-114.

Rozin, P. (2006): Naturalness judgments by lay Americans - process dominates content in judgments of food or water acceptability and naturalness. In: Judgment and Decision Making, 2006, 1, Society for Judgment and Decision Making, p. 91-97.

Saleh, R., Bearth, A., & Siegrist, M. (2019): "Chemophobia" today - consumers' knowledge and perceptions of chemicals. In: Risk Analysis, 2019, 39, John Wiley & Sons, Hoboken NJ, p. 2668-2682.

Schultz, P. W., Milfont, T. L., Chance, R. C., Tronu, G., Luís, S., Ando, K., . . . Gouveia, V. V. (2012): Cross-cultural evidence for spatial bias in beliefs about the severity of environmental problems. In: Environment and Behavior, 2012, 46, SAGE Publishing, New York NY, p. 267-302.

Schwebel, D. C., Evans, W. D., Hoeffler, S. E., Marlenga, B. L., Nguyen, S. P., Jovanov, E., . . . Sheares, B. J. (2017): Unintentional child poisoning risk - a review of causal factors and prevention studies. In: Childrens Health Care, 2017, 46, Taylor & Francis, Abingdon-on-Thames, p. 109-130.

Scott, S. E., Rozin, P., & Small, D. A. (2020): Consumers prefer "natural" more for preventatives than for curatives. In: Journal of Consumer Research, 2020, 47, Oxford University Press, Oxford, p. 454-471.

Sheeran, P., & Webb, T. L. (2016): The intention–behavior gap. In: Social and Personality Psychology Compass, 2016, 10, John Wiley & Sons, Hoboken NJ, p. 503-518.

Siegrist, M., & Bearth, A. (2019): Chemophobia in Europe and reasons for biased risk perceptions. In: Nature Chemistry, 2019, 11, Springer Nature, Berlin, p. 1071-1072.

Strudler Wallston, B., & Wallston, K. A. (1978): Locus of control and health - review of the literature. In: Health Education Monographs, 1978, 6, SAGE Publishing, New York NY, p. 107-117.

Su, T.-S., & Hsu, I. Y. (2008): Perception towards chemical labeling for college students in Taiwan using Globally Harmonized System. In: Safety Science, 2008, 46, Elsevier, Amsterdam, p. 1385-1392.

Wieck, S., Olsson, O., & Kümmerer, K. (2018a): Consumers' perceptions of biocidal products in households. In: International Journal of Hygiene and Environmental Health, 2018, 221, Elsevier, Amsterdam, p. 260-268.

Wieck, S., Olsson, O., & Kümmerer, K. (2018b): Not only biocidal products - washing and cleaning agents and personal care products can act as further sources of biocidal active substances in wastewater. In: Environment International, 2018, 115, Elsevier, Amsterdam, p. 247-256.

Wogalter, M. S., Conzola, V. C., & Smith-Jackson, T. L. (2002): Research-based guidelines for warning design and evaluation. In: Applied Ergonomics, 2002, 33, Elsevier, Amsterdam, p. 219-230.

Wogalter, M. S., Godfrey, S. S., Fontenelle, G. A., Desaulniers, D. R., Rothstein, P. R., & Laughery, K. R. (1987): Effectiveness of Warnings. In: Human Factors, 29, SAGE Publishing, New York NY, p. 599-612.

A Appendix: Questionnaire

This section presents the questionnaire that will be used in this study. For each measured variable, the response options and/or included items are presented alongside with the naming convention and coding for the statistical program.

Information for quota design

Gender

Bitte geben Sie Ihr Geschlecht an.

1	Weiblich
2	Männlich
3	Anderes

Age

Bitte geben Sie Ihr Alter in Jahren an.

State

In welchem Bundesland wohnen Sie zurzeit?

1	Baden-Württemberg
2	Bayern
3	Berlin
4	Brandenburg
5	Bremen
6	Hamburg
7	Hessen
8	Mecklenburg-Vorpommern
9	Niedersachsen
10	Nordrhein-Westfalen
11	Rheinland-Pfalz
12	Saarland
13	Sachsen
14	Sachsen-Anhalt
15	Schleswig-Holstein
16	Thüringen
17	Ausserhalb von Deutschland (→ *excluded)*

Familiarity with biocidal products and their potential risks

Spontaneous associations with the term "biocidal product"

Wenn Sie den Begriff «Biozid-Produkt» hören, was sind die ersten drei Worte, Bilder oder Gedanken, die Ihnen spontan in den Sinn kommen?

Sie können bis zu 3 Worte, Bilder oder Gedanken nennen. Bitte füllen Sie mindestens ein Feld aus.

Recall of biocidal products

Können Sie uns ein paar Produkte nennen, welche zu den Bioziden gehören?

Sie können bis zu 5 Produkte nennen. Bitte versuchen Sie mindestens ein Produkt anzugeben, welches Ihnen einfällt. Wenn Ihnen kein Produkt einfällt, können Sie die Felder leerlassen.

Use of biocidal products

Nachfolgend sind einige Beispielprodukte für Biozide dargestellt. Bitte geben Sie jeweils an, wie häufig diese durchschnittlich von Ihnen benutzt werden.

use1	Desinfektionsmittel für die Haut (z.B. Handdesinfektionsmittel)
use2	Grünbelagsentferner gegen Bewuchs auf z.B. Terrassen (z.B. gegen Algen)
use3	Pooldesinfektionsmittel für Aufstellpools im Garten (z.B. gegen Algen)
use4	Produkte gegen Fliegen (z.B. Fenstersticker, Fliegensprays)
use5	Produkte zur Bekämpfung von Ameisen (z.B. Köderdosen, Gels, Pulver)
use6	Produkte zur Bekämpfung von Flöhen in der Wohnumgebung (z.B. auf dem Sofa oder auf Decken von Haustieren)
use7	Produkte zur Abschreckung von Insekten (z.B. Moskitospray)

1	Täglich oder mehrmals pro Woche
2	Mehrmals pro Monat
3	Mehrmals pro Jahr
4	Seltener
5	Nie
6	Kenne ich nicht

Evaluation of specific instructions and their variations

Introduction to the experiment

Nachfolgend beschreiben wir Ihnen 12 Szenarien. Versuchen Sie sich bitte so gut wie möglich in das jeweilige Szenario hineinzuversetzen. Bei jedem Szenario sehen Sie ein Bild eines Biozid-

Produkts. Um Einflüsse der Marke zu vermeiden, wurde der Markenname und die Bebilderung entfernt.

Dependent variables

Comprehensibility:

Wie verständlich finden Sie die Anweisung auf dem Produkt?

1	1 sehr unverständlich
2	2 eher unverständlich
3	3 weder noch
4	4 eher verständlich
5	5 sehr verständlich

Difficulty:

Wie schwierig ist es, die Anweisung auf dem Produkt zu befolgen?

1	1 sehr schwierig
2	2 eher schwierig
3	3 weder noch
4	4 eher einfach
5	5 sehr einfach

Protection motivation:

Wie wahrscheinlich würden Sie die Anweisung auf dem Produkt genauso befolgen?

1	1 auf gar keinen Fall
2	2 eher nicht
3	3 möglicherweise
4	4 wahrscheinlich
5	5 auf jeden Fall

Environmental risk perception:

Aufgrund der Anweisungen, wie hoch schätzen Sie das Risiko für die Umwelt aufgrund des Einsatzes dieses Produktes ein?

1	1 überhaupt kein Risiko
2	2 geringes Risiko
3	3 mittleres Risiko
4	4 hohes Risiko

5	5 sehr hohes Risiko

Variation 1: environmental risk

Scenario	Basic instruction	Variation
Sie entdecken eine Ameisenstrasse in Ihrem Wohnbereich und vermuten, dass sie ein Ameisennest in Ihrer Küche haben. Sie kaufen sich das abgebildete Produkt gegen Ameisen.	Nicht mehr als eine Behandlung pro Nest und Saison vornehmen.	Nicht mehr als eine Behandlung pro Nest und Saison vornehmen, um negative Auswirkungen auf die Umwelt zu verhindern.
Sie stören sich an Schaben (Kakerlaken) auf Ihrem Balkon oder Ihrer Terrasse. Sie kaufen sich das abgebildete Produkt gegen Schaben (Kakerlaken).	Nur in Bereichen anwenden die nicht überflutet oder nass werden können, d.h. die vor Regen, Überschwemmungen und Reinigungswasser geschützt sind.	Nur in Bereichen anwenden, die nicht überflutet oder nass werden können, d.h. die vor Regen, Überschwemmungen und Reinigungswasser geschützt sind, um Umweltschäden zu vermeiden.
Sie haben einen Flohbefall in Ihrem Wohnbereich. Sie kaufen sich das abgebildete Produkt, um Flöhe auf Ihrem Sofa oder auf Decken zu bekämpfen.	Behandelte Decken oder Textilien nicht waschen.	Behandelte Decken oder Textilien nicht waschen, um Umweltschäden durch Einträge in die Kläranlage zu vermeiden.

Variation 2: positively charged animal

Scenario	Basic instruction	Variation
Sie stören sich an den vielen Fliegen auf Ihrem Balkon oder Ihrer Terrasse. Sie kaufen sich das abgebildete Produkt, um die Fliegen zu bekämpfen.	Im Außenbereich nur für die punktuelle Anwendung, um die Umwelt nicht zu gefährden.	Im Außenbereich nur für die punktuelle Anwendung, um Haustiere (z.B. Hunde und Katzen) nicht zu gefährden.
Sie stören sich an den vielen Ameisen auf Ihrem Balkon oder Ihrer Terrasse und kaufen das abgebildete Produkt.	Die Umwelt schützen, indem das Produkt abgedeckt wird (z.B. mit einem Blumentopf oder einer Fliese).	Bienen und andere Bestäuber schützen, indem das Produkt abgedeckt wird (z.B. mit einem Blumentopf oder einer Fliese).
Sie entdecken Schaben (Kakerlaken) auf Ihrer Terrasse. Sie kaufen sich das abgebildete Produkt, um die Schaben (Kakerlaken) zu bekämpfen.	Zum Schutz der Umwelt das Produkt im Außenbereich nur in Bereichen anwenden, die vor Regen geschützt sind.	Zum Schutz von im Boden lebenden Organismen (z.B. Regenwürmer) das Produkt im Außenbereich nur in Bereichen anwenden, die vor Regen geschützt sind.

Variation 3: sentence phrasing

Scenario	Basic instruction	Variation
Sie stören sich an den vielen Schaben (Kakerlaken) in Ihrem Wohnbereich. Sie kaufen sich das abgebildete Produkt, um die Schaben (Kakerlaken) zu bekämpfen.	Im Innenbereich nur für die Anwendung in Ritzen und Spalten.	Wenden Sie das Produkt im Innenbereich nur in Ritzen und Spalten an.
Sie kaufen sich das abgebildete Desinfektionsmittel zur Desinfektion von Oberflächen.	Produktreste nicht in die Kanalisation oder die Umwelt gelangen lassen.	Lassen Sie Produktreste nicht in die Kanalisation oder die Umwelt gelangen.
Sie kaufen sich das abgebildete Produkt, weil sie die vielen Fliegen in Ihrem Wohnbereich bekämpfen möchten. Hinweis: Ein Fliegenköder ist ein Motivsticker, der zur Bekämpfung von Fliegen ans Fenster geklebt wird.	Fliegenköder nicht reinigen. Wenn dennoch eine Reinigung vorgenommen wird, den Lappen sofort in den Restmüll geben.	Reinigen Sie den Fliegenköder nicht. Wenn Sie den Aufkleber dennoch gereinigt haben, den Lappen sofort in den Restmüll geben.

Variation 4: conciseness and examples

Scenario	Basic instruction	Variation
Sie entdecken ein Wespennest in der Nähe Ihres Schlafzimmerfensters. Sie kaufen sich das abgebildete Produkt, um das Wespennest zu bekämpfen.	Abdrift durch Wind vermeiden.	Abdrift vermeiden, indem Sie z.B. das Produkt nicht verwenden, wenn es windig ist.
Sie entdecken Schaben (Kakerlaken) in Ihrem Badezimmer. Sie kaufen sich das abgebildete Produkt.	Die Köderdosen nur in versteckten, schwer zugänglichen Bereichen verwenden	Die Köderdosen nur in versteckten, schwer zugänglichen Bereichen verwenden, wie z.B. unter dem Waschbecken, hinter der Toilette, in der Nähe von Abflüssen usw.
Sie kaufen sich das abgebildete Produkt, weil sie eine Ameisenstraße auf Ihrer Terrasse entdeckt haben und die Ameisen bekämpfen möchten.	Nicht auf ungepflastertem Boden anwenden.	Nicht auf ungepflastertem Boden anwenden, d.h. nur auf gepflasterten Wegen rund um das Haus, Balkone und Terrassen.

Drivers of protection motivation

Introduction to the hypothetical purchase scenario

Bitte versuchen Sie sich so gut wie möglich in die nachfolgend beschriebene Situation hineinzuversetzen. Anschließend möchten wir Ihnen gerne ein paar detaillierte Fragen dazu stellen.

Sie merken, dass in Ihrem Haus oder in Ihrer Wohnung plötzlich sehr viele Schaben (Kakerlaken) vorkommen. Sie gehen in einen Laden und kaufen sich ein Insektenspray. Auf der nächsten Seite finden Sie mehr Informationen zu diesem Insektenspray gegen Schaben (Kakerlaken).

Auf der Rückseite des oben abgebildeten Insektensprays gegen Schaben (Kakerlaken) stehen die folgenden Anweisungen:

Die Anwendung des Insektensprays ist auf Bereiche beschränkt, die nicht nass gereinigt werden oder vollständig vor Wasser geschützt sind, wie Garagen, Keller, Dachböden, Hohlräume, Lagerhallen, elektrische Betriebsräume, Heizungsräume. Das Produkt wird punktuell in Rissen und Spalten aufgetragen, die auf porösen / nicht-porösen Oberflächen vorhanden sind und kriechenden Insekten (Schaben, Ameisen, Silberfischchen, Ohrwürmer) und Spinnen als Unterschlupf dienen können. Auf porösen Oberflächen kann die Wirksamkeit geringer sein. Direkt in die Risse/Spalten einbringen. Mindestabstand zwischen zwei Pumpstößen: 20cm. Aufwandmenge: 36 Pumpstöße/m^2 (entspricht 50 ml Produkt/m^2). Max. 72 Pumpstöße/Haus und Anwendung. Max. 2 Anwendungen/Jahr. Vor der zweiten Anwendung 4 Wochen warten. Nicht in Bereichen anwenden, die nass gereinigt werden. Nicht in Küchen oder Badezimmern verwenden.

Cognitive processing: Did they read the instruction?

Haben Sie den ganzen Text mit Anweisungen zum Insektenspray gelesen?

1	Ja
2	Nein

Denken Sie bei den folgenden Aussagen bitte an eine reale Situation, in der Sie den Insektenspray in den Händen halten und verwenden möchten.

Es gibt keine richtigen oder falschen Antworten. Wir interessieren uns für Ihre ehrliche, spontane Reaktion auf die Anweisungen.

SR1	Der Text ist mir zu lange und ich würde ihn nicht lesen.
SR2	Der Text ist mir zu kompliziert und ich würde ihn nicht lesen.
SR3	Ich würde den Text mindestens zweimal lesen, bevor ich das Insektenspray verwende.
SR4	Das sind klare und konkrete Anweisungen, die einfach zu befolgen sind.

1	1 stimme überhaupt nicht zu
2	2

3	3
4	4
5	5 stimme voll und ganz zu

Protection motivation

Bitte geben Sie an, inwiefern Sie den folgenden Aussagen zustimmen.

SM1	Ich würde das Insektenspray nur in Bereichen anwenden, die vor Wasser geschützt sind.
SM2	Ich würde das Insektenspray überall anwenden, wo Schaben (Kakerlaken) vorkommen.
SM3	Ich würde so viel Insektenspray wie nötig anwenden, auch wenn das mehr Pumpstöße sind als in der Anweisung vorgegebenen.
SM4	Ich würde das Insektenspray auch in der Küche oder im Badezimmer verwenden, wenn dort Schaben (Kakerlaken) vorkommen.
SM5	Ich würde genau darauf achten, wie viele Pumpstöße pro m^2 in der Anweisung stehen und mich daranhalten.
SM6	Ich würde das Insektenspray direkt noch einmal verwenden, wenn am nächsten Tag immer noch Schaben (Kakerlaken) vorkommen.
SM7	Ich würde das Insektenspray nur punktuell in Rissen oder Spalten anwenden.
SM8	Bei der Anwendung würde ich genau auf den Mindestabstand zwischen zwei Pumpstößen achten.

1	1 stimme überhaupt nicht zu
2	2
3	3
4	4
5	5 stimme voll und ganz zu
999	weiss nicht

Coping appraisal: Response efficacy

Bitte geben Sie an, inwiefern Sie den folgenden Aussagen zustimmen.

HW1	Wenn man sich genau an die Anweisungen auf dem Insektenspray hält, schützt man seine Gesundheit.
HW2	Wenn man sich genau an die Anweisungen auf dem Insektenspray hält, stellt man die Wirksamkeit sicher.

HW3	Wenn man sich genau an die Anweisungen auf dem Insektenspray hält, schützt man die Umwelt.

Locus of control (internal locus of control: HW6, HW9; neutral locus of control: HW5, HW8; external locus of control: HW4, HW7)

Bitte geben Sie an, inwiefern Sie den folgenden Aussagen zustimmen.

HW4	Es ist Aufgabe des Herstellers von Insektensprays diese so zu produzieren, dass sie die Umwelt nicht schädigen.
HW5	Im Handel erhältliche Insektensprays sind von Behörden geprüft und daher ungefährlich für die Umwelt.
HW6	Es ist meine Verantwortung die Umwelt nicht mit dem Insektenspray zu schädigen.
HW7	Es ist Aufgabe des Herstellers von Insektensprays diese so zu produzieren, dass sie die Gesundheit nicht schädigen.
HW8	Im Handel erhältliche Insektensprays sind von Behörden geprüft und daher ungefährlich für die Gesundheit.
HW9	Es ist meine Verantwortung meine Gesundheit nicht mit dem Insektenspray zu schädigen.

1	1 stimme überhaupt nicht zu
2	2
3	3
4	4
5	5 stimme voll und ganz zu

Coping appraisal: Self-efficacy

Bitte geben Sie an, inwiefern Sie den folgenden Aussagen zustimmen.

SW1	Ich fühle mich dazu in der Lage, das Insektenspray wie in der Anweisung angegeben zu benutzen.
SW2	Es würde mir schwerfallen, mich genau an die Anweisungen auf dem Insektenspray zu halten.
SW3	Ich bin sicher, dass ich die Anweisungen auf dem Insektenspray genau befolgen würde.

Threat appraisal (likelihood and severity)

Für die Beantwortung der folgenden beiden Fragen, stellen Sie sich bitte vor, dass das oben beschriebene Insektenspray einmalig nicht sachgemäß verwendet wurde und die Anweisungen

auf der Verpackung nicht beachtet wurden (z.B. nicht vor Wasser geschützt verwendet, mehr Pumpstöße als vorgegeben, häufigere Anwendung).

Bitte geben Sie nachfolgend an, wie wahrscheinlich es ist, dass Menschen, Tiere und die Umwelt geschädigt werden, wenn das Insektenspray einmalig nicht sachgemäß verwendet wird.

prob1	Schaden an menschlicher Gesundheit
prob2	Schaden an tierischer Gesundheit (eigene oder fremde Haustiere)
prob3	Schaden an tierischer Gesundheit (Wildtiere)
prob4	Schaden an der Umwelt

1	1 sehr unwahrscheinlich
2	2 eher unwahrscheinlich
3	4 eher wahrscheinlich
4	5 sehr wahrscheinlich

Bitte geben Sie nachfolgend an, wie schwerwiegend Sie die Schäden an Menschen, Tieren und der Umwelt einschätzen, wenn das Insektenspray einmalig nicht sachgemäß verwendet wird.

sev1	Schaden an menschlicher Gesundheit
sev2	Schaden an tierischer Gesundheit (eigene oder fremde Haustiere)
sev3	Schaden an tierischer Gesundheit (Wildtiere)
sev4	Schaden an der Umwelt

1	1 überhaupt nicht schwerwiegend
2	2 eher nicht schwerwiegend
3	4 eher schwerwiegend
4	5 sehr schwerwiegend

Could they empathise with the scenario?

Wie gut konnten Sie sich in das beschriebene Szenario mit dem Insektenspray hineinversetzen?

1	1 ich konnte mich überhaupt nicht hineinversetzen
2	2 ich konnte mich eher schlecht hineinversetzen
3	3 ich konnte mich eher gut hineinversetzen
4	4 ich konnte mich sehr gut hineinversetzen

Grundsätzlich: Würden Sie ein Insektenspray gegen Schaben (Kakerlaken) anwenden, wenn Sie einen Befall in Ihrem Haus oder Ihrer Wohnung feststellen?

1	Ja
2	Nein

→falls Nein: Wie würden Sie mit Schaben (Kakerlaken) in Ihrem Haus oder in Ihrer Wohnung umgehen?

Additional insights regarding the comprehensibility and practicability of specific instructions

Im letzten Block möchten wir Ihnen gerne ein paar spezifische Fragen zur Formulierung von Anweisungen auf Biozid-Produkten stellen. Es geht primär darum abzuschätzen, welche Begriffe verständlich sind für die Personen, welche Biozid-Produkte in ihrem Haushalt verwenden. Antworten Sie deshalb bitte möglichst ehrlich.

Wissen Sie, was der Begriff «nicht regelmäßig nass reinigen» in Bezug auf Biozid-Produkte bedeutet (z.B. in der Anweisung «Das Produkt darf nur in Bereichen angewendet werden, die nicht regelmäßig nass gereinigt werden»)?

1	Ja
2	Nein

→ falls Ja: In Ihren eigenen Worten: Was bedeutet der Begriff « nicht regelmäßig nass reinigen » (z.B. in der Anweisung « Das Produkt darf nur in Bereichen angewendet werden, die nicht regelmäßig nass gereinigt werden. »)?

Wissen Sie, was der Begriff «punktuelle Anwendung» in Bezug auf Biozid-Produkte bedeutet (z.B. in der Anweisung «Im Außenbereich nur für punktuelle Anwendung»)?

1	Ja
2	Nein

→ falls Ja: In Ihren eigenen Worten: Was bedeutet der Begriff «punktuelle Anwendung» (z.B. in der Anweisung «Im Außenbereich nur für punktuelle Anwendung»)?

Wissen Sie, welche Bereiche in und um das Haus Sie vermeiden müssen, wenn auf einem Biozid-Produkt steht, dass es nicht in die «städtische Kläranlage» gelangen soll?

1	Ja
2	Nein

→ falls Ja: In Ihren eigenen Worten: Wo darf das Biozid-Produkt nicht angewandt werden, wenn in der Anweisung steht «Nicht anwenden, wenn das Biozid-Produkt in die städtische Kläranlage gelangen kann.»?

Bitte lesen Sie die folgende Anweisung auf einem Biozid-Produkt durch: «Um eine korrekte Dosierung zu gewährleisten, einen normalen Teelöffel verwenden. Gebrauchten Teelöffel nicht mit Wasser abspülen. Auf sichere Weise wiederverwenden oder entsorgen.»

Bitte wählen Sie aus, wie Sie sich in der Situation am ehesten verhalten würden?

1	Ich würde einen Teelöffel verwenden.

2	Ich würde einen Teelöffel aus Plastik besorgen und verwenden.
3	Ich würde das Biozid-Produkt nach Augenmaß dosieren (ohne Teelöffel).
4	Anderes. Was?

→ falls 1 ausgewählt: Sie haben vorab angegeben, dass Sie zur Dosierung einen Teelöffel verwenden würden.

Was würden Sie am ehesten nach der Verwendung des Biozid-Produktes machen (z.B. nach Abschluss der Bekämpfung oder wenn das Produkt aufgebraucht ist)?

1	Ich würde den Teelöffel im Hausmüll entsorgen.
2	Ich würde den Teelöffel von Hand oder in der Spülmaschine mit Wasser reinigen und wiederverwenden.
3	Ich würde den Teelöffel ohne Wasser reinigen (z.B. mit einem Tuch abwischen) und wiederverwenden.
4	Ich würde den Teelöffel beschriften und nur noch für ähnliche Zwecke verwenden.
5	Anderes. Was?

Socio-demographic variables

Sie haben es fast geschafft. Wir möchten uns schon einmal herzlich für Ihre Teilnahme bedanken. Am Ende des Fragebogens möchten wir gerne noch ein paar Dinge über Ihre Person erfahren.

Education

Welches ist Ihr höchster Bildungsabschluss?

1	Kein Schulabschluss
2	Hauptschulabschluss
3	Realschulabschluss (z.B. mittlere Reife, Fachoberschulreife)
4	Abitur (allgemeine Hochschulreife), fachgebundene Hochschulreife oder Fachhochschulreife
5	(Fach-) Hochschulabschluss (Bachelor, Master, Magister, Diplom, Staatsexamen, Promotion)
6	Anderes ___

Presence of children in household

Wie viele Erwachsene und Kinder wohnen in Ihrem Haushalt, wenn auch nur tageweise?

adults	Erwachsene (18 Jahre und älter)
teens	Jugendliche (13 bis 17 Jahre)

school	Kinder im Schulalter (7 bis 12 Jahre)
preschool	Kinder im Vorschulalter (3 bis 6 Jahre)
babies	Babies und Kleinkinder

Relevant job

Sind Sie in einer Branche (Gewerbe, Handel, Industrie) tätig, welche chemische Produkte herstellt, importiert, handelt oder verwendet (z.B. Landwirtschaft, Hausmeister)?

1	Ja
2	Nein

Place and circumstances of residence

Was trifft am besten auf Ihren momentanen Wohnort zu?

1	Stadt
2	Land

Verfügen Sie in Ihrem Zuhause über einen Keller?

1	Ja
2	Nein

Verfügen Sie in Ihrem Zuhause über einen Balkon, eine Terrasse oder einen Garten oder haben Sie einen Klein- oder Schrebergarten?

1	Nein
2	Balkon oder Terrasse
3	Garten oder Rasenfläche
4	Klein- oder Schrebergarten an einem anderen Standort
5	Anderes ___

Haben Sie momentan ein Haustier in Ihrem Haushalt (z.B. Katze, Hund, Kaninchen, Vogel, Meerschweinchen, Hamster)?

1	Ja
2	Nein

Zum Abschluss noch eine Frage zu einem anderen Thema:
Wie hoch schätzen Sie die Gesundheitsgefährdung der Deutschen Bevölkerung aufgrund der nachfolgenden Themen ein?

comp_1	Pestizide bzw. Pflanzenschutzmittelrückstände auf Obst und Gemüse
comp_2	Rückstände von Antibiotika im Fleisch und Fisch
comp_3	Putzmittel mit synthetischen (künstlich hergestellten) Chemikalien

1	sehr niedrig
2	
3	
4	
5	
6	sehr hoch

Concluding remarks

Möchten Sie uns gerne noch etwas mitteilen?

B Appendix: Response distributions of single items

Tables B.1 to B.6 present the response distributions for the single items of the PMT variables.

Table B.1: Response distribution of protection motivation (*N* = 1062)

	1 do not agree at all	2	3	4	5 fully agree	do not know
Compliance with instruction						
I would only use the insect spray in areas that are protected from water.	46 (4%)	62 (6%)	179 (17%)	232 (22%)	477 (45%)	66 (6%)
I would pay close attention to how many pumps per m^2 are given in the instructions and follow them exactly.	89 (8%)	147 (14%)	241 (23%)	209 (20%)	323 (30%)	53 (5%)
I would only use the insect spray in cracks or crevices.	38 (4%)	57 (5%)	195 (18%)	281 (27%)	437 (41%)	54 (5%)
When applying, I would pay close attention to the minimum distance between two pump strokes.	75 (7%)	140 (13%)	233 (22%)	280 (27%)	279 (26%)	55 (5%)
Opposing the instruction						
I would use the insect spray everywhere where cockroaches are present.	309 (29%)	175 (17%)	215 (20%)	186 (18%)	132 (12%)	45 (4%)
I would use as much insect repellent as necessary, even if it is more than the number of pumps specified in the instructions.	279 (26%)	204 (20%)	223 (21%)	206 (19%)	109 (10%)	41 (4%)
I would also use the insect spray in the kitchen or bathroom if cockroaches are present there.	382 (36%)	178 (17%)	181 (17%)	153 (14%)	104 (10%)	64 (6%)
I would use the insect spray again if there were still cockroaches the next day.	334 (32%)	170 (16%)	204 (19%)	171 (16%)	129 (12%)	54 (5%)

Table B.2: Response distribution of threat appraisal: likelihood (*N* = 1062)

	1 very unlikely	2 rather unlikely	3 rather likely	4 very likely
Harm to human health	53 (5%)	351 (33%)	485 (46%)	173 (16%)
Harm to animal health (own pets or other people's pets)	32 (3%)	204 (19%)	516 (49%)	310 (29%)
Harm to animal health (wild animals)	70 (7%)	332 (31%)	429 (40%)	231 (22%)
Harm to the environment	51 (5%)	239 (23%)	479 (45)	293 (28%)

Table B.3: Response distribution of threat appraisal: severity (*N* = 1062)

	1 not severe at all	2 rather not severe	3 rather severe	4 very severe
Harm to human health	77 (7%)	501 (47%)	360 (34%)	124 (12%)
Harm to animal health (own pets or other people's pets)	41 (4%)	333 (31%)	491 (46%)	197 (19%)
Harm to animal health (wild animals)	86 (8%)	401 (38%)	415 (39%)	160 (15%)
Harm to the environment	64 (6%)	373 (35%)	426 (40%)	199 (19%)

Table B.4: Response distribution of coping appraisal: response efficacy (*N* = 1062)

	1 do not agree at all	2	3	4	5 fully agree
If you follow the instructions on the insect repellent exactly, you protect your health.	68 (6%)	94 (9%)	327 (31%)	321 (30%)	252 (24%)
If you follow the instructions on the insect repellent exactly, you will ensure its effectiveness.	25 (2%)	75 (7%)	304 (29%)	413 (39%)	245 (23%)
If you follow the instructions on the insect repellent exactly, you protect the environment.	106 (10%)	144 (14%)	370 (35%)	256 (24%)	186 (17%)

Table B.5: Response distribution of coping appraisal: self-efficacy (*N* = 1062)

	1 do not agree at all	2	3	4	5 fully agree
I feel able to use the insect spray as instructed.	21 (2%)	53 (5%)	187 (18%)	341 (32%)	460 (43%)
I would find it difficult to follow the instructions on the insect repellent exactly.	327 (31%)	247 (23%)	213 (20%)	190 (18%)	85 (8%)
I am sure that I would follow the instructions on the insect spray exactly.	30 (3%)	97 (9%)	265 (25%)	328 (31%)	342 (32%)

Table B.6: Response distribution of locus of control (*N* = 1062)

	1 do not agree at all	2	3	4	5 fully agree
It is my responsibility not to harm the environment with the insect spray.	28 (3%)	54 (5%)	198 (18%)	318 (30%)	464 (44%)
It is my responsibility not to damage my health with the insect spray.	15 (1%)	49 (5%)	178 (17%)	299 (28%)	521 (49%)
Commercially available insect sprays have been tested by the authorities and are therefore safe for the environment.	272 (26%)	230 (22%)	350 (33%)	143 (13%)	67 (6%)
Commercially available insect sprays have been tested by the authorities and are therefore safe for health.	263 (25%)	232 (22%)	340 (32%)	164 (15%)	63 (6%)
It is the responsibility of the manufacturer of insect sprays to produce them in a way that does not harm the environment.	39 (4%)	90 (8%)	270 (25%)	303 (29%)	360 (34%)
It is the responsibility of the manufacturer of insect sprays to produce them in such a way that they do not harm health.	48 (4%)	91 (9%)	255 (24%)	293 (28%)	375 (35%)

C Appendix: Comparability with prior study

Due to the acute pandemic and complex political situation in Germany in November and December 2021, the data collection was postponed once to January 2022. The concern was that participants' responses would be impacted by the context, which would bias the conclusions that could be drawn from this study. To check for potential impacts of the situation, three measures were included from a prior study on chemical risk perception in Germany (Buchmuller, Bearth, & Siegrist, 2022). The data collection in 2020 also occurred during the SARS-CoV-2 pandemic, however, in the summer during a time of lower infection rates and less preventive measures compared to 2022. In the 2020 study, a smaller sample was collected compared to this study (N = 561). However, the samples are comparable in sex and age distribution.

Table C.1 shows the descriptives of the three included risk measures in comparison. The participants were asked to judge how high they estimate the risk for the German population originating from three different topics (response options: 1 "very low" to 6 "very high"). A comparison of the means suggested that for two of the three topics, namely pesticides or pesticide residues on fruit and vegetables ($t(1621) = 2.7$, $p = .007$) and antibiotic residues in meat and fish ($t(1621) = 2.8$, $p = .005$), risk perception was significantly lower in 2022 compared to 2020. The risk perception for cleaning agents with synthetic (man-made) chemicals in 2022 was comparable to 2020, $t(1621) = 1.4$, $p = .168$. However, the effect sizes for these differences were small, which means that these effects should not be overrated.

Based on these results, it is possible that the German public's risk awareness and perception of biocidal products is underestimated in this study because individuals are currently more focused on the pandemic. However, it is not expected that the results would have varied much if they were collected at a different time. Particularly, the experimental and correlational results of this study are highly robust and should not have been impacted by the situation.

Table C.1: Comparison of responses to three risk measures between study from 2020 (Buchmuller et al., 2022) and this study.

	2020		2022	
	M	*SD*	*M*	*SD*
Pesticides or pesticide residues on fruit and vegetables	4.5	1.2	4.3	1.2
Antibiotic residues in meat and fish	4.7	1.2	4.5	1.3
Cleaning agents with synthetic (man-made) chemicals	4.1	1.2	4.0	1.3

D Appendix: Open responses

The participants were asked at the end of the questionnaire whether they wanted to tell us anything. Analysing these responses can be illuminating and might add new ideas for future studies. A large number of participants used the open response field to provide positive feedback regarding the subject and survey (n = 72; e.g., interesting, important, well-designed) or provide more or less constructive feedback (n = 8; too long, boring). The more detailed responses are listed below.

Table D.1: German responses in the open response field.

	Responses in German
1	Ich nehme solche Pestizide sehr selten, ich habe Hauskatzen, die nur ins Fenster kommen, meine Kanarien waren noch nie krank oder hatten irgendwelches Ungeziefer, die Ameisen waren mal schlimm, der ganze Küchentisch & die Schränke waren voll, ich habe es erst mit Backpulver & sonstige Hausmittel probiert, ging aber nicht, habe dann Pulver gekauft, danach in die Mülltonne geschmissen! Das ist aber schon ein paar Jahre her!
2	Auf den Produkten steht oft nicht, ob Handschuhe oder ein Mund- oder Augenschutz benötigt wird. Oder dass unverzüglich nach Anwendung die Hände gewaschen werden müssen. Diese Hinweise sollten unbedingt mitgegeben werden!
3	Ich versuche Chemikalien in meinem Haushalt zu vermeiden und putze mit Easyclean.
4	Die Fragen waren sehr produktbezogen solche Produkte verwende ich sehr selten
5	Die Fragestellung bei den Bioziden ist meist so, dass der Befragte nach meiner Meinung meistens auf die negativste Antwort hingeschoben wird. Das ist in diesem Befragungszyklus meiner Ansicht nach auf jeden Fall erkennbar. Es würde mich interessieren, was Sie von dieser meiner Meinung halten, denn schliesslich heißt das Befragungsforum ja MEINUNGSPLATZ!
6	Die Umfrage hat mir sehr gut gefallen und ich habe sie auch sehr gerne beantwortet. Im Alltag macht man sich über solche Themen weniger Gedanken, da man diese Produkte sehr selten benutzt. Dies war eine sehr interessante Umfrage, vielen Dank und Ihnen einen schönen Tag.
7	Es ist absolut möglich, dass ich falsch liege, aber ich finde, wir verschmutzen unsere Umwelt zu sehr, sind aber aufgrund der hohen Industrie und Enge sowie das Überangebot gezwungen, Gift einsetzen zu müssen. Was die Gefahr birgt, dass wir uns und unser Haus und Nutztiere mit vergiften, schleichend aber unweigerlich.
8	Es wäre schön, wenn mehr auf weniger umweltschädliches und gesundheitsschädliches geachtet werden würde! Und es mehr umweltfreundliche Mittel im Supermarkt/Drogeriemarkt gäbe.
9	Hausmittel sind manchmal die beste Wahl :)
10	Ich berücksichtige in der Dosierung der Mittel manchmal den Verdacht mit ein, dass seitens der Hersteller der Wunsch besteht, höhere Mengen des Produkts zu verwenden, um schneller ein neues Produkt zu kaufen. Wenn auf dem Anwendungsbereich sehr stark auf einzelne Bereiche beschränkt ist, wende ich das Produkt öfters auch an ähnlichen Bereichen an, auch wenn sie nicht auf der Packung angegeben sind, um mir nicht extra ein neues Produkt zu kaufen. Ich kaufe mir öfters erst dann ein neues chemisches Produkt, falls ein ähnliches, zuvor ausprobiertes nicht hilft.
11	Ich besitze keine Biozide, verwende keine, etwaiger Flohbefall meiner Katze wird bestens mit Kieselerde beseitigt. Ameisen dürfen auf meiner Terrasse leben...

	Responses in German
12	Ich bin der Meinung, dass man nicht gleich immer mit Kanonen auf Spatzen schießen muss. Es gibt sicherlich genug Hausmittel, um z.B. Ameisen in der Wohnung wieder loszuwerden und bei Wespen muss sowie professionelle Hilfe geholt werden.
13	Ich bin pragmatisch und es geht mir zuallererst darum das gewünschte Ergebnis zu erzielen. Die Einhaltung der empfohlenen Regeln reduziert die Wirksamkeit und auch das Anwendungsgebiet. Ich würde zuerst immer versuchen mich strikt an die Regeln zu halten. Wenn das Produkt wirkt, dann ist alles gut. Wenn das Produkt nicht wirkt, würde ich in einem zweiten Versuch einige Regeln mißachten, z. Bsp. die doppelte bis dreifache Dosis verwenden und großflächiger anwenden aber auch mehr Vorsicht walten lassen, also absperren, lüften etc.
14	Ich habe einen Master-Abschluss in Wirtschafts- und Sozialwissenschaften des Landbaus und war 34 Jahr in der Entwicklungszusammenarbeit in Asien, Afrika, Süd-Amerika und Ozeanien tätig. Was einem da so an Ungeziefer in Haus und Garten begegnet...
15	ich nutze seit Jahren umweltschonende Wasch- und Putzmittel der Firma Amway. Das ist mein Beitrag zu dem Thema.
16	Ich verwende nur biologisch abbaubare Produkte, ich finde diese persönlich viel besser. Diese Produkte greifen nicht die Umwelt an, damit bin ich sehr zufrieden.
17	Ich weiß nicht, ob ich Menschen solche Mittel zur Verfügung stellen würde. Es gibt nur wenig vernünftig eigenverantwortlich handelnde Menschen. Daher bin ich dagegen.
18	Ich würde mich über ökologische Mittel gegen Schädlingsbekämpfung freuen, die nicht der Umwelt schaden.
19	Ich würde mir wünschen, dass auch Produkte vom Ausland untersucht und bei zu hohem Gesundheitsrisiko verboten werden
20	Zum Schutz von Mensch und Tier wünschte ich mir, dass die ganzen Pestizide verboten würden. Man muss nicht jede Schabe oder Ameise mit der chemischen Keule umbringen. Diese Tiere gehören nun Mal zum funktionierenden Ökosystem dazu. Die Bienen sind schon fast ausgerottet.