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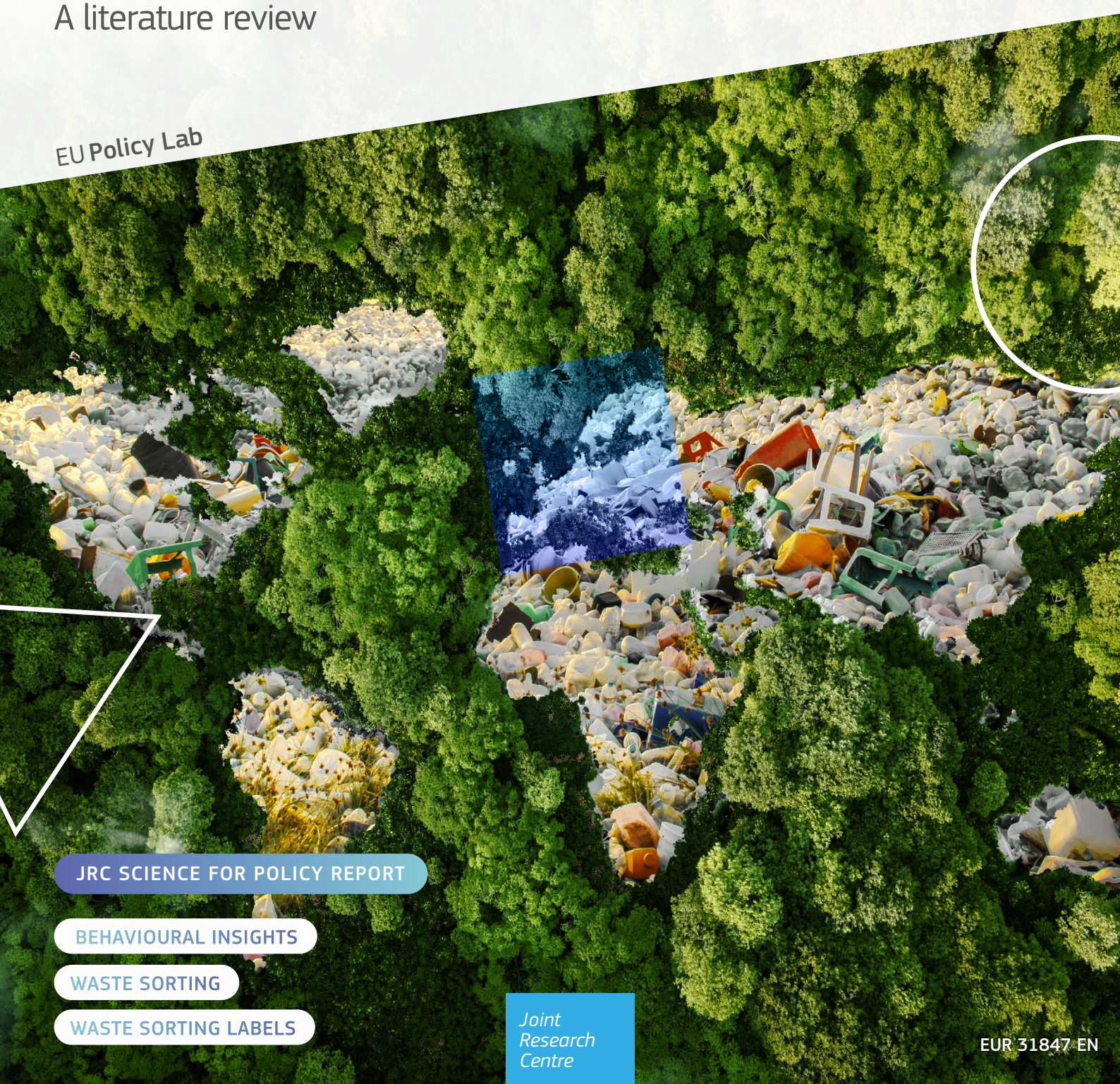
BEHAVIOURAL INSIGHTS FOR WASTE-SORTING LABELS IN THE EUROPEAN UNION

A literature review

EU Policy Lab



JRC SCIENCE FOR POLICY REPORT

BEHAVIOURAL INSIGHTS

WASTE SORTING

WASTE SORTING LABELS

Joint Research Centre

EUR 31847 EN

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Behavioural insights for waste-sorting labels in the European Union

A literature review

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Abstract

As part of the transition to a circular economy, the EU has been introducing a diverse range of initiatives along the entire life cycle of products. One such initiative aims to increase municipal recycling rates by improving household and packaging waste collection, sorting and recycling by consumers through the use of EU harmonised waste-sorting labels. To inform the evidence-based design and empirical testing of such labels, this report reviews the behavioural science literature for insights into the design of waste-sorting labels. The report derives key lessons, insights and implications from the literature reviewed and suggests concrete recommendations for the design of an effective and valued harmonised labelling system. Through careful interpretation of the limited evidence, the report provides insights regarding various crucial characteristics of waste-sorting labels, namely their presentation (in terms of clarity benefitting from consistent placement, conciseness, persuasiveness, compatibility with other labels, inclusion of instructions for the preparation of packaging components, minimum size, actionability/intuitiveness and consistent use of text and graphical elements), accessibility (the use of colours and of complementary digital solutions, actionability/ intuitiveness, consistent use of text an graphical elements, minimum size, and clarity of presented information), and quality and content (in terms of perceived quality benefitting from accuracy, factuality, resistance to destruction, and consistent use of text and graphical elements). Taken together, these lessons, insights and recommendations can feed into a participatory and empirical approach to designing EU harmonised waste-sorting labels.

Foreword

This report is an outcome of the work conducted by the Joint Research Centre, together with scientific experts, under part 2 (on medium-term actions) of the administrative agreement for support for the 2020 circular economy action plan (CEAP 2.0).

Acknowledgements

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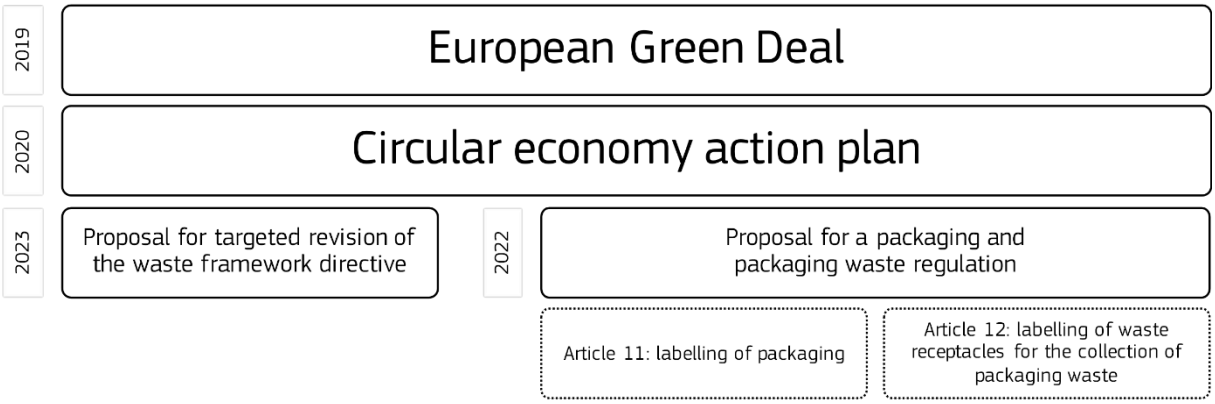
Executive summary

As part of the transition to a circular economy, the EU has been introducing a diverse range of initiatives along the entire life cycle of products. One such initiative aims to increase municipal recycling rates by improving household and packaging waste collection, sorting and recycling by consumers through the use of EU harmonised waste-sorting labels (WSLs). To inform the evidence-based design and empirical testing of such labels, this report reviews the behavioural science literature for insights on the design of WSLs. The report derives key lessons, insights and implications from the literature reviewed and suggests concrete recommendations for the design of an effective and valued harmonised labelling system.

Policy context

Figure ES1. EU policies relevant for waste sorting labels



The **proposal for a packaging and packaging waste regulation** mandates the use of harmonised WSLs that identify materials on both product packaging and waste receptacles, addressing the current disparity in information across EU Member States. EU policies relevant to WSLs are shown in Figure ES1.

The Directorate-General for Environment tasked the Joint Research Centre (JRC) with providing information for and guiding the design of an EU harmonised waste-sorting labelling system. The present literature review for informing the design of WSLs is one deliverable. It adopts a behavioural perspective, examining the impact of WSLs and recycling labels on consumer perception, understanding, behavioural intention to sort waste and actual waste-sorting and recycling behaviour.

Key conclusions

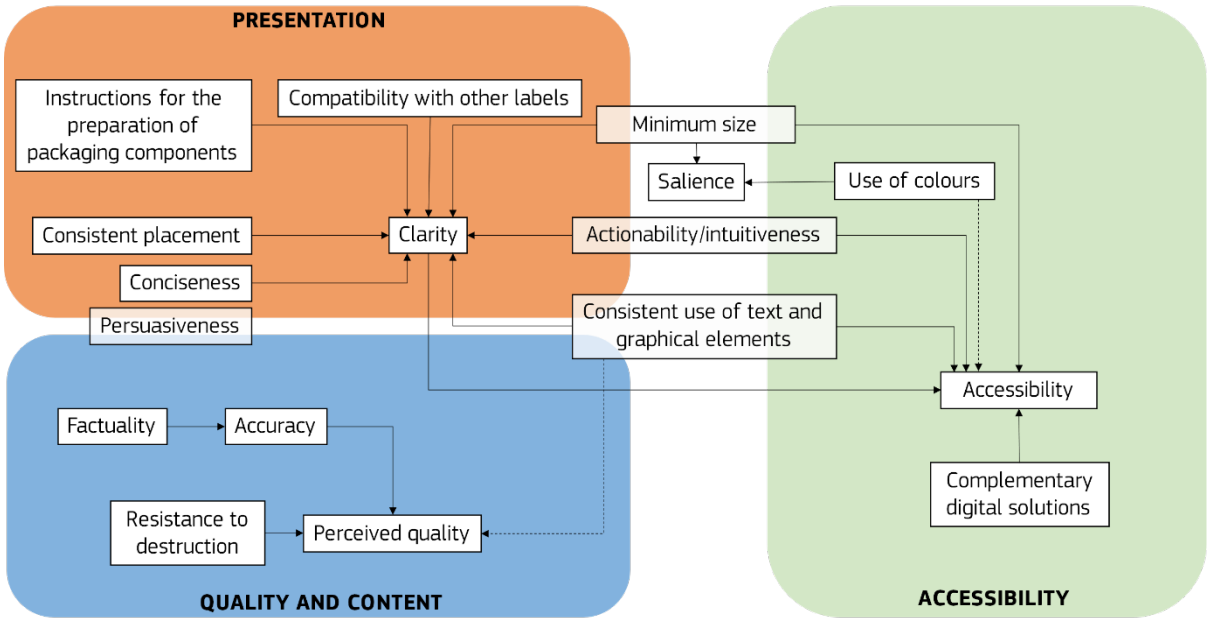
We first acknowledge the **scarcity of robust and reliable evidence from the behavioural science literature** focused on the design of WSLs. Nevertheless, this review provides some pertinent insights, which are visualised and described in Figures ES2 and ES3.

When designing WSLs, three critical factors must be carefully considered:

1. **presentation**, that is, how information is displayed on the labels, with a strong emphasis on clarity to ensure that the message is easily understood;
2. **quality and content**, that is, the substance and perceived value of the labels, focusing on the information provided, independent of its presentation style;
3. **accessibility**, that is, how user-friendly the labels are and if they cater to a broad audience, including people with diverse needs.

Figure ES2 illustrates the key design elements to consider for each of these factors, highlighting their interrelations. Design principles and their definitions are shown in Figure ES3 (see also Table 3 in the conclusion section).

Figure ES2. Graphical representation of design insights and their relations to each other (indicated by arrows) across the three main topics



We also recommend carefully considering the following aspects, ideally through experimental testing.

- Consumer attention is key, as it has to be captured for new labels and maintained for existing labels. This may require innovative, attention-grabbing updates to WSLs, especially as waste streams evolve, to ensure correct and long-term label engagement.
- Sorting multicomponent packaging requires cognitive and physical effort for correct sorting, augmenting the need to consider the design elements and principles in Figures ES2 and ES3.
- On-receptacle labels offer flexibility in conveying essential sorting information, which is not possible with on-pack labels alone, although consistency between both label types is critical.
- On-pack labels should enhance packaging value and complement its design, including disassembly instructions, to encourage correct disposal practices.
- The design of WSLs should consider existing waste management instruments, such as recycling labels, pay-as-you-throw models and deposit refund schemes, to ensure consistency of information across instruments.
- Robust educational and information campaigns can support WSLs by enhancing their salience and understanding, addressing the gap in consumer knowledge for effective label use.
- WSLs can play a social role by highlighting waste sorting as a socially important and desirable action.
- WSLs have limitations, as positive perceptions and understanding do not automatically translate into effectiveness.

Main findings

On-pack labels and packaging design

- Labels must be designed consistently for **clarity, readability, noticeability, understandability** and **relevance to the packaging material**, ensuring a **clear relationship between labels and materials**. This is even more important when WSLs are positioned next to labels sending different messages.
- A nuanced approach is needed to **cater to different consumer perceptions and responses**, with extensive **testing** for optimisation.
- Labels should facilitate ease of understanding and action, avoiding vague messages, and should be **easily removable** and **recyclable**.
- **Digital solutions** (e.g. QR codes) can provide additional information without requiring additional space.

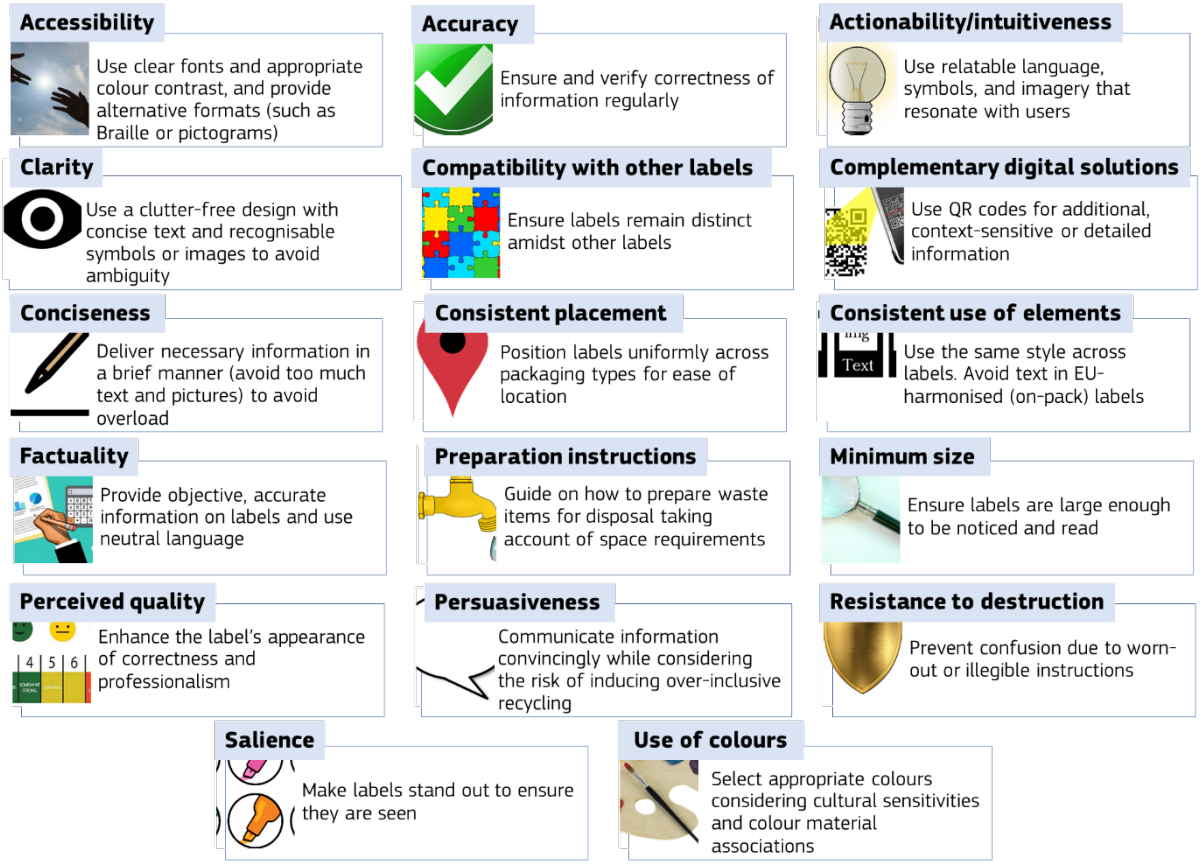
On-receptacle labels and receptacle design

- **Clear, actionable instructions** on receptacle labels complement on-pack labels by providing more space for detailed sorting information.
- The design should focus on **salient, easily understandable, consistent** and **well-positioned** labels that avoid information overload and are adaptable to changing waste management protocols.
- Colour selection for labels should consider **cultural associations and consumer experiences**, to enhance recognition.
- Labels should **display only a few frequently discarded items**, to bridge users' knowledge gaps.
- The integration of **pro-environmental messages requires careful consideration**, to avoid confusion and enhance the motivational aspect of waste sorting.

Multicomponent/multi-material packaging

- Consumers prefer and recycle single-component and single-material packaging more effectively, highlighting the **importance of simplicity**.
    - Packaging requiring disassembly should be designed for easy separation, while labels should offer **clear instructions for disassembly and sorting**, to minimise confusion and errors.
    - The consumer experience should be considered when designing and labelling packaging.

Figure ES3. Design principles and their definitions



Related and future JRC work

The JRC is working on / has planned the following: (1) a report presenting Eurostat data on packaging waste, describing WSLs in the EU and advancing the conceptual understanding of harmonised WSLs; (2) country sheets providing an overview of packaging waste- and WSL-related information in all EU Member States; (3)

participatory stakeholder workshops; and (4) an evidence-based technical proposal for harmonised labelling specifications in cooperation with external contractors. The technical proposal will inform the implementing acts that will follow 18–24 months after the date of entry into force of the packaging and packaging waste regulation to establish the methodology for identifying the material composition of packaging.

Quick guide

WSLs are visual elements that inform consumers of how to properly dispose of waste materials, whether recyclable or not, according to the relevant separate waste collection system. They can be affixed to receptacles (e.g. bins) and packaging. This review highlights several challenges in evaluating the effectiveness of WSL design in terms of consumer attitudes and behaviour. These challenges include the limited number of direct comparisons, concerns over the quality of certain studies and the lack of applicability of non-EU-conducted research. Additionally, the predominance of correlational over causal evidence and the context dependency of the findings highlight the need for cautious interpretation and application of the insights.

1. Introduction

The global amount of waste is staggering: by 2050, worldwide municipal solid waste (MSW) is expected to increase by roughly 70 % to 3.4 billion metric tonnes (Statista, 2023a). In 2021, the 27 Member States of the EU produced over 235 million metric tonnes of MSW, averaging 527 kg of MSW per EU citizen – almost 1.5 kg of waste per day, per citizen. In terms of total waste, the EU ranks second between the United States in first place (265.2 million metric tonnes in 2018) and China in third place (215.2 million tons in 2017) – accounting for roughly 17 % of global MSW production (Statista, 2024). MSW covers household waste and waste similar in nature and composition to household waste, such as organic materials from municipality services, waste from public waste bins, market cleansing waste and cemetery waste (European Commission, 2016). Households and individuals are significant waste contributors, as evidenced by the more than 200 million metric tonnes of household waste in the EU in 2020, around 455 kg per capita ([1]).

However, **households and individuals are also key in recycling and reducing the waste** that they create. Recycling – which is defined in the waste framework directive (WFD; Directive 2008/98/EC) ([2]) as any recovery operation by which waste materials are reprocessed into products, materials or substances, whether for the original or other purposes (including the reprocessing of organic material but not including energy recovery or reprocessing into materials that are to be used as fuels or for backfilling operations) – is one potential destination of waste besides incineration, landfill, and composting and fermentation (European Commission, 2016). As recycling is necessary to achieve zero waste, it is an important aspect of the EU's path to a circular economy. The transition to a circular economy is in line with sustainable development goal 12, which focuses on ensuring sustainable consumption and production patterns, changing the way people consume, produce and dispose of items, and of the European Green Deal (EGD). Achieving zero waste can be considered one, if not *the*, hallmark of a truly circular economy. In the WFD, the EU sets targets for the reuse and recycling of MSW in Europe, with weight-based national targets of 55 %, 60 % and 65 % by 2025, 2030 and 2035, respectively ([3]). These targets are set against a backdrop of an average recycling rate of 49.6 % for municipal solid waste in the EU in 2021, with considerable variation among Member States, ranging from 11 % to 71 % (Eurostat, 2023a).

Packaging waste is a crucial component of municipal and household waste: it represented around 36 % of per capita municipal solid waste in 2021. The EU packaging and packaging waste directive (PPWD; Directive 94/62/EC) ([4]) defines packaging as encompassing products to be used for the containment, protection, handling, delivery and presentation of goods, including 'non-returnable' items used for the same purposes. The average European produced around 189 kg of packaging waste in 2021 – a bit more than 0.5 kg per day per citizen – amounting to almost 85 million metric tonnes in the EU. In the same year, the EU achieved a 64 % recycling rate of packaging waste, varying between 38.4 % and 80.4 % across Member States. Reducing packaging waste and packaging in general are central goals of the EU, which has introduced recovery and recycling targets for packaging waste. To that effect, empowering EU citizens to recycle and sort their packaging waste in line with their resident country's separate waste collection (SWC) scheme is key, as consumer sorting is a step towards high recycling rates. This is particularly relevant with the rise of online shopping, which often results in extensive packaging waste, a phenomenon that accelerated during the COVID-19 pandemic and that is expected to persist (Eurostat, 2021; Statista, 2021, 2023b).

The EU's waste management policy seeks to minimise the environmental and health impacts of waste while enhancing resource efficiency. Long-term goals include waste reduction, promoting the use of waste as a resource, increasing recycling and ensuring safe disposal. To that effect, the PPWD aim is to reduce packaging waste and increase reuse, recycling and other forms of recovery of packaging waste. While there are several strategies to achieve these goals (Cristobal Garcia et al., 2022; EEA, 2023), one strategy is to use labels to improve consumer waste collection, sorting and recycling, as suggested in the Commission proposal for a packaging and packaging waste regulation (PPWR; European Commission, 2022).

([1]) See Eurostat (2023b) for the dataset and European Commission (2016) for a detailed description of the difference between municipal and household waste.

([2]) Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain directives (OJ L 312, 22.11.2008, p. 3).

([3]) In accordance with Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste (OJ L 150, 14.6.2018, p. 109), Member States may postpone the deadline for attaining any target by up to 5 years, providing they fulfil certain conditions.

([4]) European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste (OJ L 365, 31.12.1994, p. 10; consolidated version: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A01994L0062-20180704).

Increased household sorting efficiency of paper, metals, glass, hard plastic and bottles improves the environmental performance of household waste management systems in general (Andreasi Bassi et al., 2017). However, an EU-wide survey from 2014 revealed that there were diverse waste-sorting practices among Member States and that there was considerable room for improvement. Identified by 51 % of respondents to the survey as an impactful measure, more home waste reduction and better sorting can contribute to such improvement. Furthermore, 48 % stated that 'more information on how and where to separate waste' would convince them to separate more of it (European Commission, Directorate-General for Environment, 2014).

Engaging communication, including clear signage and instructions, plays a crucial role in informing and convincing households to sort waste (European Commission, 2020, p. 50). At the points of purchase, usage and disposal, product packaging is an often-used vehicle for such communication (Mielinger and Weinrich, 2023). Waste-sorting labels (WSLs) on both receptacles and product packaging can facilitate waste sorting for consumers, complementing economic incentives and awareness and information campaigns (Cristobal Garcia et al., 2022). WSLs aim to support consumers in disposing of product packaging and other waste materials in the appropriate waste receptacles. In fact, in some EU Member States, voluntary or mandatory WSLs already exist. However, to avoid the continued proliferation of incompatible schemes and labels throughout the EU, which have the potential to create barriers to the internal market, the proposed PPWR aims to implement a harmonised WSL system in the EU.

This report reviews behavioural science evidence to guide the evidence-based design of consumer-facing WSLs, deriving key lessons, insights and implications from the literature to make concrete recommendations. The report begins by detailing the objectives and scope of the review, including key concepts and definitions used. Following this, the report provides an overview of the policy background in the EU and outlines the methodology used to identify the relevant literature, with subsequent chapters presenting key findings, lessons and insights for label design. The report concludes with some critical remarks and design insights.

2. Objectives, scope and definitions

2.1. Main objectives

The main objective of this report is to gather insights from the behavioural science literature to guide the design of consumer WSLs. It presents the main insights from the literature reviewed to inform the effective design of WSLs and derives concrete and evidence-based recommendations. The primary focus is on studies that provide original empirical and experimental data, although other types of evidence were considered if they offered relevant insights. The relevant evidence primarily explores the impacts of WSLs on waste-sorting behaviour and attitudes, as well as the factors influencing how WSLs are perceived, understood and valued. Additionally, we include some of the literature addressing packaging and receptacle design to the extent that it provides insights relevant to WSLs.

2.2. Scope and key concepts

As already noted, consumers play an important role in SWC, which is defined in the WFD as collection whereby a waste stream is kept separately by type and nature so as to facilitate a specific treatment ([5]). The aim of WSLs is to aid consumers in this process. This report focuses on WSLs, their effective design and their potential to enhance consumer waste sorting. While we also consider recycling labels, as applicable insights may relate to WSLs, recycling labels have slightly different objectives from WSLs. To distinguish between WSLs and recycling labels, it is crucial to clarify the following terms.

— **Waste sorting**, also known as source separation or selective sorting, involves separating different types of waste materials at the source or point of generation. It includes categorising and separating waste items based on their material composition (e.g. paper, plastic, glass or organic waste) or other characteristics (e.g. recyclable, non-recyclable or hazardous). Individuals or households often sort waste to facilitate proper recycling, recovery and disposal in later stages. This practice manages waste by directing specific materials to appropriate waste streams, reducing contamination and enhancing resource recovery.

— **Recycling** is the process of converting waste materials into new products, reducing the need for raw materials and minimising environmental impacts associated with resource extraction and waste disposal. It involves collecting, sorting, processing and transforming waste materials into raw materials that can be used for manufacturing new goods ([6]).

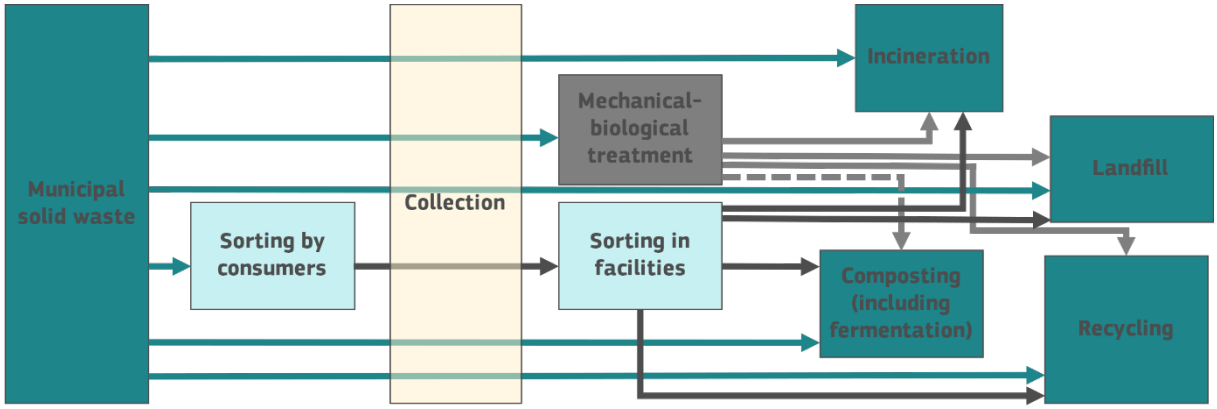
— **Recycling behaviour**, more specifically, involves individuals placing recyclable materials into the appropriate designated waste collection receptacles destined for recycling operations.

Waste sorting can be understood as a central component or prerequisite of recycling. At the same time, recycling behaviour can be understood as a specific type of waste sorting. To recycle, consumers must identify and segregate recyclable materials from the waste stream and place them in dedicated recycling receptacles – a form of sorting waste. In the WFD, recycling is considered a treatment operation of municipal solid waste, while waste sorting is considered a pre-treatment operation (Figure 1). Notably, in Figure 1, waste sorting refers to waste sorting by both consumers and sorting facilities. To be even more precise, consumer waste sorting precedes sorting conducted in sorting facilities.

([5]) SWC can be strict (e.g. collecting paper and polyethylene terephthalate (PET) bottles separately) or employ varying degrees of joint collection (e.g. collecting packaging metal, plastics and composite material together or collecting paper and packaging together) (Seyring et al., 2015).

([6]) Article 3(17) of the WFD defines recycling as 'any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes'.

Figure 1. Municipal solid waste treatment options



Source: Based on European Commission (2016).

2.2.1. Waste-sorting labels versus recycling labels

Recycling labels and WSLs serve related but distinct purposes, and their boundaries can be fluid. In this report, we specifically refer to consumer-facing labels, that is, those designed to inform consumers rather than waste facilities. When we refer to visual elements as label constituents, we are referring to the symbols, pictograms, pictures, text, colours, etc., that are frequently used on labels and that serve the label's purpose.

- **Recycling labels** are the visual elements that inform consumers about waste items that can be recycled by disposing of them in a certain way, typically by throwing them in a specific receptacle. Their main purpose is to help consumers understand if the waste can be recycled and, if so, how to do it properly.
- **WSLs** are the visual elements that inform consumers of how to properly dispose of waste materials, whether recyclable or not, according to the relevant SWC system.

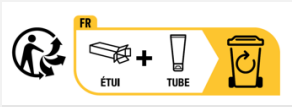
Both **recycling labels and WSLs aim to encourage and enable consumers to separate waste into different categories when collecting and/or disposing of waste** (i.e. at the source). The WFD states that Member States must set up separate collection at least for metal, plastic, glass and paper, as well as for biowaste, by the end of 2023, and for textiles by January 2025. Recycling labels can be regarded as a specific type of WSL. While they signal to consumers to dispose of waste in a particular way, and often in a particular receptacle, they often highlight a characteristic (e.g. that the item is recyclable) rather than instruct consumers on what to do with that information. This is quite a subtle distinction, but one that we think is worth making. Table 1 provides examples of WSLs and recycling labels. The term 'labels' is used as an umbrella term throughout this report to cover both WSLs and recycling labels when the articles reviewed did not distinctly differentiate between the two.

It is important to distinguish recycling labels from PRO Europe's Green Dot (Figure 2). The Green Dot does not necessarily indicate recyclability, recycling or the use of recycled materials. Widely recognised in European countries, it signifies that the brand owner or importer of the packaged product has contributed to the national compliance system, supporting recovery and recycling through a levy. This symbol is frequently misinterpreted by consumers as a label indicating recyclability and can thus lead to confusion and insecurity on how to best dispose of an item bearing that label (Recoup, 2019).

Figure 2. The Green Dot by PRO Europe

Source: PRO Europe (n.d.).

Table 1. Examples of recycling labels and WSLs

Type of label	Label name	Label	Label description
Recycling label	Mobius loop	 *Source:* Coda (2016).	The Mobius loop, which is frequently used on products sold in the EU, the United States and the United Kingdom, designates recyclable products or packaging materials (without guaranteeing that they will be accepted at all recycling locations). Its aim is to encourage and raise awareness about the recyclability of materials. Combined with a percentage in the middle, it indicates that packaging is made of the indicated percentage of recycled materials (Coda, 2016).
	MyWaste.ie symbol	 *Source:* Repak (n.d.).	MyWaste.ie is an initiative implemented by the Regional Waste Management Offices on behalf of the Department of the Environment, Climate Action and Communications of Ireland. It has developed its own symbols for use on packaging in Ireland. The symbol indicates that packaging can be recycled in a household recycling bin (left), that parts of the packaging can be recycled while other parts have to go to general waste (middle) or that an item is not recyclable at all (right) (Repak, n.d.).
WSL	Info-tri	 *Source:* Landes (2022).	In France, while the Triman logo (i.e. the person and three arrows on the left) indicates that a product or its packaging can be recycled, akin to a recycling label, the 'Info-tri' (i.e. the content in the yellow frame) guides consumers in correctly sorting packaging waste. More specifically, this WSL indicates which part of the packaging (in this example, the box and tube) should go into which bin. The plus sign indicates that components should be separated before disposal (Citeo, 2022).
	Verpackungslogo	 *Source:* Trennhinweis e.V. (2022).	The *Verpackungslogo* (English: packaging logo) was developed by the German non-governmental organisation Trennhinweis e.V. The arrows symbolise the circular waste stream for packaging materials (one to three arrows are commonly found on the labels, depending on the number of materials going to separate waste streams), while the bin and bag symbols indicate the correct destination(s) of the waste material(s). The material composition (in the case of packaging made of multiple materials) and a QR code to access further information can be included in the label (Trennhinweis e.V., 2022).

		 *Source:* https://www.waste-separation.eu/.	
	Nordic pictogram system	 *Source:* Danish Waste Association and Futu (n.d.).	The Nordic pictogram system – developed by the Danish Waste Association, Local Government Denmark, the Danish Environmental Protection Agency and the Futu Design Agency – can be used both on receptacles and on product packaging. It specifies the correct destination of waste materials by establishing visual correspondence between the materials and the bins they are attached to. On the label itself, the materials are visually and textually indicated, and categories of materials are highlighted using colours. The labelling system covers a wide range of waste fractions and materials beyond packaging (Eupicto, n.d.).

Source: Authors' own creation.

WSLs can be placed on receptacles and/or product packaging:

- WSLs on **waste receptacles** such as bags, bins (home bins or shared bins) and containers (street containers, underground containers or civic amenity site containers) are visual elements displayed on or near waste receptacles;
- WSLs on **product packaging** are visual elements on primary and/or secondary product packaging that indicate the correct waste destination and/or waste material of the packaging or specific packaging components.

Packaging is defined in Article 3(1) of the PPWD as follows:

> *all products made of any materials of any nature to be used for the containment, protection, handling, delivery and presentation of goods, from raw materials to processed goods, from the producer to the user or the consumer. 'Non-returnable' items used for the same purposes shall also be considered to constitute packaging.*

Article 3(1) of the proposed PPWR provides a more thorough definition of packaging, as follows (European Commission, Directorate-General for Environment, 2022, p. 49):

> *'packaging' means items of any materials that are intended to be used for the containment, protection, handling, delivery or presentation of products and that can be differentiated into packaging formats based on their function, material and design, including:*
>
> *(a) items that are necessary to contain, support or preserve the product throughout its lifetime without being an integral part of the product which is intended to be used, consumed or disposed of together with the product;*
>
> *(b) components of, and ancillary elements to, an item referred to in point (a) that are integrated into the item;*
>
> *(c) ancillary elements to an item referred to in point (a) that are hung directly on, or attached to, the product and that performs a packaging function without being an integral part of the product which is intended to be used, consumed or disposed of together with the product;*

(d) items designed and intended to be filled at the point of sale, provided that they perform a packaging function;

(e) disposable items sold, filled or designed and intended to be filled at the point of sale, provided that they perform a packaging function;

(f) tea or coffee bags necessary to contain a tea or coffee product and intended to be used and disposed of together with the product;

(g) coffee or tea system single-serve unit necessary to contain a coffee or tea product and intended to be used and disposed of together with the product.

Annexes of both the PPWD and the proposed PPWR offer examples to further clarify the scope of the term packaging. For instance, Annex I of the proposed PPWR lists packaging such as sweet boxes, the film around a CD case and mail pouches for catalogues and magazines (with a magazine inside) as items covered by Article 3(1)(a). Tool boxes, wax layers around cheese and printer cartridges, on the other hand, are listed as examples of non-packaging items.

Packaging can be divided into **primary and secondary packaging**. According to the proposed PPWR, primary packaging corresponds to sales packaging, which it defines as 'packaging conceived so as to constitute a sales unit consisting of products and packaging to the final user or consumer at the point of sale' (Article 3(2)), while secondary packaging refers to grouped packaging, which it defines as follows (Article 3(3); European Commission, Directorate-General for Environment, 2022, p. 49):

> *packaging conceived so as to constitute a grouping of a certain number of sales units at the point of sale whether the latter is sold as such to the end user or it serves only as a means to replenish the shelves at the point of sale or create a stock-keeping or distribution unit, and which can be removed from the product without affecting its characteristics.*

In this report, we further differentiate between **multicomponent and multi-material packaging**. Packaging can consist of multiple components (e.g. a container, a casing and a lid or cap) that may or may not be made from distinct materials (e.g. paper, plastic or glass). For instance, yogurt packaging may include a plastic cup and lid, which are different components made from the same material, and a paper casing, which is a distinct component made from a distinct material. This distinction has implications for the optimal design and placement of WSLs, as they must clearly communicate to consumers which component they are referring to, either graphically or by means of adequate positioning, and specify which materials should be sorted into which receptacle(s).

2.2.2. Attitudinal versus behavioural outcome variables

To better understand the objectives and limits of WSLs, and to provide a structure for the literature reviewed, this subsection sheds light on the different steps of consumer waste sorting and related consumer perceptions and attitudes. To sort their waste properly, consumers must engage in the following steps, as depicted in Figure 3:

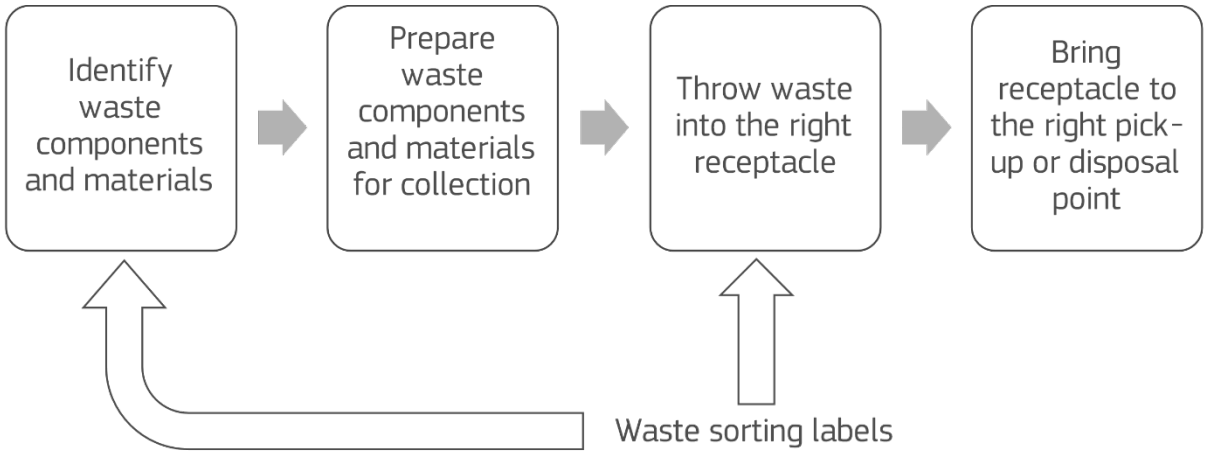
1. **identifying relevant waste components and materials**, that is, identifying the different categories that waste can be sorted into based on the local SWC scheme and identifying the materials and components that the relevant packaging is made of;
2. **preparing waste for collection**, that is, physically segregating the waste elements and, optionally, preparing them for discarding (e.g. by washing and squeezing them);
3. **throwing waste into the right receptacle**, that is, disposing of the identified and prepared waste components into (multiple types of) receptacles, which can occur at various locations, both inside and outside the home;
4. **bringing the receptacle to the right pick-up or disposal point**, that is, transporting the discarded waste to an appropriate disposal point with associated receptacles or arranging for direct pick-up.

These are the main aspects of the waste-sorting process, but, in the case of some materials, they may not all be required or carried out in full.

The main objective of WSLs is to assist consumers in identifying the components and/or materials of the packaging waste, enabling them to dispose of each component in the right receptacle(s). While some systems, such as the Nordic pictogram system, identify the material(s) of the packaging

components, others, such as the Info-tri, focus on disposal methods without specifying material types (see Table 1).

Figure 3. Consumer waste-sorting process



Source: Based on Varotto and Spagnolli (2017).

Although WSLs ultimately aim to influence behaviour, more specifically to improve the rate of correctly sorting waste, there are at least two reasons why other variables are also relevant.

First, reliable and valid data on behaviour may not always be available or easily observable ([7]). Measuring behaviour reliably can be challenging and cost-intensive, leading researchers to rely on other variables that are easier to measure and can serve as proxies for behaviour. For example, asking individuals about their behavioural intentions rather than directly observing their behaviour is a common approach ([8]).

Second, researchers or policymakers may be interested in consumers' attitudes towards or perceptions of labels rather than or in addition to their behavioural reactions to them. This interest could include understanding how users perceive the labels or certain design features, assessing how useful users find these labels, gauging the value placed on specific components (e.g. colour or symbols) or evaluating how well users comprehend (or think they comprehend) the messages that the labels aim to convey. Consumers' perception, understanding and valuation of labels are prerequisites for their effectiveness. Additionally, policymakers may find such information valuable for gaining insights into the acceptability of the policy measures planned among those who would be affected by them.

This report incorporates evidence examining labels in relation to both behavioural and non-behavioural variables. Non-behavioural variables encompass people's attitudes towards labels, specifically their perceptions and understanding. Behavioural intentions are separate from behavioural variables and include observed (or reported) recycling and waste-sorting behaviour. Further details on each of these variables are provided in Table 2.

While observing behaviour in a reliable way is generally the most preferable approach to assessing how well WSLs perform in improving waste sorting, there may be valid reasons to rely on self-reported behaviours, such as asking people about their intentions to act when faced with a WSL. However, these measures can be biased, deviating systematically from actual behaviours (Paulhus and Vazire, 2007). For instance, individuals may be inclined to report that they would behave in a manner that they perceive as socially desirable in terms of waste sorting, rather than their actual behaviour when exposed to such labels. This tendency is known as social desirability bias (Krumpal, 2013; see also Bruns and Nohlen, 2023a). Although the actual threat posed by this and other biases can be difficult to assess and quantify, the potential threat should be considered, especially when data come from methods that are prone to being affected by such biases.

([7]) Measurement validity describes the extent to which what is measured actually corresponds to what should be measured, while reliability describes the extent to which a measurement method leads to the same results under different circumstances (Middleton, 2019).

([8]) What people say they will do (i.e. their intentions) and what they actually do (i.e. their behaviour) frequently do not match. This mismatch is often labelled the attitude–behaviour gap or the intention–action gap (Kollmuss and Agyeman, 2002; Sheeran and Webb, 2016).

Table 2. Types of outcome variables involved in the literature review

Type of outcome variable	Outcome variable	Description
Attitudinal	Perception	Perceptions are how people interpret and make sense of sensory information received from the environment. Perceptions span a wide range of more specific variables. Here, perceptions relate to how individuals respond to labels or specific label components. They include the extent to which the label is considered attractive, beliefs regarding the effectiveness of the label and interpretation of the label's purpose. They also include attitudes towards the objectives of labels (i.e. promoting recycling or waste sorting). Perceptions are commonly measured by asking people to report them in surveys.
	Understanding	Here, understanding refers to the ability to comprehend the information provided on labels. This includes recognising the symbols or words used, understanding their meanings and being able to infer the specific actions that are required (e.g. how to properly recycle or sort the waste). Understanding can be assessed subjectively or objectively. Subjective understanding refers to a person's personal assessment of how well they comprehend a concept. It is subjective because it relies on individual perception and may not always align with actual knowledge or skills. On the other hand, objective understanding involves measuring a person's grasp of a concept through concrete tasks or assessments with correct and false answers. This is based on tangible evidence and provides a more reliable indication of actual knowledge or proficiency.
Behavioural intention		Behavioural intentions capture people's intentions to behave in a certain way. Here, they mostly describe people's intentions to engage in waste sorting or recycling. Attitudes, besides subjective norms and perceived behavioural control, are sometimes depicted as precursors of behavioural intentions, which themselves are precursors of behaviour (Ajzen, 1991). In many studies, behavioural intentions are measured as self-reports instead of observing real behaviours, mainly due to practical challenges surrounding the latter.
Behaviour	Correct recycling behaviour	Here, correct recycling behaviour occurs when individuals correctly dispose of materials in an appropriate recycling receptacle and, if relevant, as indicated on a corresponding label. Correct recycling behaviour may include all of the actions outlined in Figure 3. Notably, what we understand as recycling behaviour here does not correspond to recycling as a waste treatment option, as depicted in Figure 1.
	Correct waste-sorting behaviour	Here, correct waste sorting occurs when individuals correctly separate waste into the appropriate waste receptacles for waste materials and, if relevant, as indicated on a corresponding label. Correct waste sorting consists of identifying the components and/or materials that go into separate waste streams, preparing the waste components and materials for disposal (including washing and squeezing), disposing of them in the right receptacle and/or bringing the waste to the adequate point of disposal (see Figure 3).

Source: Authors' own creation.

3. Background

Before outlining the methodology used for the literature review and the findings, we set out the policy background relevant for harmonised WSLs in the EU. The primary objective of waste policy is to minimise waste and promote recycling. The **EGD**, and specifically the **2020 circular economy action plan** (CEAP 2.0), which is one of the EGD's main building blocks, forms the foundation for enhanced EU action in waste policy. More specifically, CEAP 2.0 introduces measures that aim to, among other things, empower consumers, focus on resource-intensive sectors including packaging, ensure less waste and create a circular economy that works for people. EU-wide WSLs are an explicit aim of the CEAP 2.0 (European Commission, 2020).

These initiatives primarily target key material and product value chains, such as construction and demolition, textiles and plastics, which pose challenges in terms of resource efficiency, circularity and climate impact. Together with the legal obligations of the Commission under the WFD and the review clauses of the landfill directive (Council Directive 1999/31/EC) ([9]) scheduled for 2024, the EGD and CEAP 2.0 support the implementation of initiatives as part of a new policy framework, which includes EU harmonised WSLs.

The WFD underwent revision in 2018 through Directive (EU) 2018/851 as part of a comprehensive reform of EU waste legislation aimed at establishing a circular economy, as outlined in the Commission's related action plan. The revised WFD sets targets for the reuse and recycling of municipal solid waste in Europe, with weight-based national goals of 55 %, 60 % and 65 % by 2025, 2030 and 2035, respectively.

Under Article 11(1) of the revised WFD (Article 10(2) of the original WFD), Member States are obligated to implement SWC systems for at least paper, metal, plastic and glass. Furthermore, Member States must establish separate collection systems for hazardous waste fractions generated by households (Article 20) and for textiles, both by 2025, and, by the end of 2023, needed to ensure that biowaste is either separated and recycled at the source or collected separately (Article 22(1)). Thus, for now, these waste materials constitute the minimum categories that packaging waste needs to be sorted into and that labels consequently have to consider.

The rules governing packaging and packaging waste in the EU in particular are outlined in the **PPWD**, which is expected to be substituted by the PPWR. This directive covers both packaging design and packaging waste management. It outlines the kind of packaging allowed in the EU market, packaging waste management practices and, crucially, measures for preventing packaging waste. All packaging placed on the EU market must adhere to essential requirements regarding its manufacturing, composition, reusability or recoverability, and possible labelling. The objectives of these packaging rules are to harmonise national measures concerning the management of packaging and packaging waste to:

— prevent any impact thereof on the environment or reduce such impact, thus providing a high level of environmental protection;

— ensure the functioning of the internal market and avoid both obstacles to trade and competition distortion and restriction within the EU.

The current PPWD sets two targets for recycling rates of packaging: 65 % by 2025 and 70 % by 2030, with specific targets for certain packaging materials (EEA, 2023). Additionally, Member States are required to establish producer responsibility schemes for all packaging by the end of 2024.

Article 13 of the PPWD states that Member States must ensure that packaging users are provided with various information, including details about return, collection and recovery systems for packaging; the role of users in contributing to reuse, recovery and recycling of packaging and packaging waste; the meaning of markings on packaging that exists on the market; and relevant elements of management plans for packaging and packaging waste. Furthermore, Article 13 states that 'Member States shall also promote consumer information and awareness campaigns'. However, the specific information to be promoted and the type and format of such information and of awareness campaigns are currently not harmonised. This lack of harmonised information mirrors the current lack of harmonisation of SWC systems across Member States ([10]).

([9]) Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste (OJ L 182, 16.7.1999, p. 1).

([10]) Article 8 of the PPWD states that 'packaging shall indicate for the purposes of its identification and classification by the industry concerned the nature of the packaging material(s) used on the basis of Commission Decision 97/129/EC'. Commission Decision 97/129/EC of 28 January 1997 establishing the identification system for packaging materials pursuant to European Parliament and Council Directive 94/62/EC on packaging and packaging waste (OJ L 50, 20.2.1997, p. 28) sets out a proposed system for uniform numbering and abbreviations to be used on packaging made of different materials, but this information is directed at waste operators, not consumers, and – while being harmonised – the use of the symbols is voluntary for economic operators and not uniformly applied. Despite the voluntary nature of the measure, some Member States have adopted legislation requiring economic operators to label their packaging with these harmonised symbols indicating the material(s) used in packaging.

The **proposal for a PPWR** (European Commission, 2022) introduces labelling, marking and information requirements for packaging. WSLs are planned for packaging to facilitate the sorting and separate collection of packaging at its end of life, enabling compliance with the waste hierarchy. This includes EU harmonised labelling specifications with sorting instructions linked, on the one hand, to the material composition of the end-of-life item and, on the other, to the SWC systems available to consumers in the Member State. This policy option is highlighted in the EGD and CEAP 2.0. The latter commits the Commission to assessing the feasibility of EU-wide labelling for the correct separation of packaging waste at its source.

The proposed PPWR specifically employs harmonised labelling requirements to address internal market challenges that impede the consistent application of packaging rules (European Commission, 2022). Specifically, Article 11(4) states that these labels 'shall be placed, printed or engraved visibly, clearly legibly and indelibly on the packaging'. Article 11(6) states that 'the Commission shall adopt implementing acts to establish the methodology for identifying the material composition of packaging …'. Article 12 states that labels enabling separate collection of packaging waste materials in receptacles must be printed or engraved visibly, legibly and indelibly on these receptacles ([11]). Article 10 specifies that allowing the attachment of labelling is a necessary condition for packaging to be considered reusable. Finally, Article 49 outlines the corresponding responsibilities of producer responsibility organisations.

Against the backdrop of these policy developments, the present report reviews the behavioural science literature related to WSLs to synthesise insights informing the development of harmonised EU-wide WSLs.

([11]) The proposed PPWR, in recital 46, also mentions labels indicating the recycled content of packaging. These harmonised, yet not mandatory, labels are outside the scope of this report.

4. Methodology of the literature review

To identify relevant scientific articles and grey literature, we searched the Web of Science Core Collection, specifically the Social Sciences Citation Index and Arts and Humanities Citation Index, and Google. We created a list of keywords, for example 'household waste sorting', 'bin design', 'recycling bin' and 'recycling labels'. The full list of keywords can be found in Annex 1. For the Web of Science Core Collection, each keyword was searched for in the topic, title and abstract. Searches combining multiple keywords were created using the Boolean 'AND' operator. For the most part, the search was limited to 2012–2022. The search was conducted between October and November 2022. Important articles with earlier publication dates could be included when they occurred in reference lists of relevant studies.

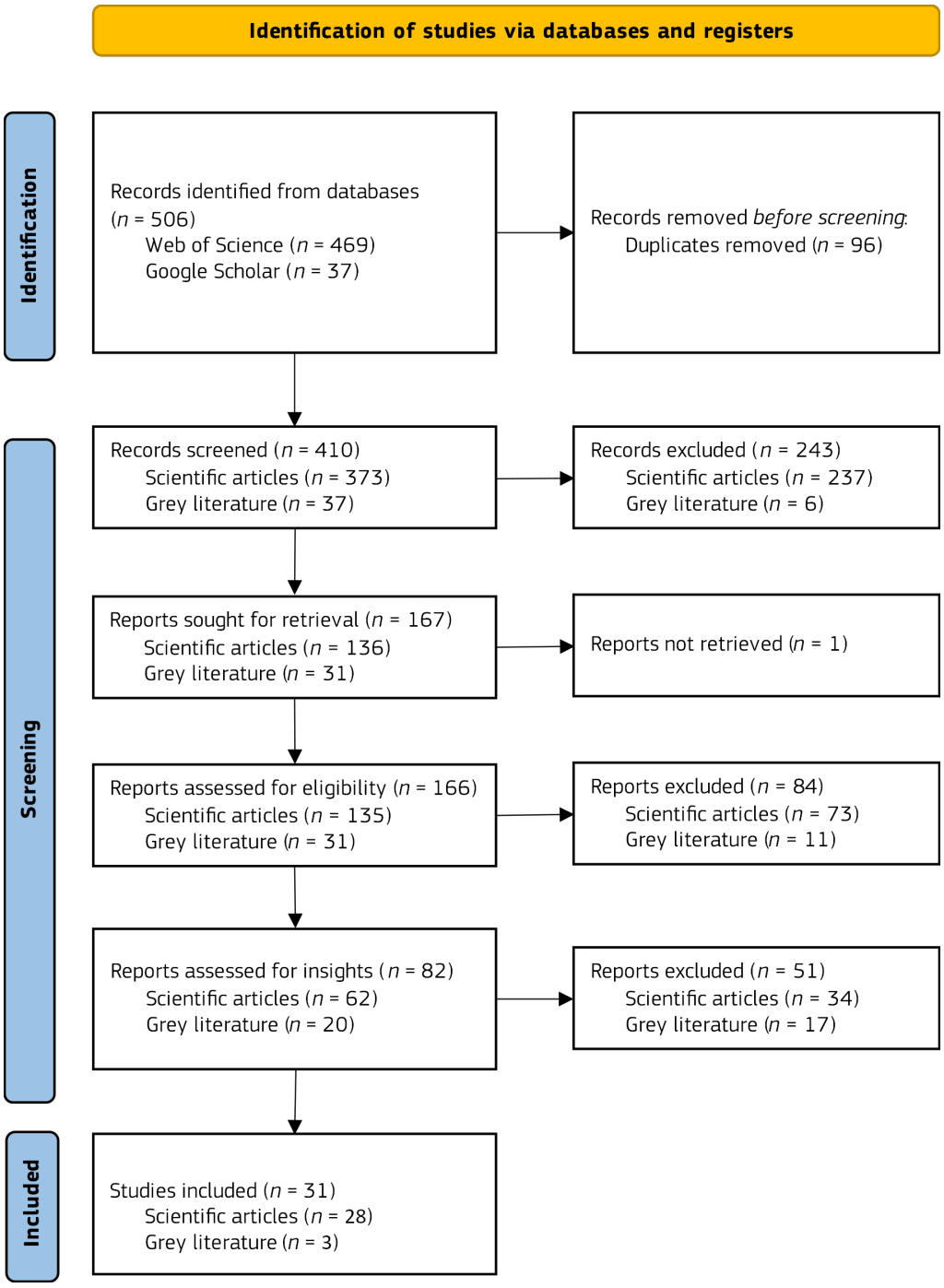
Keywords that did not return any results were used again without a filter on the publication period to ensure that no important references were missed. Additionally, when a keyword did not provide any results, it was split into separate words to further identify relevant entries. For example, 'sorting pictogram' gave no result, so we searched for 'sorting AND pictogram'. Finally, a specific search was done using 'household waste' or 'municipal waste' as a basis, combined with each of the other keywords (e.g. 'household waste AND individual behaviour'). For keywords such as 'behaviour', both the American and the British spellings were used. We searched for grey literature using Google, combining the following keywords: 'household waste', 'waste sorting', 'bins', 'behaviour' and 'report'. We focused on identifying reports, master theses, PhD theses and similar types of grey literature.

Articles selected based on their abstracts were read in detail by each member of the team of experts (OB, AK and NL). Each of the experts assessed the relevance of each article. These assessments were discussed in a meeting with behavioural scientists from the Joint Research Centre (HB and MD), during which divergent assessments were discussed and resolved. In line with the main objective of this report, articles that did not explicitly address waste-sorting labelling or that did not provide any insights into the design of WSLs were systematically removed in subsequent steps. We consciously applied very explicit and restrictive criteria to remove records that were not relevant for this report. Thus, we excluded articles dealing with the drivers of waste sorting and recycling more generally, for example. On the other hand, we opted to include references that focused on the design aspects of packaging and receptacles, if we could derive relevant insights into the design of WSLs ([12]).

As outlined in Figure 4, our initial sample identified 469 potentially relevant articles. Removing 96 duplicates left 373 scientific articles for screening. Each of these 373 articles was screened based on the abstract. Although 136 articles were chosen to be read in more detail, one study could not be retrieved, so 135 articles were read in detail in total. After closer reading, we excluded 73 articles, resulting in 62 scientific studies to be assessed for relevant insights. Of these, 34 did not offer any insights for WSLs, leaving us with a final set of 28 scientific articles. Regarding grey literature, we identified 37 potentially relevant records. Based on screening abstracts, executive summaries and/or introductions, we excluded six and screened 31 in more detail. Of these, we retained 20 to be scanned for relevant insights, and only three of these offered such insights.

([12]) While we included articles focusing on packaging and receptacle design, due to our search strings, we did not check these systematically, leading to an incomplete picture of this particular body of literature.

Figure 4. Prisma flow diagram to identify relevant studies



NB: Prisma, preferred reporting items for systematic reviews and meta-analyses.

Source: Based on Page et al. (2021).

5. Impact of labels on consumer attitudes and behaviours

In this section, we review the literature that sheds light on the impact of WSLs and recycling labels on consumer attitudes and behaviours. The review differentiates between these outcome variables and also between on-packaging and on-receptacle labels. Furthermore, it often goes beyond EU Member States because evidence coming from Member States or generating insights specifically for Member States was challenging to come by.

We highlight the main insights from this literature and the key takeaway messages for informing the role of labels in recycling and waste sorting. Even if some insights may appear trivial or self-evident, we think making them salient is important. Importantly, these insights sometimes include our contextual and especially topic-related and behavioural insights-related knowledge. This means that we sometimes complement the insights generated by the evidence presented with our contextual knowledge. We do this in cases in which implications from studies might not be convincing enough in and of themselves, but they align with our contextual knowledge. In such cases, we strive to be transparent about how we arrive at the insights generated. We use contextual knowledge to enrich and complement insights from the studies themselves. In some cases, findings from studies reveal important implications that align with our contextual knowledge. We include these implications as well, if they are helpful. Furthermore, in Section 7, we acknowledge the shortcomings of the literature analysed. Note that we frequently provide evidence on recycling labels instead of WSLs specifically. We think it is important to include this literature given the overall scarcity of relevant papers and reports dedicated explicitly to WSLs. We highlight the differences between types of behaviours and labels in Section 2.2.1.

This section starts with the evidence on on-pack labels, which is followed by that for on-receptacle labels. For each of these, the report starts with perceptions of the labels, followed by the understanding of the labels and then behavioural reactions and intentions to act in response to the labels (due to a lack of relevant literature on on-receptacle labels, the evidence on the perceptions and understanding of on-receptacle labels is put in the same subsection). Differences between the outcome variables investigated are not always clear-cut. We strive to provide the necessary information in our descriptions to enable readers to understand based on the context. The articles and reports included can be found in Table A1 in Annex 2, which sets out their main characteristics, findings and insights.

5.1. On-packaging labels

5.1.1. Perceptions of on-pack labels

Starting with evidence on how consumers perceive on-pack labels, we draw from five studies investigating perceptions of the usefulness and other characteristics (e.g. visual aspect, colour and position) of labels. The factors that influence these perceptions are also examined.

In a survey on various recycling labels conducted in Melbourne, Australia, 58 % of the 88 respondents considered them in general to be helpful to some or a large extent (Buelow et al., 2010). However, 24 % believed they were not helpful at all or helped only very slightly. Interestingly, these findings emerged despite around 90 % of respondents indicating that they generally recycled packaging waste ([13]). This evidence is consistent with a more general expectation and observation that people can and do recycle without relying on labels, although the possibility that respondents over-report their recycling rates should also be considered. We turn to other aspects of this study in the next section.

In a study with 452 Italians, participants indicated their recycling habits associated with various packaging materials and product types (Amir Kavei and Savoldi, 2021). They expressed varying degrees of satisfaction with multiple recycling labels referring to various packaging materials, despite a majority (70 %) of participants considering on-pack indications as their primary source of information on waste sorting ([14]). Almost all participants rated their knowledge about recycling and waste separation as relatively high. Recycling labels for paper and glass packaging scored highest in terms of quality of the recycling indications, with an average of 6.83 and 6.70, respectively, on a Likert scale ranging from 1 to 10 (with 1 indicating the worst- and 10 the best-quality indications). Recycling indications on Tetra Pak and wood packaging, on the other hand, were considered of lower quality, scoring only 5.27 and 5.29, respectively, on average. Metal and plastic scored an average of 5.81 and 5.97, respectively. It is less clear in this study, however, why labels for some packaging

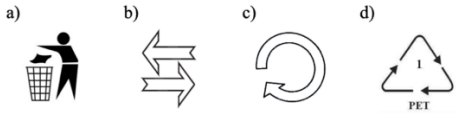
([13]) The insights from this study should not be over-interpreted, as only 88 of the 800 people invited participated in the study. Such a low response rate (11 %) can signal problems in study design and can lead to self-selection bias (e.g. leading to an over-representation of very motivated or pro-environmental participants), increasing the chance of non-generalisable results.

([14]) Unfortunately, the authors of the study do not specify which labels they are referring to.

were perceived as clearer than others. Better understanding the reasons for label clarity would greatly benefit label strategies to improve waste sorting and recycling. More research is thus needed. Although of limited insight because it is unclear which labels these evaluations refer to, the findings could reveal that perceptions of recycling labels may differ considerably by material or packaging type; however, instead, the findings could also be explained by the labels themselves, which may vary in clarity. This may indicate a need to refine recycling labels based on packaging materials. In terms of insights and implications from this study for the design of WSLs, we deduce the importance of clarity and unambiguity and of testing WSLs extensively and applying them consistently to different packaging waste materials and to special cases such as multicomponent and multi-material packaging (more insights from this study are provided in Section 5.1.3).

Explicit recycling guidelines via mandatory, accurate and detailed labelling on packaging can mitigate misunderstandings of labels. As suggested by a study investigating the four most frequently used eco-labels in Poland (Figure 5) – which built on the observation that the level of actual knowledge on proper waste sorting among respondents was poor overall – consumers consider the information-related function of packaging to be important for waste sorting (Wojciechowska and Wiszumirska, 2022). Specifically, the study reported that interactive packaging solutions, such as QR codes or augmented reality, were judged by around 70 % of participants to be useful or very useful because of the helpful information they provided ([15]). The study identified three different consumer segments among the 1 029 participants, broadly differentiated based on their attitudes (i.e. consumers with high, moderate or low pro-environmental attitudes). Interestingly, the levels of actual knowledge about segregation rules among these segments were judged to be equally insufficient. Nevertheless, different types of consumers can perceive and respond to WSLs differently, suggesting that there are potential benefits of a nuanced understanding of consumer segments and potentially of support for information campaigns targeted towards particular user segments (Bruns and Nohlen, 2023b). Understanding and acknowledging differences between user segments during the design of WSLs can potentially contribute to improving the accessibility of the labels. At the same time, the evidence suggests that even pro-environmentally motivated people might profit from information on how to recycle properly. Despite their limitations (e.g. they require smartphones, apps and user familiarity), QR codes could potentially meet some of these needs, especially for targeted and tailored administration of waste-sorting information to specific consumer segments (especially because the digital information can be tailored based on the geolocation of users).

Figure 5. Four common types of eco-labels used in Poland



NB: The labels have the following meanings: (a) dispose of according to the local regulations, (b) reusable packaging, (c) packaging suitable for recycling and (d) packaging material type: 1 – polyethylene terephthalate.

Source: Wojciechowska and Wiszumirska (2022).

A study that involved journey mapping of 37 Australians and interviews with another 50 reported that many participants did not feel empowered to reduce food waste or food packaging waste and thus required large, simple and visually appealing (with respect to colour combinations) labels that help to improve purchasing decisions, to reduce food waste at home (Langley et al., 2021). While this article does not focus on waste sorting or recycling, the majority of interviewees voiced confusion regarding recycling logos on food packaging, especially when they appeared on non-recyclable packaging, and advocated for easier recycling and food waste disposal systems ([16]). Consequently, on-pack information should be easy to find but should not add to information clutter on packaging. We summarise further insights from this study in Section 6.1.1.

Interviews with (only) 15 Swedish households suggested that the placement of graphical elements on packaging can be crucial for whether they are noticed or ignored (Nemat et al., 2020). This extends to placement among different packaging or products, where inconsistency can lead to labels being ignored (voluntarily or involuntarily) and may discourage consumers from seeking the correct information. Consequently, placement should be consistent and the size of WSLs should be appropriate to make sure they are noticed and considered

([15]) The study also contained some interesting hints regarding the type of information that respondents judged to be helpful when sorting waste. Unfortunately, the data reporting in the paper does not allow this information to be extracted.

([16]) The study relies on two quite small samples (n = 37; n = 50).

in waste-sorting-related decisions. All of the elements shown in Figure 6 were rated by interviewees to some extent as unclear, inconvenient, uncertain or unknown.

Key lessons, insights and implications

- While people recycle and sort waste even without labels, labels can aid in related efforts.
- How labels are perceived and valued influences their acceptability and effectiveness and thus, we argue, their political feasibility.
- Perceptions of labels depend on factors such as their design and on aspects of the packaging and the materials they refer to.
- The relation between labels and the materials they refer to is important. Consistent application of labels on different packaging waste materials is key to establishing a clear relation between labels and materials.
- WSLs should be easy to find and of sufficient size, but should not disproportionally add to information clutter on packaging.
- The evidence reviewed is far from sufficient to generalise to the various existing WSLs or recycling labels in the EU. Nevertheless, design aspects of existing labels, specifically their clarity, size, positioning, readability and noticeability, appear to be important aspects of harmonised WSLs. Advanced digital solutions (e.g. QR codes) might also be relevant, providing benefits due to their flexibility.
- As different types of consumers can perceive and respond to labels differently, a nuanced understanding of consumer segments can be insightful.
- Even environmentally motivated people can profit from WSLs.
- Testing WSLs extensively is crucial to proper design.

5.1.2. Understanding of on-pack labels

Without proper understanding of on-pack labels, even well-intended and informative labels might fail to serve their purpose (Fogt Jacobsen et al., 2022). We identified only three studies explicitly dealing with aspects of understanding labels, which we outline below.

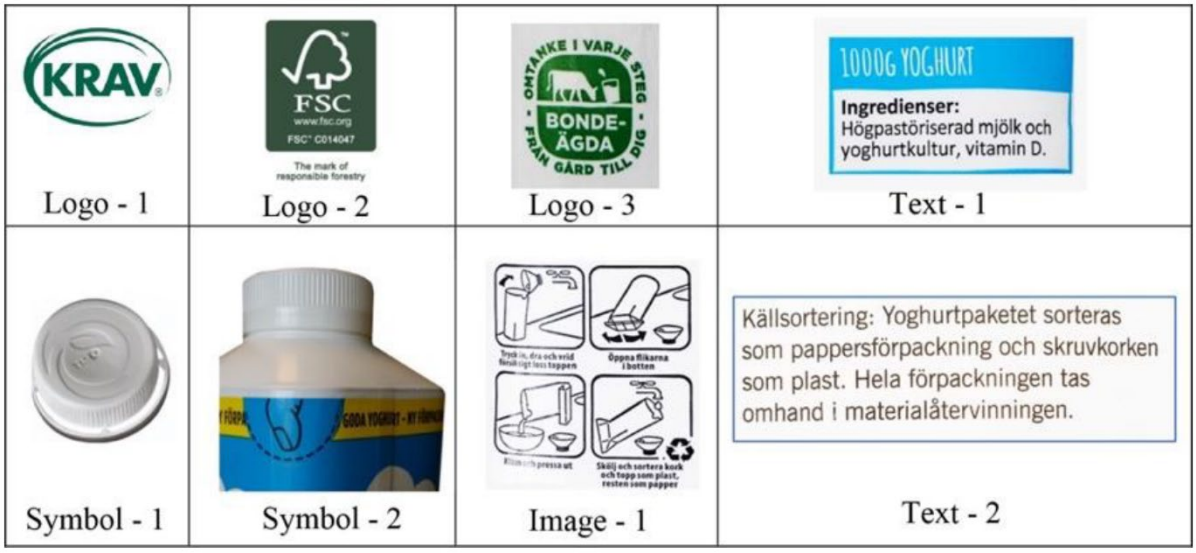
Badly designed symbols and images on packaging can decrease consumers' understanding of waste-sorting instructions and lead to deteriorating waste-sorting rates. Elements of bad designs include small size, poor positioning and inconsistent use across different products of the same company or across the same products from different companies (Nemat et al., 2020). In the survey involving 15 Swedish households mentioned in the previous section, confusion mostly arose from unclear messaging (see text 2 in Figure 6) or a lack of visibility (see logos 1–3, symbols 1 and 2 and image 1 in Figure 6). Specifically, symbol 1 was featured on a packaging cap, indicating that the cap was made from biodegradable material, in this case sugar cane. The symbol aims to indicate that the production and recycling process of the cap entails lower carbon emissions. However, without additional information and clarity, this symbol was frequently misunderstood. Furthermore, the fact that some caps were not marked with this symbol confused participants, highlighting the risks of the inconsistent use of signage.

A lack of proper information on the cleaning and segregation of materials and components also created uncertainty. Swedish participants were particularly confused when facing a package that consisted of a plastic cap and a paperboard carton with an integrated plastic neck. The producer's recommendation to place the paper carton in the paper recycling bin and the separate cap in the plastic recycling bin left participants wondering how to deal with the plastic neck. Despite the small sample size, this study provides insights for the case of multi-material and multicomponent packaging, which can be particularly challenging for WSLs to address in a clear and unambiguous manner. Labels would optimally address all components explicitly to avoid misunderstanding and ambiguity. Furthermore, visual elements combining graphical and textual elements can be particularly effective in providing meaningful information, and colour combinations can aid understanding and salience (Nemat et al., 2020).

Furthermore, the logos, symbols, images, and text presented in Figure 6 were mostly judged as confusing and unclear – so they can be used as bad examples. However, the insights are limited due to the small number of participants. In addition, many of the participants may never have noticed the labels before (Nemat et al., 2020).

This is relevant because labels usually require some form of learning and familiarisation before they are properly understood.

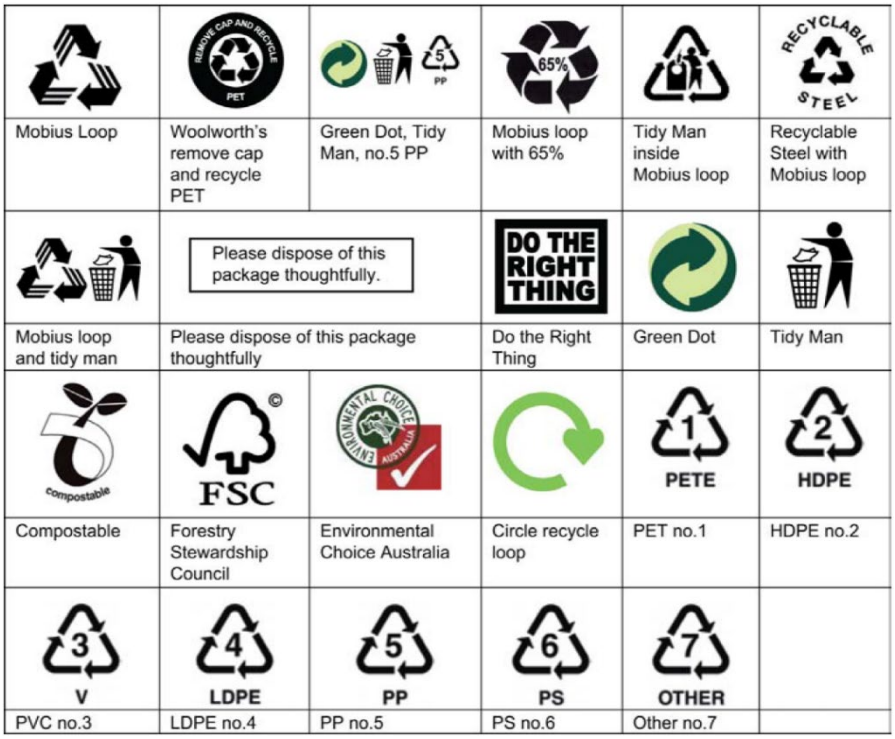
Figure 6. Logos, symbols, images and text often found on selected packaging and discussed in the interviews conducted by Nemat et al. (2020)



NB: Text 1 reads 'Ingredients: Highly pasteurised milk and yogurt culture, vitamin D'. Text 2 reads 'Source sorting: The yogurt package is sorted as paper packaging and the screw cap as plastic. The entire packaging is taken care of in material recycling'.

Source: Nemat et al. (2020).

Figure 7. Labels used in the surveys conducted by Buelow et al. (2010)



NB: HDPE, high-density polyethylene; LDPE, low-density polyethylene; PET/PETE, polyethylene terephthalate; PP, polypropylene; PS, polystyrene; PVC, polyvinyl chloride.

Source: Buelow et al. (2010).

Vague and confusing labels can naturally be a barrier to proper understanding and sorting. The Australian study conducted by Buelow et al. (2010) found that, when the Green Dot, Tidyman and No 5 polypropylene (PP) labels appeared together (first row in Figure 7) on a flexible foil wrapper package, they were largely misunderstood, leading to incorrect sorting despite their presence. Study participants were first asked how they would dispose of the packaging without any recycling label, then gave their answer again after they had seen the labels. While, initially, 80 % of the participants gave the correct answer (discard the packaging in general waste), only 23 % did so after having seen the confusing labels. The Mobius loop recycling symbol also caused confusion, as participants considered it the sole indicator of a product's recyclability, leading to errors when the symbol was absent (Buelow et al., 2010). This suggests that new WSLs need to be consistent with existing recycling (or other types of) labels, so as not to send mixed signals to consumers and confuse them. If not properly designed (e.g. by including ambiguous prompts such as 'Do the right thing' or 'Please dispose of this package thoughtfully'; second row in Figure 7), WSLs can fall short of expectations.

Another study investigated the understanding of the 'chasing arrows symbol' (i.e. the Mobius loop) in the United States in close detail (Latkin et al., 2022). The survey of 808 individuals found that a staggering 81.3 % misunderstood the label as indicating that the item could definitely be recycled, while 16.3 % reported that a thus-labelled component could probably be recycled. Additionally, most respondents did not know about the meaning of the numbers sometimes included in the middle of the symbol (see bottom row of Figure 7), and almost one third gave an incorrect response with respect to this version of the symbol. New WSLs, which might have to accompany such misunderstood and ambiguous labels, should take the presence of such labels into account and work regardless. While this might be challenging, and either getting rid of misunderstood symbols or an information campaign about their correct interpretation might be desirable, additional information to improve understanding of the label using technological solutions such as QR codes or other digital means might be worth considering.

Finally, in a report by the German World Wildlife Fund (WWF), recommendations for recycling-friendly packaging include easily removable labels with minimal direct printing on the container. Labels should avoid additives, barriers, coatings, adhesives or ink that could hinder recycling (WWF Deutschland, 2021) ([17]).

Key lessons, insights and implications

- Labels must be understood for them to work as intended.
- Labels need to be understandable when positioned next to labels that send different or conflicting messages.
- Elements of bad label design include small size, unclear and vague messages, inconsistent use and poor positioning.
- Information on the necessity of and instructions for cleaning and segregating packaging materials and components can be relevant, although available space on labels might be too limited.
- Proper understanding of labels requires time. New labels, even if well designed, might not be judged to be clear and understandable from the beginning.
- Visual elements should be carefully chosen to reflect the intended message or function and should possibly combine graphical and textual elements to provide meaningful and unambiguous information.
- Action-oriented labels with clear instructions for consumers can improve their efficacy and clarity.
- Ambiguous prompts such as 'Do the right thing' or 'Please dispose of this package thoughtfully' do not provide precise enough information to guide individuals in correctly sorting waste and should be avoided.
- WSLs might benefit from being easily removable, applied with minimal direct printing on the container, and free of additives, barriers, coatings, adhesives or ink that might create problems for recycling.

5.1.3. Behavioural reactions and intentions to act in response to on-pack labels

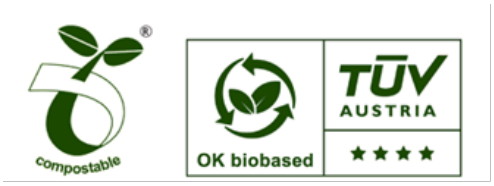
Turning to evidence on how people react to waste labels, we present insights from only three studies shedding light on labels in relation to behaviours and behavioural intentions. The Italian study referred to in Section 5.1.1 offers some insights into the link between the quality of on-pack labels and behavioural intentions to sort waste

([17]) The report was not peer reviewed and lacks information on the methodology used, the sample characteristics and the sample size.

correctly (Amir Kavei and Savoldi, 2021). In particular, the survey dealt with labels on single-component and multicomponent packaging (see Box 1 for more details on the issue of multicomponent and multi-material packaging). Clarity and unambiguity are as important for such labels as for labels addressing single-component and single-material packaging. About 74 % of the study respondents believed that clear and simple recycling labels would dramatically change their sorting behaviour, while only 17 % of the respondents found the current recycling labels to be sufficiently clear (Amir Kavei and Savoldi, 2021) ([18]). As before, this highlights the benefits of label clarity, particularly for multicomponent packaging and when waste management practices vary between municipalities.

A study in the Netherlands with 199 participants investigated recycling behaviour as regards bioplastics using a combination of natural field experiments and surveys (Ansink et al., 2022). Interestingly, the study revealed that the participants were often unresponsive to information, including to logos such as the 'seedling' and 'OK biobased' logos, which specify the type of bioplastics being used (Figure 8). More specifically, only 35 % of the participants noticed the presence of a bioplastic logo when it was there. Additionally, those who recognised the logo did **not** recycle better than those who did not notice it. This suggests that attention can be hard to garner (especially when various labels on packaging compete for user attention) and that awareness of a label does not guarantee intended effects on behaviour. Knowledge of SWC appears necessary for WSLs to have the desired effects. This knowledge is commonly acquired through education, learning, personal experience and/or awareness campaigns. This aligns with the argument that motivations, opportunities and abilities are all important factors in waste-sorting behaviour (Cristobal Garcia et al., 2022). Design factors such as label size, design novelty and the clarity of accompanying text were also mentioned as contributors to effective labels, aligning with the findings of Amir Kavei and Savoldi (2021), who highlighted the links between label design, education and recycling habits. Finally, the fact that bioplastics are a relatively recent material used for packaging could explain the lack of effectiveness of the associated labels. It may take some time for consumers to become aware of and understand new labels and for these labels to become effective in fostering the desired behavioural changes.

Figure 8. Seedling logo for compostable plastics and OK biobased logo for bioplastics



Source: Ansink et al. (2022).

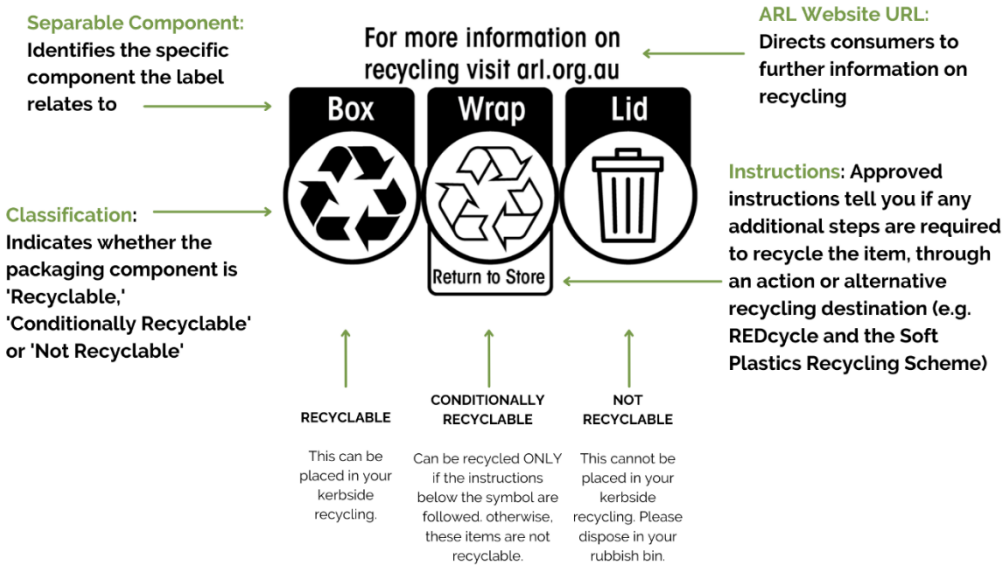
Delving into a specific case, in 2018, the Australian Packaging Covenant Organisation launched the Australasian Recycling Label (ARL; Figure 9) to increase consumer recycling rates in Australia. The governments of both Australia and New Zealand now acknowledge the ARL as the preferred choice for labelling. The ARL informs consumers about required actions and the recyclability of the packaging components, gives further instructions, and includes a link to a website where further information can be obtained. Packaging items bearing an ARL can be classified as recyclable, conditionally recyclable or not recyclable.

According to a report of a study on the effect of the ARL on consumer behaviour, the ARL has had a positive impact on recycling intentions (APCO and Planet Ark, 2021) ([19]). For instance, the proportion of people who reported that they intended to recycle soft plastic wraps was 19 % without the ARL and 46 % with the ARL. Similar improvements in recycling intentions were noted with other materials, such as aluminium foil lids, rigid plastic tubes and soft plastic films, underscoring the potential effectiveness of the ARL. This label clearly highlights the necessity of providing further information (here via a weblink) and of consumers having prior knowledge for properly understanding and 'using' the label. For example, while the icons should be clear to almost all users, even in the absence of any further background information, correct interpretation of the black arrows indicating that the packaging is recyclable and the white arrows indicating that it is conditionally recyclable relies on information that must be accessible off the label (since it is not found on the label). Effective label designers need to be aware of which label components are 'self-explanatory' and which rely on external information. Finally, the study found that that certain consumer segments are more aware of this label than

([18]) As already indicated, the study does not provide more detail on the labels that respondents were referring to.
([19]) The report was not peer reviewed and lacks sufficient information on the methodology used, outcome variables, statistical analyses, sample characteristics and sample size.

others. Specifically, 16- to 44-year-olds are more aware of the label than + 45-year-olds, suggesting that some consumer segments might benefit more from awareness campaigns surrounding new WSLs than others.

Figure 9. The on-pack ARL



Source: APCO (n.d.).

Box 1. Labelling multicomponent and multi-material packaging

Packaging often consists of multiple components and materials, which poses distinct challenges for recycling and waste-sorting practices, as well as for labels. Here, we explore consumer preferences regarding single-component and multicomponent packaging, along with their perceptions of convenience and difficulties in sorting the different packaging types.

Figure A1 in Annex 2 provides a visual categorisation of packaging according to the number of components and materials, as well as packaging characteristics in terms of whether or not the components are separable. This results in nine different theoretical types of packaging. These are:

1. a single component made of a single material (e.g. a simple carton box);
2. a single component made of multiple separable materials (e.g. a simple carton box with one side made of thin plastic);
3. a single component made of multiple inseparable materials (e.g. a box made of a mix of plastics and paper);
4. multiple inseparable components made of a single material (e.g. a drinking cup with an attached lid and sleeve, all made of paper);
5. multiple inseparable components made of multiple separable materials (e.g. a drinking cup with an attached lid and sleeve with each component made of a single material);
6. multiple inseparable components made of multiple inseparable materials (e.g. a drinking cup with an attached lid and sleeve with at least one component made of a mix of plastics and paper);
7. multiple separable components made of a single material (e.g. a drinking cup with a separate lid and sleeve, all made of paper);
8. multiple separable components made of multiple separable materials (e.g. a drinking cup with a separate lid and sleeve, each made of paper or plastic);
9. multiple separable components made of multiple inseparable materials (e.g. a drinking cup with a separate lid and sleeve with at least one component made of a mix of plastics and paper).

Some of these types of packaging will be more common than others. Some of them pose specific challenges to users, such as identifying components made of mixed materials that cannot be recycled properly or the requirement to rip off certain parts to dispose of them appropriately.

Overall, consumers tend to prefer single-component packaging (Langley et al., 2011, 2021; Amir Kavei and Savoldi, 2021). Specifically, in a study with 452 Italian participants, ratings on a 10-point Likert scale (where 1 is the worst and 10 is the best rating) for existing on-pack recycling indications were 6.89 for single-component packaging and 5.43 for multicomponent packaging (Amir Kavei and Savoldi, 2021). Higher satisfaction levels with single-component packaging predicted more effective recycling, meaning that the more satisfied users were with the label, the more likely they were to recycle correctly. In contrast, multicomponent packaging can result in increased amounts of non-recycled waste, probably because of its complexity. The complexity of multicomponent packaging often results in increased non-recycled waste because it requires more effort to sort and recycle, that is, multiple packaging materials and components need to be identified by users, separated and allocated to their respective waste streams. This requires more cognitive and practical effort than in the case of single-component and -material packaging.

Some studies deal explicitly with the convenience and complexity of separating materials in multi-material and multicomponent packaging. Field experimental evidence shows that consumers, despite clear recycling cues, tend to dispose of multicomponent waste incorrectly due to the complexities involved in separating them (Borgman et al., 2018). Specifically, consumers may have to disassemble, separate and clean components, such as a plastic cap that needs to be separated from a paperboard carton, a process that can discourage recycling because of the additional cognitive (remembering to separate and how to do it) and practical (the act of separating and washing) effort required (Nemat et al., 2020; WWF Deutschland, 2021). Furthermore, multiple materials and a shortage of time may lead consumers to sort the entire package as mixed waste, as reported by a majority of the 18 Swedes interviewed by Nemat et al. (2022).

In conclusion, convenient sorting of multicomponent and multi-material packaging, both separable and inseparable, is crucial to increase correct sorting and recycling rates. While clear labels and instructions are beneficial, they should be paired with user-friendly packaging designs that consider the consumer time and effort required and local waste management protocols. Packaging designers should prioritise simplicity of disassembly, including the use of a single component/material instead of multiple components and materials and, if that is not possible, should facilitate the separation of components and materials used in packaging.

Key lessons, insights and implications

- WSLs that are perceived positively and understood well are not **automatically** effective. Effectiveness should always be verified empirically or experimentally.
- WSLs must be clear, salient and actionable.
- It is crucial to be aware of which label components are self-explanatory to consumers and which rely on external information. Digital solutions may serve to provide additional information without requiring additional space.
- An important aspect that should be considered for WSLs is multi-material and multicomponent packaging. These types of packaging can be more difficult for consumers to handle and sort than single-material or single-component packaging, because their correct preparation and sorting require more cognitive and practical effort. While this makes a case for simple packaging, it also suggests that WSLs should be as clear as possible when referring to multiple components and materials, to avoid confusion and ineffectiveness.
- Some consumers might rely more than others on additional information and awareness campaigns.

5.2. On-receptacle labels

5.2.1. Perception and understanding of on-receptacle labels

On-bin labels and stickers play a crucial role in offering clear sorting guidance at the location where disposal happens. They can either complement or replace on-pack labels. We examine two studies focusing on how people perceive and understand these labels.

Australian respondents perceived the on-bin labels shown in Figure 10 as effective tools for raising awareness and educating people on recycling and proper bin use; the labels display both admissible and non-admissible waste items. These labels help address misunderstandings, as they often provide more extensive information than on-pack labels – simply because there are fewer space constraints. This makes them valuable complements to on-pack labels (Buelow et al., 2010).

Figure 10. An example of a local council 'bin sticker' used in Maribyrnong, Australia

Source: Buelow et al. (2010).

A US study delved into the emotional impact of receptacle signage, uncovering challenges tied to emotionally charged prompts such as 'Save the earth, recycle more' or 'Don't destroy the Earth, trash less' (Catlin et al., 2021). Such prompts can confuse people, leading to incorrect and 'overinclusive' waste sorting. Overinclusive sorting is understood as the recycling of non-recyclable items. Indeed, the researchers found indications of the emotional content of the text pushing participants to put non-recyclable items into recycling bins, contaminating the waste stream. It is important to choose words carefully; for instance, using 'landfill' instead of 'trash' to highlight the negative impacts of non-recycling may lead to overinclusive recycling because some consumers aim to avoid landfill and thus put items in the recycling bin that should go into landfill. Thus, this study emphasises the need to carefully test persuasive content on labels to avoid unintended consequences.

Key lessons, insights and implications

- On-receptacle labels can provide valuable information at the point of disposal. They can complement on-pack labels, as they offer more space for information.
- As regards on-pack labels, clear and actionable instructions are important, as is consistent and prominent placement on receptacles.
- Persuasive messages should be used with caution, as they can lead to confusion and overinclusive recycling and sorting.

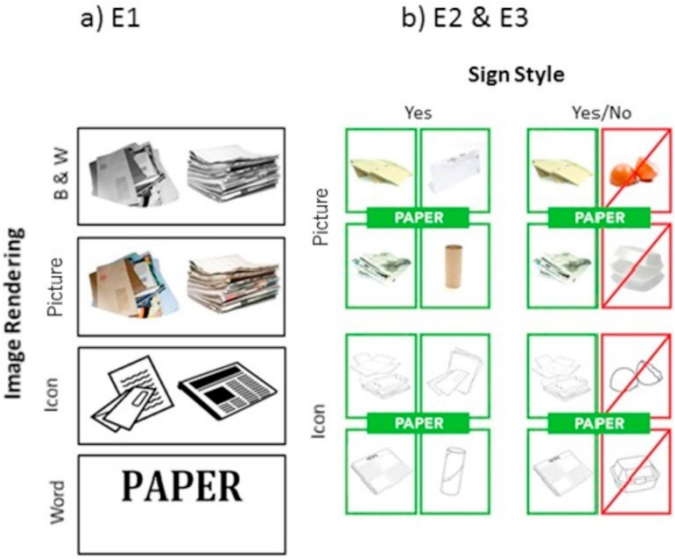
5.2.2. Behavioural reactions and intentions to act in response to on-receptacle labels

On-receptacle labels play a crucial role in minimising receptacle contamination (Austin et al., 1993). Seven studies explored their behavioural impacts. As briefly mentioned earlier, on-bin stickers placed on the inside or outside of bin lids can provide sufficient space for precise instructions.

Wu et al. (2018), based on Wogalter and Laughery (1996), rely on a four-step process for effective signage: (1) attracting attention, (2) facilitating understanding, (3) changing beliefs and attitudes and (4) increasing motivation. Like the original authors of this model, they state that most research has focused on the final two steps, although the initial two steps are equally important. To substantiate this, they conducted three experiments at the University of British Columbia, Canada (referred to as E1, E2 and E3 in Figure 11). The experiments revealed that images and icons led to more effective waste disposal than text alone, except when the images were unfamiliar to respondents. Additionally, 'permitted-only' signs were as effective as or better at inducing correct sorting than 'permitted and prohibited' signs (see the column 'Yes/No' on the right-hand side of Figure 11). Finally, they found that consistent spatial positioning on the bins bolstered sorting performance. Consequently, we note that WSLs should consider the use of images and icons while ensuring user familiarity with these visual components. Additionally, presenting both permitted and prohibited items on WSLs (for whatever reason) may reduce performance and should thus be critically assessed. Finally, WSLs should be placed consistently on waste receptacles so that they can be easily located by users.

In a study conducted in the office of a financial accounting firm in downtown Vancouver, Canada, signage depicting a marine animal trapped in plastic debris (Figure 12) reduced the number of plastic waste items by 17 % (Luo et al., 2022), highlighting the potential of emotionally engaging visuals to change behaviour. The reduction was solely attributed to the image, not a combined effect with text. Improved recycling signage and signage with a pledge (see 'Improved signage' and 'Signage and pledge' in Figure 12) showed no statistically discernible effects, attributed to the lack of employee promotion of the pledge during the study, as very few employees reported having noticed the posters, signed the pledge or changed their waste disposal behaviour over the course of the studies. This indicates that the effective signs might work subconsciously and need to be carefully designed to avoid overinclusive recycling, as outlined above. This suggests, as previously discussed, that labels need to not only induce individuals to engage in sorting, but also guide them to do so correctly (Cristobal Garcia et al., 2022).

Figure 11. Examples of signs used in experiments by Wu et al. (2018) indicating how the image was rendered and the sign style, namely whether only permissible or also impermissible items were shown

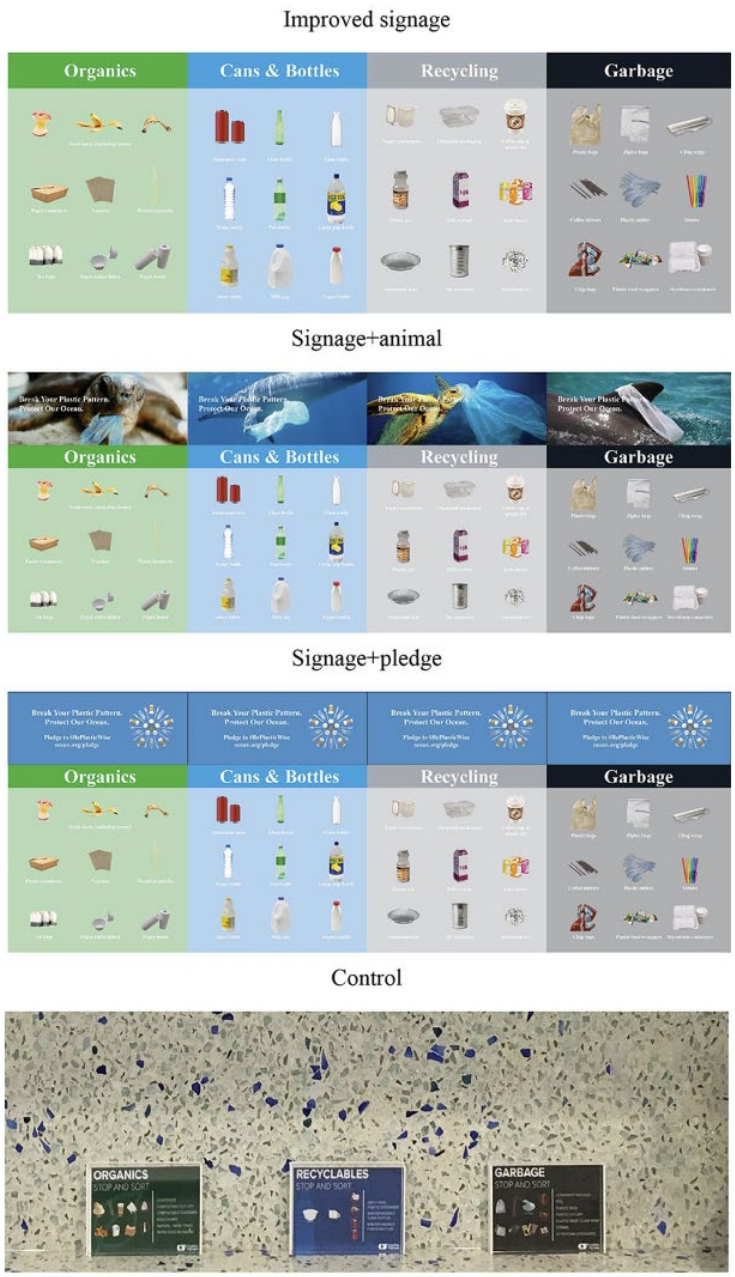


Source: Wu et al. (2018).

Additionally, motivational pro-environmental signs (see the left-hand side of Figure 11 for the initial sign and the right-hand side for the three experimental signs) increased the volume of waste sorting at a music festival in Adelaide, Australia, where 889 waste disposal decisions were examined (Verdonk et al., 2017). Motivational prompts were embedded in the signage along with waste-sorting information and pro-environmental pictures. Despite attracting more users, indicated by the higher usage rate of experimental signs, the motivational pro-environmental signs did **not** enhance actual sorting accuracy. The researchers speculate that the motivational signs were too cluttered, causing information overload for users ([20]). They thus recommend clear and legible motivational messages associated with each waste stream. We note that, when WSLs are designed, potential information overload should be considered along with the need for uncluttered motivational messages and clear, legible pictures indicating the correct waste stream. Furthermore, this study implies that the impact of pro-environmental prompts on WSLs may be limited, emphasising the importance of thorough testing when incorporating such elements.

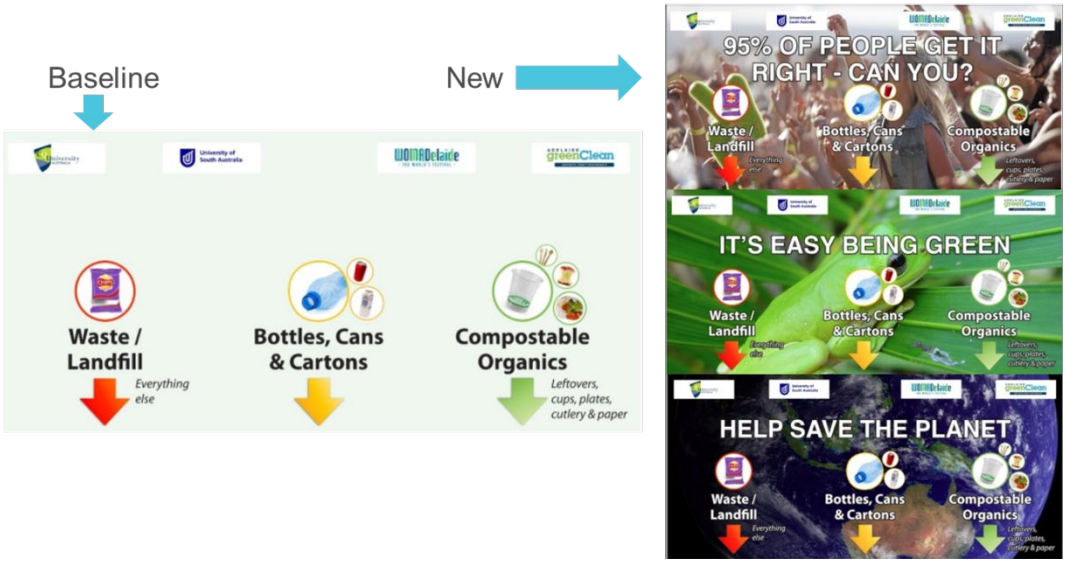
([20]) Information overload can be the reason for the low performance (in terms of adequate decision-making) of an individual due to the high amount of information they are exposed to (Eppler and Mengis, 2004). This does not necessarily mean that people cannot handle the amount of available information; instead, they simply might not engage with all of the information because of cost–benefit considerations.

Figure 12. Signage used in the different studies done by Luo et al. (2022)



Source: Luo et al. (2022).

Figure 13. Baseline and new signs used by Verdonk et al. (2017)



Source: Verdonk et al. (2017).

An empirical study from the Philippines emphasises the crucial role of WSLs, along with other waste receptacle design aspects, in guiding users to correctly identify the appropriate waste bin (Gutierrez et al., 2021) ([21]). Informative labels, featuring brief text and a limited number of well-designed images resembling commonly discarded items (Figure 14), can compensate for users' lack of knowledge about waste sorting. The redesign of bins, incorporating both WSLs and alterations to the bin opening (Figure 14), led to a significant decrease in inaccurately sorted items, from 62.29 % to 14.29 %. However, the study could not attribute this effect solely to the change in labels or bin opening. The impact of receptacle design will specifically be investigated in Section 6.2.

Figure 14. Top and final design of the waste bin used in research by Gutierrez et al. (2021)

Source: Gutierrez et al. (2021).

Stickers placed on bin lids had a significant impact on increasing food waste recycling behaviour (Shearer et al., 2017). In a 30-week randomised controlled trial involving 64 284 households in Surrey, United Kingdom, stickers reading 'No food waste please' were attached to the outside of bin lids (Figure 15). These stickers served as reminders to avoid discarding food waste in general waste bins and encouraged the use of the

([21]) It is unclear if this publication was peer reviewed, as it is a chapter in a book.

designated recycling bin. Compared with the control group without stickers, the weight of food waste in recycling bins increased by 20.74 %. This positive impact persisted over the 4-month treatment period. The stickers were deemed cost-effective, practicable and feasible for large-scale implementation by local authorities. The enduring impact may be attributed to the stickers' more permanent nature compared with leaflets or posters, which are often seen just once. It is also possible that distributing stickers to all households by visibly displaying them on all bins could have signalled the socially acceptable nature of food waste recycling and/or socially unacceptable nature of not recycling food waste. Recognising the social desirability of waste sorting may have motivated households to increase their efforts to recycle correctly ([22]). From this study, we deduce that WSLs may function as permanent and straightforward reminders for actions such as recycling or sorting waste correctly – actions that people do not constantly have on their minds when disposing of waste. At the same time, WSLs may implicitly or explicitly communicate what should not be commingled in a general waste bin and guide users on proper disposal in specific receptacles. While WSLs in sticker form are cost-effective and flexible, they may not always be practicable, and they can degrade over time, potentially losing their effectiveness.

Figure 15. Sticker prompt designs used by Shearer et al. (2017)

Source: Shearer et al. (2017).

The effectiveness of on-receptacle labels can vary. While studies such as those of Shearer et al. (2017) and Austin et al. (1993) show improved sorting when signage is introduced, a study carried out on a US university campus found that simply changing signage by adding images and new headings did not significantly enhance waste-sorting rates (Figure 16; Andrews et al., 2013) ([23]). This suggests that altering label design alone may not be sufficient, and more extensive awareness and education campaigns might be needed to bring about a substantial impact. It is evident that the design of labels is not the sole factor influencing the impact of these labels on waste-sorting behaviour. Drawing attention to updated label features or using altogether new WSLs might be necessary, because they would otherwise remain obscure to prospective users.

Figure 16. New signage for bin type 1 (top) and bin type 2 (bottom) for research conducted by Andrews et al. (2013)

([22]) For a more extensive focus on the role of social factors influencing SWC, see Knickmeyer (2020). For the role in food waste in particular, see Blondin and Attwood (2022).

([23]) There is no information on the original signage used by Andrews et al. (2013).

Source: Andrews et al. (2013).

A Swedish field experiment involving households revealed that on-receptacle WSLs (depicted in Figure 17) and newly provided general waste bins jointly reduced incorrectly sorted nappies by approximately 70 % between 2011 and 2013 (Rousta et al., 2015). The correct sorting of food waste was less affected; while the amounts in the correct bins remained unchanged, there was a reduction in incorrectly disposed of food waste in 2013. However, the study design did not allow a determination of whether it was the labels or the new general waste bins that drove the behavioural change. The limited insight gained emphasises the importance of WSLs providing visible and easily understood information at the time of disposal, consistent with the relevant SWC scheme.

Figure 17. Old sticker (left) and new sticker (right) on the general waste bins for black bags intended for food waste investigated by Rousta et al. (2015)

NB: From left to right and top to bottom, the old sticker (left) reads 'compostable, leftover food, eggshell, meat and fish; teabags, leftover tea and coffee, tea bags and coffee filters; peels and other remains of fruit and vegetables; wet towel paper, nappies, pads and similar; leftover bread; flower soil and waste, cat litter'; the new sticker (right) reads 'In the black bag you throw away food waste. These are counted as food waste: leftover meat, fish, dairy product; bread, rice, pasta; fruit and vegetables'.

Source: Rousta et al. (2015).

Key lessons, insights and implications

- On-receptacle labels can reduce waste contamination by highlighting which materials should and/or should not be disposed of in a receptacle.
- Images and icons are valuable complements to text if they are meaningful and familiar to users.
- The number of items shown on the labels should be limited and should resemble commonly discarded items, as this can compensate for users' lack of knowledge.
- In contrast to on-pack labels, on-receptacle labels have the advantage of being attachable to some receptacles as stickers, making them more flexible and cost-effective.
- WSLs should be designed and applied in a way that minimises the risk of information overload – they should be salient and clear and should provide information that is consistent with the relevant SWC scheme.
- Pro-environmental prompts should be used with care.
- A combination of information on desired and undesired behaviours might improve correct sorting.
- WSLs can benefit from separate informative and pro-environmental messaging.

6. Insights from packaging and bin design

This section delves into packaging and bin design, highlighting their potential roles in supporting recycling and WSLs. We define these concepts as follows.

— **Packaging design** involves the specific visual and functional arrangement of elements, materials, graphics and information on product packaging. Key aspects include materials (prioritising eco-friendly or recyclable options), structure (ensuring easy disassembly or sorting) and visual appeal (colours and shapes that may indirectly influence consumers' recycling behaviour). Packaging design also encompasses the use of smart technology, tactile cues or other innovative features to enhance consumer engagement. It can be crafted to facilitate waste sorting, minimise negative environmental impact and improve consumer experience.

— **Receptacle design**, and particularly **bin design**, refers to the specific visual and functional arrangement of elements, materials and features on receptacles designed for collecting, holding and organising waste or recyclables. Relevant aspects include physical properties such as size, shape and the inclusion of multiple compartments for sorting. Colour use can also play a role, with different colours indicating various waste types. Strategic placement and accessibility of bins are both considered to be design aspects in this report. Receptacle and bin designs may integrate technology or behavioural nudges to facilitate and prompt proper waste sorting and recycling. They can be designed to promote easy, intuitive and habitual waste sorting.

It is essential to note that the literature search primarily focused on WSLs, so evidence related to packaging and bin design may be incomplete. Despite this, we have included papers providing relevant insights for WSL design. Table A2 in Annex 2 lists all of the articles and reports included that focus on labels and sets out their main characteristics.

6.1. Packaging design

6.1.1. Perception and understanding of packaging design elements

We start by exploring consumers' perception and understanding of packaging design by mainly drawing on four studies. Nemat et al. (2019), in a literature review on the impact of food-packaging design attributes on household recycling behaviour, assert that packaging design can diminish barriers to waste sorting by shaping consumers' perceptions of packaging quality and value. Their review highlights how characteristics of food packaging can convey environmental considerations. Visual attributes – including labels, images, colours, graphics and shapes – can communicate recycling-relevant information and enhance the perceived value of the packaging. These visual elements are commonly valued by consumers. Practical design elements,, such as symbols and label size and functionalities, such as ease of separation, foldability and seamless cleaning, contribute to practical design, positively influencing perceived recyclability, actual recycling and sorting. These characteristics play a crucial role in simplifying the sorting process, emphasising the link between perceived convenience and responsible consumer behaviour (we elaborate on the key insights regarding convenience considerations in Box 2). We posit that packaging can serve as a natural vehicle for WSLs to convey sorting instructions to consumers, emphasising the need for WSLs to contribute to the perceived value of packaging.

Furthermore, the role of colour in aiding the understanding of waste-sorting instructions has been emphasised, although most participants in a Swedish study did not initially consider it beneficial when applied to the main body of the packaging (Nemat et al., 2020). However, participants suggested that using bright colours, such as red, for specific components (e.g. caps) could serve as a visual reminder to separate and sort these components differently from other components of the same packaging. It is crucial to note that associations between colour and actions or perceptions need to be established first (Schloss et al., 2018; Schoenlein and Schloss, 2022), which may potentially explain cultural differences in colour–object associations (Leeabai et al., 2021).

Langley et al. (2011) conducted four studies using various methodologies (bin raids, digital diaries, a visual questionnaire and video ethnography) in the United Kingdom ([24]). Their findings indicate that households generally do not incorporate on-pack information in their waste disposal decisions. Confusion regarding recycling labels exists, and prior knowledge about waste sorting appears to matter more than on-pack information. Additionally, recycling efforts may be hindered if materials are perceived as dirty and disgusting (labelled the 'ick factor' by the authors), particularly in the context of packaging for meat products. From these findings, we infer that WSLs will need to contend with existing and potentially conflicting consumer knowledge about waste sorting and with perceptions of waste as unclean and unpleasant. It is essential to recognise that

([24]) The study features fairly small sample sizes and some aspects appear to be of questionable quality.

complementary information campaigns might be crucial to establish an adequate knowledge foundation on the basis of which WSLs can effectively operate.

Box 2. Convenience considerations

Convenience plays a key role in getting people to sort their waste correctly, that is, how easy (or hard) it is for individuals to sort their waste correctly. It is influenced by factors such as the design of product packaging, the availability and design of waste bins and labels, the accessibility of waste facilities (including the convenience of waste collection), the clarity of waste-sorting information and the time it takes to sort waste. WSLs should make waste sorting more convenient or, at the very least, should not make it less convenient (Nainggolan et al., 2019).

Perceived inconvenience is a significant barrier to waste sorting (Rousta et al., 2015; Pedersen and Manhice, 2020; Gutierrez et al., 2021), and the convenience provided by certain packaging features, such as resealability and the ease of emptying or cleaning, were valued by consumers, leading to less missorting (Nemat et al., 2022). Clearly visible recycling containers, clear recycling instructions and accessible collection points increase participation and sorting rates (Bernstad, 2014; Arbués and Villanúa, 2016). Conversely, obstructive lid designs or overly detailed labels can be counterproductive, highlighting the need for user-friendly and efficient WSLs (Gutierrez et al., 2021). Increasing recycling convenience could also foster people's intrinsic motivation (i.e. their motivation not including external motivations, such as financial incentives) to sort waste (Gilli et al., 2018).

There are several central design features of effective and convenience-enhancing WSLs. Simplicity, clarity and unambiguity are especially relevant. Clear labels are paramount, favouring clutter-free, concise design and layout, which supports users in quickly identifying the correct waste category, avoiding cognitive overload. The positioning of WSLs should be strategic to support visibility and accessibility, placing them at or slightly below eye level (although this can be challenging depending on the size and shape of the bin), and adequate font size should be used when there is text. Furthermore, labels could capitalise on intrinsic motivation to bolster eco-friendly behaviour. This could involve integrating elements such as progress indicators or environmental impact statements into the label design. Nonetheless, in practice, this could potentially lead to too much information being on the label, which might lead to cognitive overload and backfire (i.e. lead to less correct sorting after providing more information to encourage waste-sorting behaviour). Therefore, the fact that, as previously outlined, emotional and value-laden messages can lead to overinclusive sorting should be considered.

The study by Langley et al. (2021) offers insights into consumers' understanding of the role of packaging in reducing food waste. While the objective of reducing food waste differs from inducing correct waste sorting, there are relevant takeaways for optimal label design. The study suggests that consumers can be motivated to reduce food waste through appropriate prompts and packaging that is designed to minimise cognitive, conative and affective burdens. Additionally, the study reveals a consumer tension between the desire to reduce packaging, especially plastic, and the goal of reducing food waste. While neither packaging nor food waste reduction is the primary factor in food-purchasing decisions, packaging reduction was perceived as more important than food waste reduction. The study argues that packaging design that provides clear information and instructions and avoids additional clutter can assist users in reducing food waste while correctly disposing of the packaging. In this context, WSLs could complement the objective of food packaging, which primarily is to conserve food. Furthermore, the authors emphasise the likely benefits of collaborative packaging design involving relevant stakeholders to balance commercial and consumer considerations. This notion may extend to the development of WSLs, highlighting the importance of involving various stakeholders in ensuring the effectiveness and alignment of WSLs with both commercial and consumer needs.

Key lessons, insights and implications

- Insights on how packaging design elements are perceived and understood are limited.
- Packaging serves as a natural platform for WSLs to convey sorting instructions to consumers.
- WSLs should complement the relevant messages conveyed by packaging and simultaneously enhance the perceived value of packaging.
- WSLs compete with prior and potentially conflicting consumer knowledge on how to sort waste correctly and with perceptions of waste as disgusting and dirty.
- Complementary information campaigns can develop the required knowledge.
- The co-design of WSLs by different types of stakeholders is essential.

6.1.2. Effects of packaging design on behaviour and behavioural intentions

Delving into the effect of packaging design on behavioural outcomes, we derive insights from four studies. In a study utilising photo-based observations and semi-structured interviews, it was found that the form, size, durability and visual communication properties of packaging significantly influenced how much consumers valued packaging. Packaging that was perceived as low value tended to be discarded without proper sorting (Nemat et al., 2022) ([25]). This emphasises the crucial role of packaging design and perceived value in promoting recycling, a principle that is likely to be applicable to the design of WSLs. The study further highlights the influence of informal consumer knowledge on consumers' evaluation of packaging and subsequent sorting behaviour. Practical and visual attributes of packaging – including resealability, size and aesthetics – can be leveraged to enhance the effectiveness of waste sorting and recycling labels. Additionally, the study notes the challenge posed by torn and ripped pieces of packaging waste, which respondents reported as difficult to sort, leading to frequent missorting. Considering these findings, it is crucial for WSLs to contribute positively to the perceived value of packaging and offer consumers a sense of convenience when sorting their waste, including hints on dealing with torn and destroyed waste components.

A set of six studies from the United States, primarily conducted through laboratory experiments, investigated the impact of distortion and size of paper on people's recycling behaviour (and their perception of this type of waste in one of the studies; Trudel and Argo, 2013). A key finding was that paper was more likely to be recycled when the pieces were large and non-distorted. The studies suggest that participants' perceptions of the usefulness of paper waste explain their recycling decisions. When participants were prompted to list potential uses for the paper, they were more inclined to recycle it. These findings were also observed with empty soft drinks cans, which resemble actual waste items more closely than pieces of paper. From these insights, it can be inferred that the distortion of packaging waste influences its disposal and probably affects the effectiveness of complementary WSLs. Whether correct handling and sorting instructions for damaged or torn packaging are addressed on WSLs may primarily be a question of practical feasibility, particularly considering space constraints.

A student thesis presenting findings from three studies using an online ranking survey, a conjoint analysis and a field experiment suggest that visual elements (colour and imagery) play a larger role than either information (claims, logos and labels) or sustainable packaging design (the amount and type of material and the reusability) in waste-related consumer decisions (Borgman et al., 2018) ([26]). Furthermore, the study affirms other findings emphasising the importance of the consistent placement of labels on packaging. While sustainability information appeared to be appreciated by consumers, their willingness to pay for an extra sustainability label was low ([27]). Based on these findings, it appears unclear if recycling labels and related textual information reliably improved consumer recycling decisions. Consequently, we note that graphical elements could be preferred over text on WSLs to provide important information. Finally, WSL design should consider that consumers might have only weak preferences for additional labels.

One study from the Netherlands focused on littering behaviour, that is, the act of disposing of waste materials in inappropriate places ([28]). Naturally, there are some important distinctions between littering, waste-sorting and recycling behaviour. Littering behaviour often involves careless and undeliberate disposal of waste – meaning that littering is rarely done with intent, but rather without thinking about it – while waste-sorting and recycling behaviour primarily involves deliberation and volition. Littering is associated with low pro-environmental attitudes, while proper waste sorting is typically a result of high pro-environmental attitudes.

In experiments assessing the impact of design solutions on littering, researchers attached a label to disposable coffee cups with the message 'Throw this cup in the litter bin or it will still be here in 6 months from now …' (Wever et al., 2010) ([29]). This label reduced littering in the short term (from 11.2 % to 6.7 %) but not in the long term, as littering returned roughly to above baseline levels (14.1 %) after removing the labels. The short-lived effect might be explained by the short-term implementation of the labels. In a subsequent experiment, littering of reclosable polyethylene terephthalate (PET) bottles was compared with littering with non-reclosable CartoCans, a cylindrical cardboard box with a peel-off closure. The PET bottles were littered less than the

([25]) The study features a small sample size of 18 individuals.
([26]) This publication was not peer reviewed. It contains many incomplete responses and statistical analyses are lacking.
([27]) Unfortunately, the authors of the study do not appear to provide any information to further substantiate what is meant here as low.
([28]) Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment (OJ L 155, 12.6.2019, p. 1) introduced labelling requirements for informing consumers about the plastic content of some products (e.g. cigarette filters, plastic cups for beverages and toiletries), set out the disposal options that are to be avoided and outlined the harm done to nature if the products are disposed of in the environment (van den Akker et al., 2021).
([29]) We note that at least one of the experimental designs featured in this article is not convincing (i.e. experiment 4 in the article).

CartoCans (2.6 % versus 5.8 %, respectively). In particular, the design of the PET bottles encouraged reuse because they could be refilled and carried around. These findings suggest that designs can encourage packaging reuse or repurposing.

In another trial, different confectionery wrapper designs were compared for their likelihood to be littered (Wever et al., 2010). One wrapper design was nearly transparent, the second was brightly coloured and the third was not only vividly coloured but also featured half a proverb on each wrapper. The third type is used to wrap a traditional Dutch type of confectionery. The proverbs engaged individuals for a longer period, with one wrapper displaying a line such as 'All good things come …' and another complementing it with '… in small packages'. The intention was to capture people's attention, potentially making it more likely for them to remember to dispose of the wrapper properly. Surprisingly, this approach increased littering, as individuals were more likely to leave the wrappers on tables. This suggests that, while adding extra elements to packaging may catch consumers' attention and engage them, it can inadvertently lead to increased littering if it diverts the product from environments with accessible waste bins.

There is a balance between using packaging design to attract consumer attention and encouraging proper waste-sorting behaviours. Packaging design should combine educational messages, reusable designs and careful consideration of consumer interaction with the product in different environments. As regards WSLs, we can only derive the general insight that they should be noticeable, salient and conspicuous, and that the effects of WSLs are limited by the available waste disposal infrastructure.

Key lessons, insights and implications

- WSLs should positively contribute to the perceived value of packaging and provide consumers with a sense of convenience when sorting their waste.
- Characteristics of practical packaging design (i.e. being easy to empty, clean, reseal and reuse) may be complemented and highlighted by labels.
- Graphical elements might be preferable over text on WSLs.
- WSL design should consider that consumers may have weak preferences for additional labels.
- WSLs should be noticeable, salient and conspicuous.
- The effects of WSLs on littering and waste sorting are limited by available waste disposal infrastructure.

6.2. Receptacle design

6.2.1. Perception and understanding of receptacle design elements

In this section, we will review six studies on the impact of receptacle design elements, encompassing mainly the shape and size of both bin lids and insertion slots, as well as their colours. The articles reviewed highlight the potential complementarity between WSL design and bin design as part of improving correct sorting.

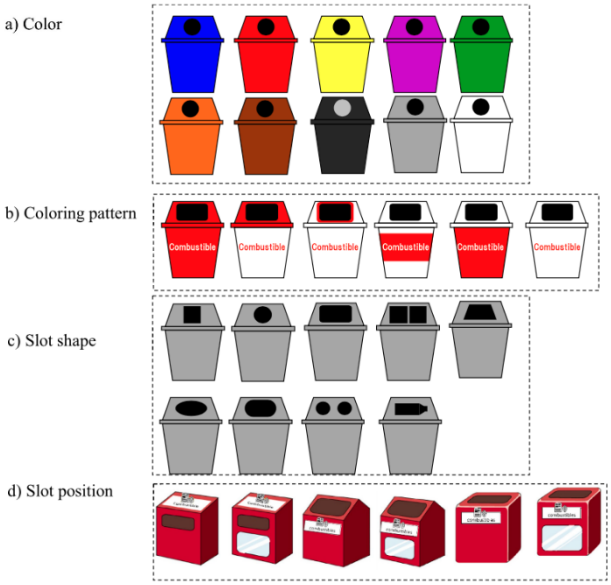
An article including two surveys and a field experiment from Thailand found that individuals with strong motivation for correct waste disposal tended to locate appropriate bins and sort correctly due to their high motivation (Leeabai et al., 2021). Bins with less noticeable colour combinations, however, required more effort to be found and were consequently used less by people with lower motivation to sort. Participants exhibited a preference for yellow bins, but greater preferences for certain colour bins were generally associated with lower waste separation efficiency. Consequently, the authors suggest that increased efforts to grab attention, through appropriate bin design and configuration, could lead to more efficient collection of separated waste. We extend this to WSLs, suggesting that attention-grabbing labels could lead to more efficient SWC and that WSLs with less-preferred colours do not necessarily perform worse.

Several studies conducted in Japan, including a design categorisation survey with 730 participants focusing on recycling bins used in public spaces, revealed that the preferred colours for bins depended on specific design elements and the type of waste the bins were intended for (Jiang et al., 2021). Preferred colours aligned with those of frequently used design items, such as the slot frame colour for Japanese combustible and incombustible waste bins and the body colour for PET bottle bins. These colour preferences were not arbitrary,

as the correlations between colour preferences and the actual usage rates of those colours in the bin designs were statistically significant ([30]).

Moreover, by measuring preferences for specific shapes and positions of insertion slots depending on the type of waste (Figure 18), Jiang et al. (2021) revealed that preferences for the shape of the insertion slots in recycling bins primarily depended on the size of the slot, with larger slots receiving higher preference scores. From this study, we can infer that colours for WSLs should be carefully selected, considering consumers' previous encounters with colours and their associations with specific waste materials.

Figure 18. Recycling bin designs used in online questionnaires designed to elicit preferences regarding colour, colour pattern, slot shape and slot position conducted by Jiang et al. (2021)



Source: Jiang et al. (2021).

Two surveys conducted in Greece, an exploratory survey with 757 respondents and a validation survey with 430 respondents, explored preferences for recycling bin characteristics such as colour, shape, type of lid and insertion slot. The findings revealed that respondents tended to associate the colour of the bin with the colour of the recyclable material (Keramitsoglou and Tsagarakis, 2018). For example, participants associated white or grey with paper, metallic grey with aluminium, different shades of green and red-brown with glass (depending on the colour of the glass) and green or brown with organic waste. For materials with non-defined colours such as plastics or packages, hues of orange, yellow or purple were preferred. Interestingly, participants associated blue – which, according to the authors, is frequently associated with paper in many countries – with mixed-material recycling, possibly influenced by Greece's 'blue bin' packaging recycling programme. The authors also emphasised that public participation in the design of recycling facilities could increase willingness to recycle. From this it can be inferred that public participation in the design of WSLs could be beneficial and that the colours of WSLs should take into consideration people's colour associations with specific materials.

Another study suggests that the association between colours and objects extends beyond a simple one-to-one match (Schloss et al., 2018). The relationship can be one-to-many, whereby one colour is linked to several concepts, or many-to-one, whereby various colours correspond to a single concept. In their research on recycling, the authors explored how people interpreted colour-coding systems through a process called assignment inference, determining how colours relate to specific concepts. Participants were shown images of coloured but unlabelled bins and were then asked which bins they would use for different types of recyclables and rubbish. Participants tended to choose bins that best optimised the entire set of colour–object associations, rather than simply matching each object with its most strongly associated colour. Intriguingly, this approach occasionally led to objects being discarded in bins whose colours had only a weak association with the object, even when a

([30]) While the authors undertook an experimental study to investigate the impact of colour on sorting accuracy, their design did not seem to allow for an unbiased detection of colour impacts, as colour, waste type and insert slot shape varied at the same time (see Jiang et al., 2021, Figure 8 on p. 139). Furthermore, the article presentation and methodology were of questionable quality, including confounders in the experiment investigating the effect of colour on waste-sorting accuracy.

more strongly associated option was available. This provides a more nuanced and holistic understanding of how people use colour for categorisation and decision-making, especially in contexts, such as recycling, in which visual cues play a crucial role. The only general insight for WSLs is that colours used on WSLs should consider users' prior colour–object associations.

Based on a survey of 785 United States-based waste professionals on the size, type and colour of waste receptacles used in waste collection systems, the authors concluded that there was no single best recycling container (Lane and Wagner, 2013) ([31]). They cited a host of contextual variables as the main reasons for this (including sociopolitical variables and variables related to waste infrastructure), which would therefore require context-dependent design. Furthermore, the authors recommended that recycling programmes target dwelling type (single- versus multiple-family dwellings) and follow a 'purposeful incrementalism' approach in the design of SWC systems, based on distinct and ordered goals informed by pilot studies. Finally, the authors stressed the importance of considering purchase costs, assembly needs, durability, maintenance, adaptability to new technology, impacts on worker safety, collection limitations/needs and additional technology needs. From this study, we conclude that various contextual factors influence what would be considered the best design of WSLs, that the costs of WSLs and their implementation need to be considered during their design and planning, and that optimal WSLs should be based on pilot studies, if possible.

Finally, three studies conducted on a university campus in the United States investigated the impact of waste bins that gave users feedback on the number of deposited items via a digital number display. The findings suggest that new technologies can garner interest, increase waste deposits and decrease contamination rates (Mozo-Reyes et al., 2016) ([32]). We deduce from this study that feedback can facilitate appropriate interaction with new technologies, which could potentially include WSLs, and that technology has the potential to make recycling more attractive and entertaining.

Key lessons, insights and implications

- The colours of WSLs should be carefully selected, and consumers' previous encounters with colours and their associations with certain waste materials should be considered.
- The colour coding of labels could align with public perceptions of the type of waste. Relating various colours to a particular waste type, rather than just one colour, could cater to a wider range of individual associations. This may be particularly relevant when developing harmonised EU WSLs. However, consumer confusion may outweigh potential benefits of a multicolour scheme.
- WSLs with less-preferred colours do not necessarily perform worse.
- Various contextual factors influence what is considered the best design of WSLs.
- The costs of WSLs and their implementation need to be considered during their design and planning.
- WSLs should be based on pilot studies, if possible.

6.2.2. Effects of receptacle design on behaviour and behavioural intentions

Turning to evidence of the impact of receptacle design on waste-sorting behaviour and intentions, we explore the insights from four studies. A previously mentioned study exploring user needs and waste bin attributes in the Philippines, focusing on waste-sorting and recycling behaviour, investigated eight key waste bin attributes: body shape, opening shape, opening position, lid type, label/signage design, label/signage position, categorisation and colour (Gutierrez et al., 2021). The research, based on focus group discussions and a small survey, identified user difficulties with bin usage and sorting, including obstructive bin lids, a lack of waste disposal knowledge, time-consuming on-bin label reading and inaccurate label images. In response to these challenges, the researchers developed a waste bin prototype with nine insertion slots and three colours, featuring labels on the front side and around the slots (Figure 14). This new design addressed many of the issues identified by enabling lids to be removed for easier use, using informative labels to guide waste separation, reducing the number of labels for quicker identification and designing labels based on actual waste items for better visual recognition, resulting in improved waste sorting. Extrapolating the findings of this study to potential insights for WSLs suggests that WSLs should not display too many different items, the references

([31]) The survey provides only anecdotal evidence, as stated by the original authors themselves.

([32]) While many of the studies featured in this report rely on convenience samples (mostly students), the findings of this study may be particularly influenced by the sample being mainly students and university staff, who tend to be more open to new technologies than the wider public.

to items should be unambiguous using icons and pictograms, and WSLs should provide sufficient information on the SWC scheme they refer to.

The design elements and colours of waste bins might influence their salience and consequently recycling rates. For example, a bright-green bin increased recycling rates compared with an arguably less noticeable grey bin (from 52 % to 88 % of an albeit small number of 48 participants) in a US university (Montazeri et al., 2012) ([33]). Although the reasons for this increase are unclear, factors such as salience or association with concepts such as sustainability might be responsible. We conclude from this study that colours are important components of WSLs and that certain colours may be better remembered and associated with certain concepts than others. The colour green may be especially associated with concepts such as recycling and pro-environmental behaviour more generally. Thus, it should be used consciously on WSLs.

Relatedly, covering recycling bins on three sides with bright yellow sunflower covers increased the capture rates of food waste (Lin et al., 2016). The success of visually appealing stimuli can be attributed to their ability to induce a positive emotional state in individuals. Consequently, the benefits gained from inducing positive emotional states using visual prompts could also be extended to WSLs.

Key lessons, insights and implications

— Consciously designed bin shapes, lid designs and colour choices, together with well-placed, easy-to-understand labels, can increase user engagement, waste sorting and recycling rates.

— WSLs should be placed in prominent positions and be designed in close correspondence with the waste material to be disposed of, for easy recognition, and the number of labels should be minimised to facilitate quicker identification of the relevant label and information.

— Because well-designed lids can promote recycling and decrease contamination, it is important to consider the compatibility of labels with different bin and lid designs. The labels should be designed and positioned (or attachable, if they are stickers) in a way that complements the bin design and does not interfere with the usage of lids or slots.

— Using bright and appealing colours may induce a positive emotional state and encourage more participation in waste sorting; however, the colours that are perceived as appealing can vary greatly.

([33]) This publication does not appear to be peer reviewed.

7. Critical reflections

When evaluating the evidence and deriving policy recommendations from the studies considered, several important caveats should be considered. First, there is a noticeable scarcity of robust and reliable evidence from behavioural science studies specifically focused on the design of WSLs. Most studies lack a direct comparison between WSL design elements or specific WSL designs to determine effectiveness. This is a clear limitation with respect to our objective. The limited evidence may stem from the fact that relevant insights are primarily found in areas such as design research and practice, rather than behavioural sciences. Although we employed a fairly inclusive approach to identifying the relevant evidence, we also systematically excluded literature focusing on connected but different kinds of labels or label objectives. For example, we excluded the vast body of literature on front-of-pack nutrition labels (Nohlen et al., 2022) because of the distinct objectives of these labels. Similarly, we focused on waste sorting instead of waste avoidance or littering. Furthermore, we excluded more general evidence on behavioural drivers of waste sorting or recycling, for which dedicated articles exist (Passafaro and Livi, 2017; Geiger et al., 2019; Knickmeyer, 2020; Raghu and Rodrigues, 2020; Fogt Jacobsen et al., 2022). Although we somewhat widened our scope by including evidence on packaging and receptacle design, we do not paint a comprehensive picture of this line of research.

Second, for a substantial number of the papers included, we had potential concerns regarding their quality. Our subjective assessments indicated issues with some papers, with concerns raised about the reliability of the findings of 18 articles. The results of this subjective quality assessment were significant, especially considering the relatively small number of articles included and the criticism of the publisher of one of the journals (Crosetto, 2021). While we decided not to exclude these papers, we think this should be considered when interpreting the evidence and when considering routes for future policy-relevant research.

Third, the generalisability of insights to EU countries is a challenge, as many of the studies included were conducted outside the EU. Behavioural science evidence is often context dependent, making it challenging to assess the level of generalisability (Mažar and Soman, 2022). Scholars and practitioners should avoid overgeneralising findings to different contexts (Peters et al., 2022). However, not all insights need to be verified for all contexts and Member States. In the end, the level of generalisation relies on expert judgements, which should be considered carefully.

Fourth, this report incorporates empirical evidence from various methodologies, including interviews, case studies, surveys and experiments. While these methods serve different types of inquiries, it is crucial to note that only experiments establish causality, while other methodologies reveal correlations at best.

Finally, large effect sizes should be taken with a grain of salt, especially when they emerge in studies with relatively small numbers of respondents – which is true of a substantial number of reviewed papers (Button et al., 2013) – and when they result from laboratory studies (DellaVigna and Linos, 2022). The current publication system in science still over-incentivises the publication of positive results and this leads to studies that do not find impressive effects or that find no effects never being published (Franco et al., 2014). However, to get an unbiased overview of the effects of interventions, these results would also be insightful. These shortcomings are not exclusively of academic concern but should also be considered when deriving policy recommendations from single papers and studies.

8. Conclusions and design recommendations

The primary goal of WSLs is to streamline waste sorting so that it is more convenient and to equip individuals with the necessary skills to sort waste accurately (Cristobal Garcia et al., 2022). Additionally, WSLs can serve other purposes, such as boosting motivation to sort waste and enhancing individuals' abilities to do so correctly. This report compiles evidence from the field of behavioural sciences to guide the creation of harmonised WSLs in the EU. While the relevant literature is limited in quantity, scope and general applicability, it provides some pertinent insights. Although somewhat broad, these insights can inform the design and testing processes that are crucial for developing harmonised EU WSLs. While the key lessons, insights and implications are summarised in the boxes throughout Sections 5 and 6, Table 3 lists general recommendations for the design and content of WSLs informed by the evidence reviewed. We think it is worthwhile considering them. The table can serve as a checklist when planning and designing harmonised WSLs.

Table 3. Insights on the design of harmonised WSLs

Design element	Definition	Insight
Accessibility	Accessibility refers to the ease with which people can access and understand the WSLs. This includes considerations for different user groups, such as individuals with disabilities, those who speak different languages or potentially those who have problems sorting correctly.	Designing accessible WSLs ensures that everyone, regardless of their abilities or language, can comprehend and follow the instructions. Using clear fonts, employing appropriate colour contrast and providing alternative formats (e.g. Braille or pictograms) makes the labels accessible for a wide audience.
Accuracy	Accuracy pertains to the correctness of the information provided on the WSLs. It ensures that the labels correctly identify the relevant waste materials and/or represent which waste items belong to each waste stream.	Accurate WSLs prevent confusion and incorrect waste disposal. Inaccurate information would induce incorrect sorting, confusion and distrust. Regular verification and updating of information are crucial to maintain accuracy.
Actionability/intuitiveness	Actionability or intuitiveness is about making the labels easy to understand and follow without requiring additional information or significant contemplation and mental effort.	WSLs should use relatable language, symbols and imagery that resonate with users and facilitate quick and accurate decision-making (i.e. be actionable). An intuitive label design reduces the cognitive effort required for users to determine where each waste item should go. Intuitive labels transmit clearly to users what the required actions are, providing them with the information necessary to act accordingly.
Clarity	Clarity involves presenting information in a straightforward and easily comprehensible manner, avoiding ambiguity or confusion.	Clear WSLs leave no room for interpretation. Users should be able to quickly determine the appropriate waste category and undertake the corresponding disposal behaviour without having to decipher complex wording or unclear images. A clutter-free design with concise text and

		recognisable symbols or images enhances clarity.
Compatibility with other labels	This refers to designing labels that remain clear and distinct, even when placed near other labels, especially recycling labels, which might convey similar yet distinct messages.	Product packaging (especially primary packaging) often contains various graphical and textual elements, including labels and signs. Ensuring that WSLs remain distinguishable amid the visual clutter allows users to quickly locate the relevant information without confusion. Users must be able to understand relations between similar labels, such as recycling labels, and be able to resolve contradictions to derive the appropriate actions.
Complementary digital solutions	This refers to the optional and complementary use of QR codes or other digital tools that can provide additional context-sensitive information when scanned.	Digital solutions enable users who seek deeper insights to access detailed and country- or region-specific sorting guidelines, recycling processes or other relevant information. An interactive approach caters to users who want to engage further, without cluttering the primary label with excessive details. Limitations to the use of digital solutions in specific segments of the population and regarding long-term usage rates should be considered, and their relevance and effective impact should be evaluated.
Conciseness	Conciseness refers to the quality of being brief and to the point without unnecessary details or elaboration. In the context of labels, being concise is important, to ensure that the information is clear, easily understandable and not burdened with excessive or irrelevant details.	WSLs should contain all of the necessary information to enable consumers to take appropriate waste-sorting actions. This information should be presented in a concise – meaning brief and 'on-point' – fashion. Being concise (i.e. avoiding too much text or too many pictures) prevents information overload in users.
Consistent placement	Consistent placement refers to the uniform positioning of WSLs across different packaging types, products and receptacles, as well as potentially across countries and time.	Placing labels consistently in the same position on different packaging types, products and receptacles, as well as across countries and time, creates a sense of familiarity and predictability for users. This reduces the cognitive load, as users can anticipate where to find the label, making consultation of the labels and the act of waste sorting a more habitual and efficient process.
Consistent use of text and/or graphical elements	The consistent use of text and graphical elements refers to maintaining uniformity in the way	Text and/or graphical elements should be used consistently. While a combination of text and graphics

	information is presented using both written text and/or visual symbols.	caters to different learning styles, language preferences can make the use of text on an EU-wide harmonised label difficult. Graphical elements can serve to ensure that users understand the message regardless of their language preferences. If text is used, it should be used consistently with graphical elements.
Factuality	Factuality involves presenting information objectively and avoiding subjective or overly persuasive and motivational wording.	The primary goal of WSLs is to enable people to sort their waste correctly. While there can be room for motivational and persuasive messages aimed at increasing the motivation to sort waste, labels should focus on conveying accurate information without imposing personal beliefs or motivations. Neutral language prevents confusion and psychological reactance and maintains the label's credibility, ensuring that users receive clear and unbiased guidance.
Instructions for the preparation of packaging components	Instructions for the preparation provide guidance on how to properly prepare packaging waste items before sorting them.	The recycling of packaging waste often requires consumers to undertake specific actions, such as rinsing containers or flattening boxes. Clear instructions ensure that users prepare their waste correctly, contributing to a smoother recycling process and minimising contamination. Some of these instructions might come with non-negligible space requirements, making it necessary to evaluate their cost–benefit ratio.
Minimum size	Having a suitable minimum size means ensuring that the labels are large enough to be easily noticed, read and understood.	Labels that are too small might fail to capture attention and may be challenging to read and understand, especially for individuals with visual impairments. A suitable minimum size (based on the label's location on packaging or receptacles) guarantees legibility, ensuring that users can quickly grasp the information presented on the label.
Perceived quality	Labels that are perceived as high quality are those that are perceived as correct, well made and professional and instil a sense of trust and reliability.	Labels with a polished and high-quality appearance are more likely to capture users' attention and convey a sense of authority and reliability. This can enhance users' confidence in following the sorting instructions and contribute to the perception of a well-

		organised waste management system.
Persuasiveness	Persuasiveness refers to the ability to influence or convince others to adopt a particular belief, attitude or course of action. It involves using effective communication, reasoning and sometimes emotional appeals to sway someone's opinion or behaviour in a specific direction. In the context of WSLs, persuasiveness refers to their effectiveness in influencing and convincing individuals to correctly and consistently sort their waste.	A persuasive WSL is designed to communicate information in a compelling and convincing manner, encouraging people to take the desired action. In terms of motivation, opportunity and ability, persuasive labels aim to increase users' motivation to sort their waste. However, the risk of inducing overinclusive recycling should be considered (see also the factuality insight).
Resistance to destruction	Resistance to destruction involves designing labels that either withstand destruction through the use of the packaging or that still work on torn packaging.	Labels should be durable and resistant to fading, peeling or other damage. Labels that remain intact over time and after use of the packaging maintain their effectiveness, preventing confusion due to worn-out or illegible instructions. The limitations of destroyed labels or packaging should be analysed and considered.
Salience	Salience refers to making the labels stand out and easily noticeable in their surroundings (i.e. on packaging and on receptacles).	Labels should be visually prominent so that users can quickly locate them amid other elements, especially other labels. A salient label design catches users' attention and guides them towards the appropriate waste disposal, reducing the chances of confusion.
Use of colours	This involves selecting colours that are culturally appropriate and align with relevant habits, ensuring that they do not convey conflicting meanings.	Colours have cultural associations that can influence how people perceive and respond to them. There are also various prior associations between colours and waste materials or waste streams. Careful colour choice (or the choice to not rely on the use of colours at all) can prevent misunderstandings or cultural sensitivities, ensuring that the intended message is conveyed accurately.

Source: Authors' own creation.

Figure 19 illustrates potential interrelations among the design elements outlined in Table 3. While the proposed interrelations are subjective in the sense that they rely on a subjective method, we think the figure reveals some interesting considerations. We categorise design elements into three main topics: presentation, quality and content, and accessibility.

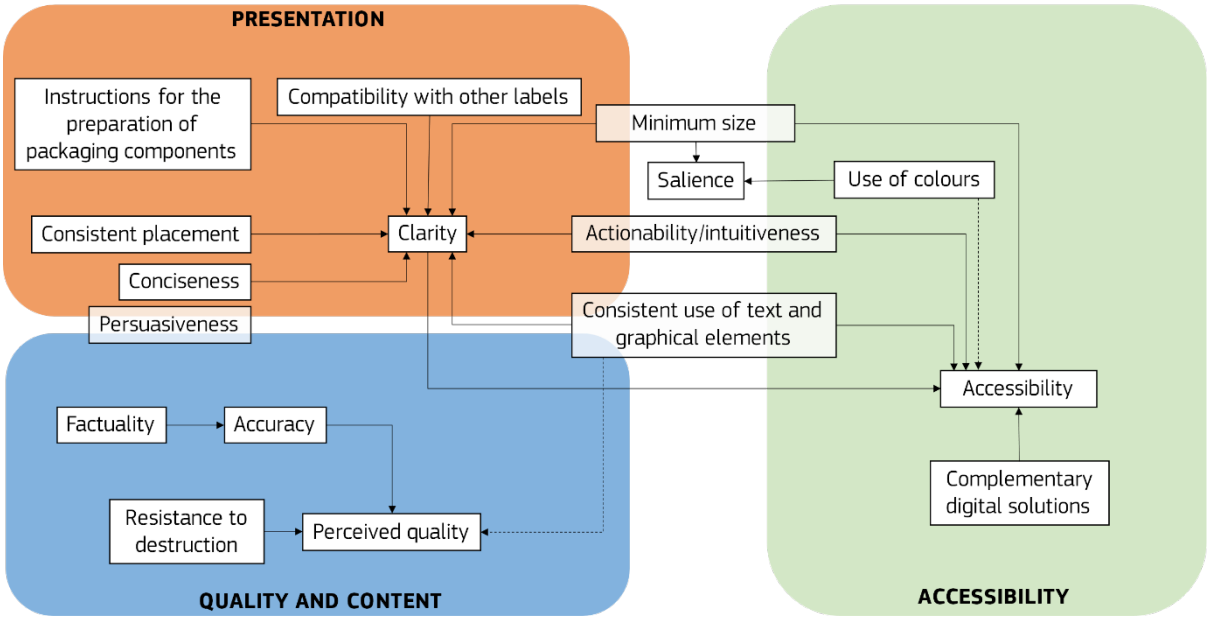
1. **Presentation considerations** refer to the way information is presented on the WSLs, emphasising clarity. Design elements contributing to clarity include instructions for the preparation of packaging

components, compatibility with other labels, minimum size, actionability/intuitiveness, consistent use of text and graphical elements, conciseness, persuasiveness and consistent placement.

2. **Quality and content considerations** focus on the content and perceived quality of labels, separate from considerations of how the content is presented. Factual accuracy, especially when paired with destruction-resistant labels, contributes to a high degree of perceived quality. Focus on graphical vehicles for communication and, if text is used, the consistent use of both elements is proposed to enhance perceptions of quality, instilling a sense of reliability and trustworthiness. The content should also be persuasive.
3. **Accessibility considerations** centre on labels being usable by many different types of people. Accessibility benefits from an adequate minimum size (especially for people with impaired eyesight), actionable and intuitive information (requiring less prior knowledge), consistent use of graphical elements potentially with text (e.g. to reduce reliance on language skills), considerate colour use (considering alternatives for people with colour blindness) and the availability of complementary digital solutions to enhance accessibility.

Salience, identified as an outcome of colour use and minimum size, stands apart from the three main considerations. These considerations offer a holistic view of WSL design elements and their potential interrelations, providing a valuable framework for creating labels that are clear, of high quality and accessible to a diverse audience.

Figure 19. Graphical representation of design insights and their relations to each other (indicated by arrows) across the three main topics



Source: Authors' own creation.

Other important aspects emerged while reviewing the relevant literature that need to be considered to design effective WSLs. First, consumers are likely to pay less attention to WSLs over time. While they may absorb and apply the information initially, constant evaluation might not occur. This poses a challenge for long-term use, especially when waste streams change, necessitating updates to the labels. For instance, noticeable visual changes may be needed to capture attention, particularly for information accessed through QR codes or digital means not directly inferable from the label.

Second, multicomponent and multi-material packaging poses specific challenges to WSLs, as this type of packaging requires more cognitive and physical effort for correct sorting than single-component or single-material packaging. These challenges render many of the design elements outlined in Table 3 and Figure 19 more relevant.

Third, on-receptacle labels provide additional space for information at the point of disposal, presenting flexibility compared with on-pack labels. An advantage of an EU-harmonised waste-sorting labelling system that does

not rely on text in the country's language is that producers do not have to create different packaging for different countries. However, this does not apply to receptacles, for which labels could be attached with stickers (as is the case in the Nordic scheme) and thus can be adapted to changing circumstances, including preferred languages, or complemented with additional information. This is an advantage over a scheme relying solely on on-pack labels. Naturally, however, if both are used, consistency between on-pack and on-receptacle labels must always be ensured and must be obvious to all types of users. It must be clear to users if product icons or pictures (if used) refer to waste that should or should not be disposed of in the receptacle. If icons are used to indicate both waste items that should and waste items that should not be disposed of, this must be unambiguous.

Fourth, on-pack labels should maintain or enhance the perceived value of packaging, and could inform users about central packaging design aspects, such as how to clean or disassemble the packaging before disposal (e.g. the Info-tri from France indicates which components of the packaging must be separated before disposal, even when the components are going in the same bin). While the available space and a requirement for self-contained labels set some limits on the possibility of providing cleaning and separation instructions, this content should be considered and tested.

Fifth, WSLs should consider existing waste management instruments, especially pay-as-you-throw models and deposit refund schemes, because these can affect the primary objectives of labels. Most importantly, it should be obvious to users that the objectives of different waste management instruments are consistent. Receiving mixed signals from different instruments might create undesirable effects. Whether or not WSLs should be combined with similar existing labels (e.g. labels indicating recyclability, instructions for repurposing of packaging or labels indicating recycled content) should be considered carefully and tested beforehand. In line with this, the extent to which WSLs communicate pro-environmental messages should be carefully considered. They could, for example, inform users about the reusability of packaging or about ways to repurpose it, or they could persuade users of the beneficial effects of waste sorting on the environment (although it should be acknowledged that these impacts may be rather small; see, for example, Andreasi Bassi et al., 2017; Wynes and Nicholas, 2017). However, this might conflict with sorting objectives or distract from the objective of **correct** sorting. In addition, certain pro-environmental messages, especially those with a persuasive aim, might lead to overinclusive recycling ([34]). A potential benefit could be that such components might change over time, which might increase the attention paid to labels as new content is implemented.

Sixth, education and information campaigns can support WSLs by enhancing their salience, understanding and valuation. Even well-designed WSLs require a certain amount of prior knowledge to be effective. This knowledge, if not conveyed directly through the labels, must be sourced from somewhere else. While WSLs would optimally 'speak for themselves', meaning that they would not require supplementary information to work, educational and informational campaigns, especially during the time of implementation of the labels, are noteworthy complements.

Seventh, the social role of WSLs should be considered. WSLs are unlikely to shift social norms towards pro-sorting or pro-recycling attitudes by themselves. However, they might send a relatively strong signal that waste sorting in the EU is important and socially desirable if they are accepted by a significant majority of people. While it would in theory be conceivable that WSLs could communicate social information regarding waste sorting (e.g. 'The majority of people in your country sorts 96 % of their waste correctly. Be one of them!'), it might not be practical due to the space constraints and the importance of clarity of labels. In any case, before including such types of persuasive communication, it is strongly advisable to test them in various Member States to verify their effectiveness and sensitivity to country-specific characteristics.

Finally, WSLs have limitations and these need to be made salient, assessed and acknowledged. We argue that, in line with the motivation–opportunity–ability model (Ölander and Thøgersen, 1995; Cristobal Garcia et al., 2022), people may also sort their waste correctly without WSLs, for example if they are sufficiently motivated to do so. Thus, labels serve as a complement to other approaches and are not the total solution. The goals of WSLs are to (1) reflect and support the benefits of waste sorting, (2) provide the necessary ability and opportunity to sort and, potentially, (3) build motivation through persuasive pro-environmental messaging.

([34]) Although this review does not include evidence on the potential of WSLs or recycling labels to induce psychological reactance, there might be a risk of this for certain types of citizens. Psychological reactance is a cognitive response to situations in which people perceive that their autonomy is under threat. This can be followed by behavioural reactions to reinstate that autonomy. In practice, messages aiming to induce recycling could lead to less recycling because people do not want to do what they are being told. There is ample evidence that this can result from objectively non-restricting interventions, such as recommendations (Fitzsimons and Lehmann, 2004) or certain types of nudges (Bruns and Perino, 2023). While this risk should not be overstated, it should be considered if persuasive messages are part of WSLs.

Furthermore, positive perceptions and understanding of WSLs are necessary but are not the sole component of a label's effectiveness. There are many factors that can, in theory, render well-perceived and understood labels ineffective. Experimental testing should verify effectiveness as much as possible to complement easier-to-obtain insights on the perceptions and understanding of labels ([35]).

In view of our analysis of the evidence and our critical reflections, we highlight some recommendations for future research. More extensive experimental testing of the effectiveness of on-pack WSLs and their elements would be helpful. This would include assessing the effectiveness of pictures versus words, consistent sign placement and the impact of sign styles on waste-sorting behaviour. Labelling is an instrument frequently used to influence various types of behaviour. While various valuable insights into the effects of different types of labels are backed by behavioural evidence, the context dependency of behaviours makes generalising them challenging. Although it would be a wasteful use of public resources to generate new data for every specific context, especially given the goal of science to generate generalisable insights, these limitations must be carefully assessed and considered. Research could also benefit from an integrative conceptualisation of the elements of effective label design. This does not exist, to our knowledge. Finally, a similar review focusing on design research and practices might provide important and practical insights for our objective that might well complement the limited behavioural evidence we outlined.

To conclude, this report seeks insights to inform the design of WSLs derived from the behavioural sciences literature dealing with WSLs and recycling labels, including a few key articles dealing with packaging and receptacle design. These insights are based on a fairly limited number of articles, suggesting that there is a need for further empirical research, which may well benefit from integrative conceptual work. Irrespective of these limitations, we derive key lessons, insights and implications from the literature for WSLs and propose design recommendations based on these insights.

([35]) Perceptions and understanding can in general be easier to measure because this can be done in surveys instead of through behavioural experiments. The latter are more difficult to conduct.

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List of abbreviations

ARL	Australasian Recycling Label
CEAP 2.0	2020 circular economy action plan
EGD	European Green Deal
MSW	Municipal Solid Waste
PET	polyethylene terephthalate
PP	polypropylene
PPWD	packaging and packaging waste directive
PPWR	packaging and packaging waste regulation
SWC	separate waste collection
WFD	waste framework directive
WSL	waste-sorting label
WWF	World Wildlife Fund

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Annexes

Annex 1. Keywords used to identify relevant records

The following is a comprehensive list of keywords that were used in the Web of Science search. The use of 'nothing' indicates keywords that returned no results.

- Household waste sorting
- Sorting behaviour
- Individual sorting
- Individual behaviour
- Recycling/Sorting/Waste segregation / separate waste collection
- Recycling or Trash + Bin/Containers/Can ('Recycling trash' (nothing))
- Recycling bin labels (nothing) / Trash can with recycle sign (nothing) / Bin design / Container design
- Recycling icons (nothing) / pictogram (nothing) / signage (nothing) / symbols / sign / images / labels
- Sorting icons (nothing) / sign / symbols / images / labels / pictogram / signage (nothing)
- Recycling identification and packaging / Recycling signs set trash (nothing)
- Garbage symbols (nothing)
- Nudge/Waste/Sorting/Framing
- Choice architecture + waste
- Eco-label
- Ecological label
- Waste sorting label (nothing)
- Packaging waste
- Habits + waste
- Ecological information
- Waste practice
- Behavioural changes

Annex 2. References included and their key characteristics

Table A1. Relevant references focusing on on-pack and on-receptacle labels

Reference	Journal	Focus	Label location	Main outcome variable	Methodology	Sample type	Sample size	Geographical focus	Main findings	Main insights for WSLs
Amir Kavei and Savoldi (2021)	*Sustainability*	Recycling labels	On pack	Perceptions of quality of on-pack indications of different packaging materials and product types	Survey	Non-students	452 individuals (complete responses only)	Italy	(1) Seventy per cent of participants considered on-pack indications to be the primary source of information on waste sorting. (2) The reuse of packaging was common among three quarters of participants and depended on familiarity with the circular economy. (3) Almost all participants rated their knowledge about recycling and waste separation as relatively high. (4) Multicomponent packaging was responsible for a large part of unrecycled packaging. (5) Participants were most satisfied with single-component packaging. (6) Recycling indications on paper packaging were rated best, while indications on Tetra Pak packaging received the worst evaluations. (7) Overall satisfaction with on-pack recycling indications was relatively low. (8) Almost three quarters of participants believed that clear and straightforward labelling would improve waste sorting. (9) The quality of on-pack recycling indications varied by packaging material and product type.	(1) Clarity and unambiguity are important characteristics of labels (especially for multicomponent packaging). (2) Labels should be tailored to packaging material and product type. (3) On-pack WSLs should be self-contained, meaning that they can be understood without having to refer to additional information (e.g. on bins or leaflets). (4) WSLs should be tested and applied consistently to different packaging waste materials and to special cases such as multicomponent and multi-material packaging.
Andrews et al. (2013)	*Waste Management*	WSLs	On receptacle	Sorting accuracy	Field experiment	Unclear	30 days of data collection from 15 bin locations	United States	(1) A change in signage to signs designed to inform users on which items should be disposed of in the bins may be insufficient to induce changes in recycling accuracy. (2) More extensive education may be necessary to make an impact.	(1) New WSLs might be ineffective if not salient to users. (2) WSLs might require accompanying information and awareness campaigns.

Reference	Journal	Focus	Label location	Main outcome variable	Methodology	Sample type	Sample size	Geographical focus	Main findings	Main insights for WSLs
Ansink et al. (2022)	*Ecological Economics*	Bioplastics labels	On pack	Recycling behaviour	Field experiment and survey	Non-students	199 individuals	Netherlands	(1) The bioplastics logo displayed on a cup did not significantly affect the likelihood of recycling. (2) The bioplastics logo was noticed by only 35 % of participants, and those who noticed it did not sort better than those who did not. (3) Over 90 % of subjects incorrectly disposed of their cup as plastic waste. (4) Recycling behaviour for bioplastics was not affected by information, moral norms or environmental concern.	(1) Labels need to succeed in grabbing attention and inducing the intended behaviour; however, gaining attention is not enough to induce the correct behaviour. (2) Some basic knowledge – for WSLs, particularly knowledge on the relevant SWC schemes – appears necessary for them to have the desired effects. (3) In the case of new waste materials that require new WSLs, it should be taken into account that they may need some time to be perceived, be understood and become effective.
APCO and Planet Ark (2021)	Grey literature	Recycling labels	On pack	Awareness, valuation and perceptions of different recycling and disposal logos. Recycling intentions	Unclear	Unclear	Unclear	Australia, New Zealand	(1) Awareness of the ARL was relatively low compared with awareness of other logos, such as the Tidyman, the Mobius loop and the plastic identification code, but increased between 2018 and 2020. (2) Awareness of the ARL was somewhat higher among 16- to 44-year-olds than among 45- to > 65-year-olds. (3) Forty per cent of respondents said that they would recycle a little or a lot more if the ARL was on all packaging. (4) The ARL improved various recycling intentions for aluminium foil lids, soft plastic wraps and other materials (although it is not clear if these differences were statistically significant).	(1) It appears important to provide further information to help people understand a new WSL. (2) It requires time for WSLs to become known among the population and among different population segments. (3) Some population segments become aware of new labels earlier than others and might consequently benefit more from accompanying awareness campaigns.

Reference	Journal	Focus	Label location	Main outcome variable	Methodology	Sample type	Sample size	Geographical focus	Main findings	Main insights for WSLs
Buelow et al. (2010)	*Management of Environmental Quality: An International Journal*	Recycling and WSLs	On pack and on receptacle	Perceptions of helpfulness and understanding of labels	Mixed research (surveys and interviews)	Non-students	88 individuals	Australia	(1) Most respondents reported recycling packaging waste and sorting their waste carefully, but their understanding of recycling information on packaging labels was often poor. (2) Labels were considered neither overly helpful nor unhelpful in assisting with waste sorting. (3) Stickers on bins were found to be helpful but sometimes contained incorrect or confusing information. (4) The best-understood labels were action oriented and specific, while vague and contradicting labels were the least understood. (5) Respondents demonstrated confusion around various recycling symbols and their meanings. (6) Incorrect, misleading and vague labelling provided by manufacturers was a significant barrier to proper waste sorting.	(1) Effective WSLs must provide clear, straightforward and actionable information. (2) Usually, on-receptacle labels offer more space for communication than on-pack labels and can thus be important complements to on-pack labels. (3) The beneficial effects of WSLs might be limited and fall short of expectations (especially if they are not properly designed). (4) WSLs must be consistent with existing recycling (or other types of) labels.
Catlin et al. (2021)	*Journal of Consumer Psychology*	Recycling labels	On receptacle	Sorting accuracy	Study 1: field experiment Study 2: field experiment Study 3: online experiment	Study 1: students Study 2: students Study 3: Amazon Mechanical Turk	Study 1: 259 recycling decisions Study 2: 122 recycling decisions Study 3: 399 individuals	United States	(1) Pro-environmental receptacle labelling can lead to overinclusive recycling (defined as the proportion of decisions to recycle non-recyclable items). (2) Both approaches (including the message 'Recycle more, save the Earth' on the label) and avoidance (including the message 'Landfill' on the label) increased overinclusive recycling. (3) There was no evidence that pro-environmental labelling increased the likelihood of recycling recyclable items.	Pro-environmental/persuasive labels can have detrimental effects or at least may not have positive effects on recycling behaviour. WSLs should thus use these types of messages only after careful testing.
Gutierrez et al. (2021)	*Convergence of Ergonomics and Design* (book)	WSLs and receptacle design (body	On receptacle	Preferences and ability to identify the correct waste bin	Quality function deployment approach, focus group discussions and	Students and university staff	Study 1: n/a Study 2: 8	Philippines	(1) Difficulties in using the bin, a lack of knowledge regarding SWC, inconvenience (a large number of items depicted on labels) and confusion (as a result of images on labels not accurately representing	(1) WSLs should not show too many different items. (2) The items referred to on WSLs should be unambiguously inferable from the icons and pictograms used. (3) WSLs should strive to provide

Reference	Journal	Focus	Label location	Main outcome variable	Methodology	Sample type	Sample size	Geographical focus	Main findings	Main insights for WSLs
		shape, opening shape and position, lid type, labels/ signage design and position, categorisation and colour)			user needs survey		individuals Study 3: 81 individuals		what items look like) were the main reasons for waste-sorting difficulties. (2) Removing lids, using informative labels, reducing the number of labels on the top of the bins and using images on labels that correspond to actual items lowered the amount of inaccurately separated waste, from 62.29 % to 14.29 %.	sufficient information on the SWC scheme they refer to, to make them self-contained, or be accompanied by complementary information campaigns.
Langley et al. (2021)	*Sustainability*	Labels aimed at reducing food waste (date and storage information) and packaging design (visual and functional arrangements of elemen	On pack	Consumer perceptions of food packaging and food waste, and how these perceptions might be influenced by packaging design and information	Study 1: journey mapping Study 2: interviews	Non-students	Study 1: 37 individuals Study 2: 50 individuals	Australia	(1) Consumers did not feel empowered to reduce food waste or food packaging waste. (2) Food packaging or reducing food waste was rarely a primary motivation in food purchasing decisions. (3) Reducing packaging, including plastic packaging, was seen by participants as more important than reducing food waste. (4) Consumers can be encouraged to save food with appropriate prompts and with packaging designed to limit the cognitive, conative and affective burden placed on them. (5) Packaging design needs to be developed collaboratively with industry to balance commercial and consumer considerations. (6) On-pack information should not add to the information clutter on packaging.	(1) Situating WSLs close to information that people seek when looking at product packaging can increase their salience and impact. (2) The design of WSLs needs to consider if their objective conflicts with other objectives, especially those indicated by other labels on packaging and those that consumers have. (3) WSLs should make people feel empowered to sort their waste correctly. (4) Involving central stakeholders in the design of WSLs might be beneficial. (5) On-pack information should be easy to find in relevant places on packaging but should not add to information clutter on packaging. (6) WSLs should be perceived as increasing the convenience of sorting waste. (7) WSLs should consider the cognitive, conative and affective

Reference	Journal	Focus	Label location	Main outcome variable	Methodology	Sample type	Sample size	Geographical focus	Main findings	Main insights for WSLs
		ts, materials, graphics and information)								burdens that consumers face during waste sorting.
Latkin et al. (2022)	*Sustainability*	Recycling labels	On pack	Understanding of 'chasing arrows' symbol	Survey	Non-students	808 individuals	United States	(1) The majority (81.3 %) of respondents misunderstood the 'chasing arrows' symbol as an indication that the item could definitely be recycled, while 16.3 % reported that it indicated that the item could probably be recycled. This suggests that a large proportion of individuals do not correctly understand the 'chasing arrows' symbol on plastics. (2) Most respondents did not know the meaning of the numbers included in the middle of the symbol, and almost one third gave an incorrect response.	(1) WSLs should not contradict other, potentially conflicting and potentially misunderstood, recycling labels or, at the very least, there should be an acknowledgement that the misunderstanding of related labels might affect the extent to which WSLs are understood and acted upon. (2) Additional information to help in understanding WSLs could be communicated via QR codes or other digital means.

Reference	Journal	Focus	Label location	Main outcome variable	Methodology	Sample type	Sample size	Geographical focus	Main findings	Main insights for WSLs
Luo et al. (2022)	*Environment and Behavior*	WSLs	On receptacle	Sorting accuracy	Study 1: field experiment Study 2: field experiment	Non-students	Study 1: unclear but potentially like study 2 Study 2: between 915 and 4 925 items disposed of, depending on the week during which the study was conducted	Canada	(1) Signage showing a marine animal trapped in plastic debris resulted in the largest reduction in plastic waste (17 %), compared with improved recycling signage alone, signage with a pledge to reduce plastic waste and the control condition. (2) Seeing the animal image in the kitchen area several times may have resulted in consumers retaining a mental image that triggered a reconsideration when they attempted to use a plastic item. (3) The fact that plastic waste was reduced across all bins suggests that the signage with the animal minimised the plastic items entering the waste streams, rather than diverting plastic items from one bin to another. (4) The signage with the animal was more effective in reducing plastic waste than commitment making or improving information about the appropriate disposal behaviour alone. (5) The reduction was solely due to the image of the marine animal, rather than a combined effect of the text and the image on the signage. (6) Very few employees reported that they had noticed the posters, signed the pledge or changed their waste disposal behaviour over the course of the studies. (7) The visual image of a marine animal trapped in plastic debris may not require conscious awareness to elicit behavioural change.	(1) Emotionally engaging visuals can motivate correct plastic waste sorting (as plastic waste is responsible for animal suffering) and could thus be beneficial as part of WSLs. (2) Such visuals can be effective without having to include text on WSLs. (3) Such visuals on WSLs most likely work subconsciously.

Reference	Journal	Focus	Label location	Main outcome variable	Methodology	Sample type	Sample size	Geographical focus	Main findings	Main insights for WSLs
Nemat et al. (2020)	*Sustainability*	Food packaging design (form, shape, material, colour and size) and on-pack labels in general, with specific focus on recycling logos as part of packaging design	On pack	Perceptions of graphical elements on packaging (logos, symbols, images and text) and their usefulness in enhancing recycling knowledge and motivating sorting; the process of separating food packaging waste; and packaging types and attributes that gave the largest impression of quality/value	Interviews	Non-students	15 families including 37 individuals	Sweden	(1) Recycling behaviour was influenced by packaging attributes such as perceived quality, value and recyclability. (2) Some graphical elements were not clear, were confusing or were inconvenient, making the participants uncertain on how to separate and sort the packaging. (3) There were packaging types and attributes that contributed to perceptions of quality/value and that benefited consumer sorting (e.g. dotted or perforated lines to indicate where the packaging should be folded or providing declarative and oriented information about waste sorting aligned with consumer needs). (4) Most participants saw no benefit in using different colours for the main body of packaging. Vivid colours were seen as good reminders to sort. (5) Inconsistent placement of information and small size were considered the main barriers to usefulness.	(1) The placement of graphical elements on packaging can be crucial in affecting whether they are noticed or ignored. Placement should be consistent and the size of WSLs should be appropriate to make sure they are being noticed and incorporated in waste-sorting-related decisions. (2) There are several potential elements of bad label design: small size, poor positioning and inconsistent use across different products of the same company or across the same products by different companies. (3) Combining graphical and textual elements is important. (4) Vivid colours could function as sorting reminders (making WSLs salient).
Rousta et al. (2015)	*Waste Management*	WSLs	On receptacle	Sorting accuracy	Field experiment	Non-students	28 bins	Sweden	New on-bin stickers reduced the number of incorrectly sorted nappies considerably, but did not have as big an effect on food waste.	WSLs should provide visible and easily understood information at the time of disposal and should be consistent with the relevant SWC scheme.

Reference	Journal	Focus	Label location	Main outcome variable	Methodology	Sample type	Sample size	Geographical focus	Main findings	Main insights for WSLs
Shearer et al. (2017)	*Waste Management*	'No food waste please' stickers	On receptacle	Amount of separately collected food waste	Field experiment	Non-students	64 284 households	United Kingdom	(1) The use of visual prompts in the form of stickers on food waste bins significantly increased the amount of food waste recycled by households. (2) The effect was sustained over time, with the treatment group continuing to recycle more food waste than the control group in the short, medium and long terms. (3) The stickers were cost-effective, with a cost of GBP 0.35 per household. (4) There were multiple potential explanations of the observed effects, such as the semi-permanent nature of the stickers, increased visibility and the potential change in social norms for food waste recycling.	(1) WSLs can function as simple reminders of desired actions (recycling food waste) while highlighting what should not be commingled in a general waste bin ('No food waste please') and what instead should be done (i.e. '… use your food recycling caddy'). (2) WSLs as stickers can be particularly cost-effective (but naturally are not always feasible).
Verdonk et al. (2017)	*Sustainability*	WSLs	On receptacle	Sorting accuracy	Field experiment	Non-students	889 disposals	Australia	(1) Motivational pro-environmental signs attracted participants' attention, and more items were deposited in the bins featuring new signage. (2) The motivational pro-environmental signs did not improve sorting accuracy.	(1) As the motivational signs may have been ineffective because they were too cluttered, potentially leading to information overload, WSLs should be designed with this limitation in mind. (2) Motivational messages and WSLs should avoid being cluttered, and the pictures indicating the correct waste stream should be clear and legible. (3) The effectiveness of pro-environmental prompts on WSLs may be limited.
Wojciechowska and Wiszumirska (2022)	*Sustainability*	Eco-labels	On pack	Attitudes towards recycling, experiences and attitudes regarding SWC, practical information about SWC and the level of awareness of	Survey	Non-students	1 029 individuals	Poland	(1) The study identified three clusters of consumers based on their attitudes towards recycling: pro-recycling, indifferent and anti-recycling. (2) Consumers' level of knowledge about SWC in Poland is generally low, and there is a need for more practical information about SWC. (3) Consumers considered the information-related function of packaging to be important for waste sorting. (4) There is a need for	(1) Interactive solutions, including QR codes, can provide additional and updated information that does not fit on the physical labels themselves. (2) Correct waste sorting can also be challenging for people with pro-environmental attitudes, making it important that WSLs speak to and are understood by different types of consumers

Reference	Journal	Focus	Label location	Main outcome variable	Methodology	Sample type	Sample size	Geographical focus	Main findings	Main insights for WSLs
				respondents regarding SWC					innovative packaging solutions that are both sustainable and functional.	and for consumers with a limited understanding of SWC.
Wu et al. (2018)	*Journal of Environmental Psychology*	WSLs	On receptacle	Sorting efficiency (time to sort divided by sorting accuracy)	Motion tracking experiment	Students	Study 1: 43 individuals Study 2: 20 individuals Study 3: 26 individuals	Canada	(1) Signs conveying information using images or icons were better than signs conveying information using only words (at least when the images and icons were familiar to users). (2) Displaying prohibited items along with permitted items did not yield a net benefit compared with signs that displayed only permitted items. (3) Consistent positioning of the four waste categories enhanced sorting performance.	(1) WSLs should consider the use of images and icons and make sure that the images and icons used are familiar to users. (2) Presenting both permitted and prohibited items on WSLs can interfere with performance when the signs are icons and should thus be critically assessed before being featured on WSLs. (3) WSLs should be placed consistently across waste categories.
WWF Detuschland (2021)	Grey literature	Unclear	On pack	n/a	n/a	n/a	n/a	Germany	n/a	(1) All labels should be easily removable, with minimal direct printing on the container. (2) Only transparent, uncoloured containers should be used. (3) The additives, barriers, coatings, adhesives and ink used should not be problematic for recycling. (4) Closure material choices should not create a problem for recycling (e.g. silicone seals and valves, polystyrene, polyvinyl chloride, aluminium and steel caps should be phased out).

NB: n/a, not applicable.

Source: Authors' o*wn* creation.

Table A2. Relevant references focusing on packaging and receptacle design

Reference	Journal	Focus	Specific focus	Outcome variable	Methodology	Sample type	Sample size	Geographical focus	Main findings	Main insights for WSLs
Borgman et al. (2018)	Grey literature (student thesis)	Packaging design (including labels)	Graphical label design, certification information and bottle form	Preferences, and purchasing and recycling intentions	Study 1: online ranking survey Study 2: conjoint analysis Study 3: field experiment	Study 1: unclear Study 2: unclear Study 3: non-students	Study 1: n/a Study 2: 73 individuals Study 3: 200 individuals (200 cups; 96 opinions)	Unclear	(1) Graphics played a larger role than information and form in consumer decisions. (2) Sustainability information was appreciated by consumers. (3) Graphical congruency with the product was important. (4) The willingness to pay for an extra sustainability label was low. (5) It was unclear if recycling labels and text could affect the recycling intentions of consumers.	(1) Graphical elements should be used by WSLs to provide information. (2) WSL design should consider that consumers might have only weak preferences for additional labels.
Jiang et al. (2021)	*Waste Management*	Receptacle design	Colour preferences, slot shape preferences and slot position preferences, as well as the impact of past perceptions on these preferences	Study 1: colour preferences Study 2: slot shape preferences for PET bottle bins Study 3: slot shape preferences for other bins Study 4: slot position preferences Study 5: sorting accuracy	Studies 1–4: surveys Study 5: field experiment	Studies 1–4: non-students Study 5: mostly students	Study 1: 730 individuals Study 2: 730 individuals Study 3: 210 individuals Study 4: 3 090 individuals Study 5: 240 recycling bins used in public spaces	Japan	(1) Common perceptions of colours used in certain design items of recycling bins affected colour preference. (2) Common perceptions of certain insertion slot design items affected slot design preference. (3) The colours that were popular depended on the design items and waste types.	(1) Colours for WSLs should be carefully selected. (2) Previous encounters of consumers with colours and their associations with certain waste materials should be considered.

Keramitsoglou and Tsagarakis (2018)	*Sustainability*	Receptacle design	Shape, colour and type of lid and insertion slot	Preferences for bin designs	Study 1: exploratory survey Study 2: validation survey	Non-students	Study 1: 757 individuals Study 2: 430 individuals	Greece	(1) The following design elements were identified as preferred for recycling bins: easy handling, being free of risks to human health and safety, the protection of recyclables and attractivity. (2) Preferences did not always coincide with the top-down decision-making in relation to recycling bin design. (3) Respondents connected the colour of recycling items with the recycling bin colour. (4) Public participation in the designing of recycling facilities could increase willingness to recycle.	(1) Public participation in the design of WSLs could be beneficial. (2) Colours of WSLs should take into account people's colour preferences with respect to the associated materials.
Lane and Wagner (2013)	*Resources, Conservation and Recycling*	Receptacle design	Size, type and colour	Study 1: multiple Study 2: programme design of waste collection systems	Study 1: literature review Study 2: survey	Study 1: n/a Study 2: non-students (waste professionals)	Study 1: n/a Study 2: 785 individuals	Study 1: n/a Study 2: United States	(1) There was no single 'best' recycling container (i.e. no best size, colour or type) that was unambiguously statistically shown to perform best. (2) Confounding contextual variables (sociopolitical variables and those related to infrastructure) made identification of an optimal receptacle difficult. (3) Costs (purchase costs, assembly needs, durability, maintenance, adaptability to new technology, impacts on worker safety, collection limitations/needs and additional technology needs) are important factors to consider. (4) Recycling programmes should be targeted to dwelling type (single- versus multiple-family households). (5) 'Purposeful incrementalism informed by pilot studies' is a good approach. It should set distinct and ordered goals (e.g. increasing participation rates or diversion rates).	(1) Contextual factors influence the 'best' design of WSLs. (2) Costs of WSLs and their implementation need to be considered. (3) Optimal WSLs should be based on pilot studies, if possible.

Langley et al. (2011)	*Packaging Technology and Science*	Packaging design	Materials, geometry, content and information	Consumer treatment of specific examples of packaging at end of life	Study 1: bin raids Study 2: digital diaries Study 3: visual questionnaire Study 4: video ethnography	Unclear	Study 1: 10 households Study 2: 5 households Study 3: > 200 responses Study 4: 2 households	United Kingdom	(1) Some of the findings suggest that households generally do not incorporate on-pack information in their waste disposal decisions, that confusion regarding recycling symbols exists and that prior knowledge regarding waste sorting is more influential than on-pack information. (2) Recycling may be hindered if the materials are perceived as dirty and disgusting (especially related to the packaging of meat products).	WSLs will have to compete with prior and potentially conflicting consumer knowledge on how to sort waste correctly and with perceptions of waste as being disgusting and dirty. This suggests that complementary information campaigns might be important to create an adequate knowledge foundation into which WSLs are embedded.
Leeabai et al. (2021)	*Waste Management*	Receptacle design	Colour, shape, lids and aperture slots of general waste bins	Study 1: colour preferences for general waste bins Study 2: noticeability of general waste bins Study 3: correct sorting	Study 1: survey Study 2: survey Study 3: field experiment	University students and staff	Study 1: 442 individuals Study 2: 296 individuals Study 3: capture rates of three general waste bins	Thailand	(1) Participants were more likely to sort waste correctly when using general waste bins with preferred colours. (2) Bins with less noticeable colour combinations tended to require more effort to be found. Therefore, they were more likely to be found by people with high motivation to sort, leading to high effective capture rates. (3) The least preferred colour combination had the highest waste separation efficiencies. (4) Location, colour and noticeability of general waste bins affected waste collection and sorting performance.	(1) Increased efforts to grab attention through appropriate bin design and configuration (including WSLs) could lead to more efficient SWC. (2) WSLs with less-preferred colours might not necessarily perform worse.
Lin et al. (2016)	*Sustainability*	Receptacle design	Colours and symbols	Capture rates of sorted (recycled) materials	Field experiment	Non-students	13 buildings	China	Yellow bins with sunflowers resulted in lower contamination rates and good capture rates of the food waste targeted.	Induction of positive emotional states using visual prompts might explain the results and could also extend to WSLs.

Montazeri, et al. (2012)	DESIGN 2012 – 12th International Design Conference	Receptacle design	Colour	Study 1: recall of recycling bin Study 2: waste disposal	Study 1: survey Study 2: lab experiment	Students	Study 1: 99 individuals Study 2: 48 individuals	United States	(1) Colour can affect the salience of an object and trigger the associated desired behaviour. (2) Out of grey, red, blue and green, green was the most remembered colour, while grey was the least remembered. (3) Participants recycled more in green than in grey bins.	(1) Colours are important components of WSLs, and certain colours may be better remembered and associated with certain concepts than others. (2) The colour green in particular may be associated with concepts such as recycling and pro-environmental behaviour more generally. Thus, it should be used consciously on WSLs.

Mozo-Reyes et al. (2016)	*Resources, Conservation and Recycling*	Receptacle design	Special recycling bin features, including the ability to count recyclables, the salience of recycling and the embedding of recycling in social contexts to provide feedback	Study 1: number/weight of recycled items, number of unique recyclers, number of visits and user behaviour Study 2: mass/number of recycled items Study 3: number of users, interaction with bin, distance to bin, body position (including facial expressions), involvement of others, time of interaction, number of visits, number of recycled items per user, and total number and mass of recycled items	Study 1: 2-day field experiment Study 2: 1-week field experiment Study 3: 1-month field experiment	Students and university staff	n/a	United States	Study 1: the numbers of visits and recycled items were higher in the WeREcycle bin than in the baseline bin. Study 2: recycling was diverted from other bins to the new bin, and recycling rates in the new bin were higher overall. Study 3: the new bin had medium attendance (compared with the baseline and a 'non-technological' intervention), had the highest number of recycled items and had the lowest amount of contamination. Average recycled items per attendance per day was highest for the new bin. Overall, the new bin garnered a lot of interest.	(1) Feedback can facilitate appropriate interaction with new technologies, including potentially also WSLs. (2) Technology has the potential to make recycling more attractive and entertaining.

Nemat et al. (2019)	*Sustainability*	Packaging design	Visual attributes that include structural features such as material, shape, size, weight, texture and graphical /iconic features such as colour combination, image and text layout, logo, and label, as well as verbal attributes that consist of lengthier textual explanations	Consumer sorting and preferences	Literature review	n/a	42 publications	n/a	(1) The review highlights the importance of packaging design and attributes in motivating or hindering consumers to sort packaging waste correctly. (2) The ability of packaging to communicate a message, primarily through its visual attributes, was considered an important factor to stimulate sorting behaviour. (3) The recyclability of packaging should be considered an inherent value of packaging, similar to attributes such as beauty and durability.	(1) Packaging can function as a natural vehicle for WSLs to communicate sorting instructions to consumers. (2) WSLs should strive to contribute to the perceived value of packaging.
Nemat et al. (2022)	*Resources, Conservation and Recycling*	Plastic food packaging, including visual communication attribut	Packaging form, size, durability, haptic aspects, visual communication properties and	n/a	Photo-based observation study and semi-structured interviews	Consumers, students and researchers	18 individuals	Sweden	(1) Participants reported difficulties in sorting small pieces of (torn/ripped) packaging waste, which can lead to missorting. (2) Participants were not aware of on-pack recycling information, logos or symbols on packaging and did not search for such information on the internet. (3) Consumers missorted plastic packaging waste due to perceived inconvenience, such as perceived separation difficulty or lack of space,	(1) There are challenges related to labels on mixed materials that WSLs need to consider. (2) Packaging design aspects, such as the perceived value of labels, are important for WSLs to be effective. (3) If possible, WSLs should provide users with a sense of convenience of waste sorting. (4) WSLs should be designed considering the reality of ripped and torn packaging, which may disrupt label functionality and

		es (labels)	perceived value						including laziness. (4) Low perceived packaging value can deter consumers from undertaking proper disposal. (5) Packaging design can play a role in promoting proper waste separation by providing clear and visible recycling information and symbols.	affect the perceived value of packaging. (5) WSLs should contribute to the perceived value of packaging.
Schloss et al. (2018)	*Cognitive Research: Principles and Implications*	Receptacle design	Colour–object associations in the context of recycling	Response times and colour–object associations	Study 1: lab experiment Study 2: lab experiment	Unclear	Study 1: 24 participants Study 2: 96 individuals	United States	(1) People perform an assignment colour inference process when they interpret colour-coding systems. (2) Evidence supported the global assignment hypothesis (which predicts that people not only consider association strength between object and colour, but also account for association strengths between all other objects and colours within the scope of the system). This can result in weak associations between colours and objects that result in overall stronger pairings. (3) Participants were more likely to discard waste in the correct bin when the bin's colour was strongly associated with the waste type. (4) Participants had difficulty discarding waste in bins that had weakly associated colours, even if the colour was the best available choice. (5) Overall, the results suggest that a colour-coding system that maximises the association strength between assigned colour–object pairings and minimises the association strength between non-assigned colour–object pairings could improve the ease of interpreting and understanding of waste-sorting systems, leading to better sorting.	Colours used on WSLs should consider the colour–object associations that people might already have.

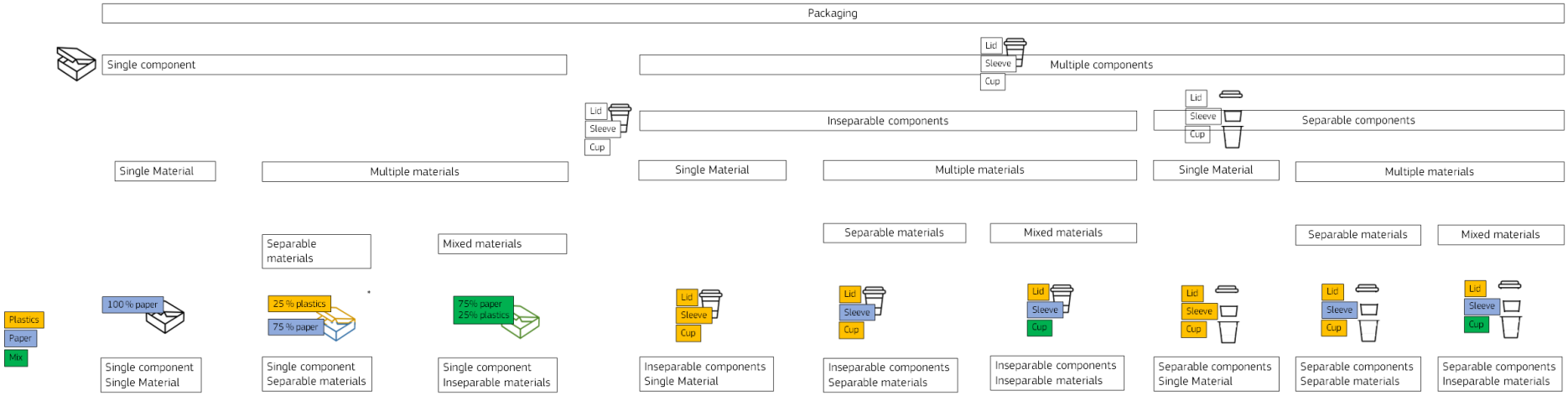
Trudel and Argo (2013)	*Journal of Consumer Research*	Packaging design	Size and distortion of waste	Studies 1–5: recycling behaviour Study 6: perceptions of waste	Study 1: field observation (exploratory) Studies 2–6: lab experiment	Study 1: non-students and university staff Studies 2–6: students	Study 1: 22 faculty assistant offices Study 2: 150 individuals Study 3: 183 individuals Study 4: 75 individuals Study 5: 130 individuals Study 6: 68 individuals	United States	Study 1: paper was more likely to be recycled when the pieces were large than when they were small. Study 2: distorted paper was less often recycled than non-distorted paper. Study 3: larger pieces of paper were more likely to be recycled than smaller pieces of paper, while distorted paper was less likely to be recycled than maintained paper. Study 4: participants were more likely to recycle after listing uses for the paper, suggesting that usefulness underlies the impact of distortion on recycling. Study 5: large cans were recycled more than small cans, and cans with a maintained form were recycled more than distorted cans. Study 6: distorted cans were perceived as less clean and useful. Distorted cans were more likely to be intended for rubbish than maintained cans.	Distortion of packaging waste affects its disposal and most likely also the effectiveness of a complementary WSL.

Wever et al. (2010)	*Packaging Technology and Science*	Packaging design	Branding, reclosability and ability to play with packaging	Littering	Study 1: field experiment Study 2: field experiment Study 3: field experiment Study 4: field experiment Study 5: field experiment	Study 1: mostly students Study 2: non-students Study 3: mostly students Study 4: mostly students Study 5: students	Study 1: around 4 000 individuals (5 000 cups) Study 2: 898 cups Study 3: 430 PET bottles + 394 CartoCans Study 4: 1 857 sampled candies Study 5: n/a	Netherlands	(1) Conspicuous anti-littering labels may reduce littering, but more research is necessary to determine the optimal level of conspicuousness. (2) Peel-off closures were sensitive to littering, while screw-on caps induced users to reclose after use, but did not reduce littering. (3) Designing packaging to capture attention may affect littering, but depends on the availability of disposal options in surroundings. (4) Premium-brand packaging may be treated differently from unbranded product packaging.	(1) WSLs should be noticeable, salient and conspicuous. (2) The effects of WSLs are limited by the available waste disposal infrastructure.

NB: n/a, not applicable.

Source: Authors' own creation.

Figure A1. Categorisation of packaging according to components, materials and their separability



NB: Single-component packaging with multiple separable materials is theoretically possible. However, it might be the case that, in such cases, a separable material might be interpreted as a separate component, simply because it is of a different material. This reflects the sometimes fuzzy definition of components.

Source: Authors' own creation.

Table A3. List of lessons and insights from the main sections of the report

Section	Lessons and insights
5.1.1	Although people recycle and sort waste without WSLs or recycling labels, such labels can aid in related efforts.
5.1.1	How labels are perceived and valued influences their acceptability and effectiveness and thus, we argue, their political feasibility.
5.1.1	Perceptions of labels depend on factors such as their design, as well as aspects of the packaging and materials they refer to.
5.1.1	The relation between labels and the materials they refer to is important. Consistent application of labels on different packaging waste materials is key to a clear relation between labels and materials.
5.1.1	WSLs should be easy to find and of sufficient size, but should not add to the information clutter on packaging.
5.1.1	The evidence reviewed is far from sufficient to generalise to the various existing WSLs or recycling labels in the EU. Nevertheless, design aspects of existing labels, specifically their clarity, size, positioning, readability and noticeability, appear to be important aspects of harmonised WSLs. Advanced digital solutions (e.g. QR codes) might also be relevant.
5.1.1	As different types of consumers can perceive and respond to labels differently, a nuanced understanding of consumer segments can be insightful.
5.1.1	Even environmentally motivated people can profit from WSLs.
5.1.1	Testing WSLs extensively is crucial.
5.1.2	Labels must be understood to work as intended.
5.1.2	Labels need to be understandable when positioned next to labels sending different or conflicting messages.
5.1.2	Elements of bad label design include small size, unclear and vague messages, inconsistent use and poor positioning.
5.1.2	Information on the necessity of and instructions for cleaning and segregating packaging materials and components can be relevant, although the space available on labels might be too limited.
5.1.2	Proper understanding of labels requires time. New labels, even if well designed, might not be judged as clear and understandable at the beginning.
5.1.2	Visual elements should be carefully chosen to reflect the intended message or function and possibly combine graphical and textual elements to provide meaningful and unambiguous information.
5.1.2	Action-oriented labels with clear instructions for consumers can improve their efficacy and clarity.
5.1.2	Ambiguous prompts such as 'Do the right thing' or 'Please dispose of this package thoughtfully' do not provide precise enough information to guide individuals in correctly sorting waste and should be avoided.
5.1.2	WSLs might benefit from being easily removable and applicable, with minimal direct printing on the container, and furthermore from being free of additives, barriers, coatings, adhesives or ink that might create problems for recycling.
5.1.3	WSLs that are perceived positively and understood well are not automatically effective. Effectiveness should always be verified empirically or experimentally.
5.1.3	WSLs must be clear, salient and actionable.
5.1.3	Being aware of label components that are self-explanatory and those that rely on external information is crucial. Digital solutions may serve to provide additional information without requiring additional space.
5.1.3	An important case for WSLs is multi-material and multicomponent packaging. These types of packaging can be more difficult to handle and sort for consumers than single-material and -component packaging, most likely because they require more cognitive and practical effort to be properly prepared and sorted. While this makes a case for simple packaging, it also suggests

	that WSLs should be as clear as possible when referring to multiple components and materials, to avoid confusion and ineffectiveness.
5.1.3	Some consumers might rely more on additional information and awareness campaigns than others.
5.2.1	On-receptacle labels can provide valuable information at the point of disposal. They can complement on-pack labels, offering more space for information.
5.2.1	Like for on-pack labels, clear and actionable instructions are important on receptacles, as is consistent and prominent placement.
5.2.1	Persuasive messages should be used with caution, as they can lead to confusion and overinclusive recycling and sorting.
5.2.2	On-receptacle labels can reduce waste contamination by highlighting which materials should and/or should not be disposed of in a receptacle.
5.2.2	Images and icons are valuable complements to text if they are meaningful and familiar to users.
5.2.2	The number of items shown on the labels should be limited and should resemble commonly discarded items, as this can compensate for a lack of knowledge among users.
5.2.2	In contrast with on-pack labels, on-receptacle labels have the advantage of being attachable to some receptacles as stickers, making them more flexible and cost-effective.
5.2.2	WSLs should be designed and applied in a way that minimises the risk of information overload – they should be salient and clear and should provide information that is consistent with the relevant SWC scheme.
5.2.2	Pro-environmental prompts should be used with care.
5.2.2	A combination of information on desired and undesired behaviours might improve correct sorting.
5.2.2	WSLs can benefit from separate informative and pro-environmental messaging.
6.1.1	Insights on how packaging design elements are perceived and understood are limited.
6.1.1	Packaging serves as a natural platform for WSLs to convey sorting instructions to consumers.
6.1.1	WSLs should complement the relevant messages conveyed by packaging and simultaneously enhance the perceived value of packaging.
6.1.1	WSLs compete with prior and potentially conflicting consumer knowledge on how to sort waste correctly and with perceptions of waste as being disgusting and dirty.
6.1.1	Complementary information campaigns can create the knowledge required.
6.1.1	The co-design of WSLs involving different types of stakeholders is essential.
6.1.1	The evidence related to packaging and bin design is often incomplete. However, we still opted to include the papers that provided relevant insights for WSL design.
6.1.2	WSLs should positively contribute to the perceived value of packaging and provide consumers with a sense of convenience when sorting their waste.
6.1.2	The practicality of packaging, such as the ease of emptying or cleaning and the resealability, could be highlighted and supported on and by labels.
6.1.2	Graphical elements might be preferable over text on WSLs.
6.1.2	WSL design should consider that consumers might have only weak preferences for additional labels.
6.1.2	Characteristics of practical packaging design (i.e. being easy to empty, clean, reseal and reuse) may be complemented and highlighted by labels.
6.1.2	WSLs should be noticeable, salient and conspicuous.
6.1.2	Effects of WSLs on littering and waste sorting are limited by the available waste disposal infrastructure.
6.2.1	Colours of WSLs should be carefully selected, and consumers' previous encounters with colours and their associations with certain waste materials should be considered.

6.2.1	The colour coding of labels could align with public perceptions of the type of waste. Relating various colours to a particular waste type, rather than just to one colour, could cater to a wider range of individual associations. This may be particularly relevant when developing harmonised EU WSLs. However, consumer confusion may outweigh potential benefits of a multicolour scheme.
6.2.1	WSLs with less-preferred colours do not necessarily perform worse.
6.2.1	Various contextual factors influence the 'best' design of WSLs.
6.2.1	The costs of WSLs and their implementation need to be considered during their design and planning.
6.2.1	WSLs should be based on pilot studies, if possible.
6.2.2	Consciously designed bin shapes, lid designs and colour choices, together with well-placed, easy-to-understand labels, can increase user engagement, waste sorting and recycling rates.
6.2.2	WSLs should be placed in prominent positions and designed in close correspondence with the waste material to be disposed of for easy recognition, and the number of labels should be minimised to facilitate quicker identification of the relevant label and information.
6.2.2	Because well-designed lids can promote recycling and decrease contamination, it is important to consider the compatibility of labels with different bin and lid designs. The labels should be designed and positioned (or attachable, if they are stickers) in a way that complements the bin design and does not interfere with the usage of lids or slots.
6.2.2	Using bright and appealing colours may induce a positive emotional state and encourage more participation in waste sorting; however, the colours that are perceived as appealing can vary greatly.

Source: Authors' own creation.

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