Battery pack recycling : behaviour change interventions derived from an integrative theory of planned behaviour study

BATTERY PACK RECYCLING: BEHAVIOUR CHANGE INTERVENTIONS DERIVED FROM AN INTEGRATIVE THEORY OF PLANNED BEHAVIOUR STUDY

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Abstract

Belgium has passed the 45% cap, mandated by the European Union, by achieving a collection rate of over 50% in 2012. Having such a collection rate, Belgium is amongst the frontrunners in battery recycling in Europe. However, despite the efforts, about 40% of used batteries are still not properly collected. Particularly troublesome according to the national producer responsibility organization are the battery packs. In this paper we therefore investigate the drivers and barriers to battery pack drop-off intention perceived by Belgian households using an integrative model based on the Theory of Planned Behaviour. An R^2 of 0.64 was found, which according to the literature on partial least squares structural equation modelling signals a moderate yet very close to substantial coefficient of determination. We find that on average perceived behavioural control and moral norms have the largest influence on the intention to drop-off used battery packs as quickly as possible. Based on the insights gained, recommendations are made for both behaviour change interventions and future research.

Key words: Pro-environmental behaviour; Recycling; Structural equations modelling; Pro-environmental communication

Highlights:

- We investigate battery pack specific recycling behaviour
- We test an integrative model using PLS-SEM and assess observed heterogeneity
- We stress the role of perceived behavioural control, moral norms, and awareness of consequences
- Having kids under the age of 12 and an ecological worldview drive heterogeneity the most
- We recommend assessing spill-overs between battery pack and WEEE recycling behaviour

1. Introduction

1.1. The environmental impact of portable batteries

We are increasingly mobile, and therefore, so are our electronic devices. Consequently, to feed our increasing energy hunger the use of portable batteries has been firmly rising (Li et al., 2013). Typical household batteries such as the AA, AAA, and AAAA-sized batteries may have a negative impact on the environment if they are not properly collected and processed. If such batteries end up in landfills, hazardous metal pollutants such as the toxic heavy metals cadmium, lead, and mercury have the potential to slowly leach into soil, groundwater or surface water (Karnchanawong and Limpiteeprakan, 2009). Recently, however, lithium-based batteries have displaced nickel−cadmium and nickel metal hydride battery types to become the dominant energy supply components in the portable consumer electronics market because of their higher energy density. Yet, these batteries may also be considered hazardous because of the presence of cobalt, copper, nickel, thallium, and silver (Kang et al., 2013).

Lithium itself has been shown to be less harmful for mankind and its environment (Aral and Vecchio-Sadus, 2008). Additionally, the further development of the lithium-based battery technology, which is crucial for the diffusion of renewable energy technologies and electric vehicles, is threatened by scarcity in the metals used (Larcher and Tarascon, 2015). Cobalt is considered a critical metal for the sustainable development of the whole of Europe's economy (European Commission, 2014). Silver and nickel on its turn, though not critical for the entire economy, are considered a potential bottleneck for the continued development of renewable energy technologies (Moss et al., 2011). Finally, lithium, copper and aluminium are plain valuable metals that can be recovered from lithium batteries (Jha et al., 2013, Zeng and Li, 2014). Recycling metals from batteries has been shown to result in natural resource savings compared to virgin production (Dewulf et al., 2010). Consequently, recycling batteries may not only avoid environmental pollution, but also saves natural resources.

As a result it is no surprise that the collection of portable batteries, both primary (i.e. non-rechargeable) and secondary (i.e. rechargeable), in Europe is mandated by Directive 2006/66/EC which requires Member States

to achieve a collection rate of 25% in 2012 and 45% in 2016 (European Union, 2006). To meet these targets, battery producers and importers, intermediaries, and the final seller are legally obliged to accept used batteries due to the extended producer responsibility (Dubois, 2012). To meet the legal obligation to collect 45% of used batteries by 2016, in Belgium these actors have created Bebat. The latter is the name of the single non-profit organization acting as the national producer responsibility organization and is in charge for collecting, sorting, and recycling of portable batteries. It has over 24,000 free collection points spread across Belgium, resulting in a coverage of about 0.8 collection points per squared kilometre. The separate disposal of used batteries at designated collection points is mandatory in Belgium. However, it is not strictly enforced. Having a longstanding tradition in separate waste collection, Belgium has passed the 45% cap by achieving a collection rate of over 50% in 2012 (European Portable Battery Association, 2013).

Reaching such a collection rate, Belgium is amongst the frontrunners in battery recycling in Europe. However, despite the efforts 24% of used batteries and accumulators were found to be hoarded at home and 10 to 13.5% end up in the waste bin. In absolute terms, an average family was found to have on average 129 batteries in its possession, be it used, new, or in use (Openbare Vlaamse Afvalstoffen Maatschappij, n.d.). This number exceeds the number of batteries that people think to have in-house (Coonen and Peeters, 2014). Whereas the obtained collection rate is worthy of praise, it should be noted that it does not differentiate between types of portable batteries. In Belgium, legislation differentiates between three types of portable batteries, being: (l) (the typical) batteries, (2) button cells, and (3) battery packs (Royal Decree, 2009). According to Bebat battery packs are collected poorly compared to other portable battery types. This is motivated by observing that the battery pack volumes being collected (which include direct collection via collection points and indirect collection from the channels collecting waste electrical and electronic equipment) over the volumes brought onto the market, while correcting the calculation for the expected average lifetime, are smaller than those for other battery types (Coonen and Peeters, 2014). Consequently, people need to be stimulated to return battery packs faster.

Battery packs are often rechargeable lithium-based batteries used to power mobile phones, digital cameras, portable game consoles, power tools, and the likes (see Figure 1). Officially, they are defined as *'any set of interconnected batteries forming a unit having a casing which is not intended to be divided or opened by the end user'*. A poor level of collection is troublesome as it has been established that recycling batteries may not only avoid environmental pollution, but also increases resource efficiency. For these reasons, our research investigates the predictors of battery pack drop-off intention perceived by Belgian households as we want to be able to infer recommendations that will motivate and facilitate people to start bringing back battery packs to a Bebat collection point more quickly.

Figure 1. Examples of battery packs:
Left: from a mobile phone, Middle: from a power tool, Right: from a laptop

1.2. Why do people recycle?

Pro-environmental behaviour refers to behaviours that either harm the environment as little as possible or benefit the environment (Steg and Vlek, 2009). The stimulation of such conduct is necessary as many environmental problems (e.g. heavy metal leaching) are rooted in human behaviour, such as not sorting correctly (Vlek and Steg, 2007). Our focus will be on a specific type of pro-environmental behaviour, i.e. recycling, being the act of collecting, sorting, and depositing waste to a suited waste management provider. Whereas it involves economically feasible actions that can greatly benefit the environment in the long run if many people perform the behaviour, it requires considerable individual effort whereas others may freeride. Note that being effortful is related to being composed of several, consequential steps, which each might be habitually performed separately, but still require thought in between each step (Limayem et al., 2007). Such routines have been named semi-automatic (Ajzen, 2002).

147 The difficulty to explain why people do endeavour in such a behaviour is the reason for it being one of the
148 most and longest studied forms of environmentally responsible behaviour (Boldero, 1995, Huffman et al.,
149 2014). We outline three types of research that have studied recycling behaviour. Firstly, research following the
150 psychological research tradition, which signals that the study subject is people-environment interaction. This
151 stream has in a more or less chronological order evolved from (i) studies aiming to profile recyclers such as
152 the research by Vining and Ebreo (1990) and Schultz et al. (1995) and explain willingness to participate in
153 recycling schemes such as the investigations by Saphores et al. (2006), Wang et al. (2011), and Saphores et al.
154 (2012) to (ii) research building socio-psychological models which help to understand socio-psychological
155 influences, captured by latent variables, on people's recycling behaviour. Support for such models has grown
156 ever since Hopper and Nielsen (1991) and Vining and Ebreo (1992) have shown that internal factors are better
157 predictors than socio-demographic variables. Moreover, it has been observed that, even when situational
158 constraints are resolved, all people still don't (fully) participate (Thomas and Sharp, 2013). For the same
159 reason, we expect the amount of battery packs that have been adopted by the respondent to be a lesser
160 predictor than internal variables. Secondly, research adhering to the socio-cultural research tradition, which
161 means that the study subject is society-environment interaction. This line of research has picked up more
162 recently and deals with the question of how environmental problems are caused by social factors and social
163 structures, how environmental problems impact societies, and how they can be solved from a societal
164 perspective (Hannigan, 2006). For an example of a study on pro-environmental behaviour change adopting
165 this perspective, we refer the interested reader to Hargreaves (2011). In their study a behaviour change
166 initiative, driven by appointing volunteers as environment champions in a workplace context, was studied by
167 answering questions resulting from social practice theory using ethnography. Thirdly, there are studies using
168 laboratory or field experiments to explain why people recycle. However, in this case "why" can be best
169 understood as "what interventions induce recycling behaviour (the most)". In the typical experiment, one or
170 more interventions are compared with a control group to determine the effect (size) of the intervention. For the
171 results of a meta-analysis on past field experiments in the pro-environmental domain we refer to Osbaldiston
172 and Schott (2011). The authors show that overall the largest effect sizes were found for the interventions based
173 on cognitive dissonance (Festinger, 1962), goal setting (Locke and Latham, 2002), social modelling, and

prompts, but that different treatments work better for different waste streams and recycling mechanisms. For instance, for central recycling, and hence in principle for battery pack collection, they found instructions and rewards to be most effective among the treatments that have been studied. To the best of our knowledge no quantitative or qualitative review is available that condenses the findings of laboratory pro-environmental behaviour experiments. For a recent example of such a study, the reader is referred to Zhang et al. (2016). The authors show that enhanced accessibility of recycling facilities would lower behavioural costs and encourage people to recycle more mixed waste.

Our study is situated within the branch of literature analysing pro-environmental behaviour while using a socio-psychological model. Most often within the literature on recycling the framework provided by the Theory of Planned Behaviour (TPB) is used to explain or predict what drives recycling (Ramayah et al., 2012). The TPB has generally been favoured over other models because of its structural simplicity and general applicability across domains and cultures (Klöckner, 2015). For instance, it has been successfully used to understand a range of pro-environmental behaviours such as sustainable tourism (Han et al., 2010), public transportation use (Heath and Gifford, 2002), energy use (Abrahamse and Steg, 2009), water conservation (Lam, 2006), and more. Additionally, on several instances the TPB has proven to outperform other decision-making models belonging to this strand of research. For instance Kaiser et al. (2005) and Aguilar-Luzón et al. (2012) showed that the TPB outperforms the Value Belief Norm (VBN) theory, which was first presented by Stern et al. (1999), in predicting recycling behaviour.

The VBN is a refined version of Schwartz's (1968) norm-activation model (NAM), which asserts that behaviour is displayed when altruistic, moral norms are activated and that their activation depends upon people's awareness of the negative consequences for others and on whether they ascribe responsibility for ameliorating these consequences. Stern et al. (1999) adapted this theory to be suited for pro-environmental behaviour by stating that people will take environmental action when they are aware of the consequences for themselves, other people and non-human species and when they consider themselves to be responsible for these consequences. Yet, as argued by Klöckner and Blöbaum (2010) none of the mentioned, often used

models on their own adequately represents the multi-determination of environmental behaviour. For a further review on decision making models that can be applied to pro-environmental behaviour, we refer to Klöckner (2015) and Darnton (2008) for brevity.

Pioneering studies that kick-started TPB-based research on recycling are those of Boldero (1995) on newspaper recycling and Taylor and Todd (1995) on household waste recycling. In its original conception the degree to which actual behaviour is displayed, is directly related to behavioural intention, being the degree to which a person plans to exert effort to enact the behaviour. On its turn, behavioural intention is formed by the following variables: (i) attitude, (ii) subjective norm, and (iii) perceived behavioural control (Ajzen, 1991). Attitude (ATT) reflects feelings of favourableness or unfavourableness towards the behaviour. Subjective norm (SN) reveals the perception that significant referents desire the individual to perform the behaviour. Perceived behavioural control (PBC) assesses beliefs about the ability of performing the behaviour. The latter was added to the Theory of Reasoned Action (Fishbein and Ajzen, 1975) as it was recognized that not all behaviours are under full volitional control. Previous efforts support the predictive power of these three constructs in predicting intention and actual behaviour (Cheung et al., 1999, Armitage and Conner, 2001). Intention and behaviour are expected to be more strongly related when measured at the same level of specificity (Ajzen, 2011) and when intentions are stable (Macey and Brown, 1983). In a review of recycling studies, Schultz et al. (1995) indicated that many studies support this assertion.

Despite the fact that such correspondence has not always been respected, the TPB has been criticized for only being able to explain a limited amount of variance in both behavioural intention and behaviour (Conner and Armitage, 1998). By consequence, under the premise of being willing to continue working with the core of the TPB, it is recommended to include additional variables in the model to be able to more adequately explain intentions and behaviour. Doing so leads to an integrative, more comprehensive model. For instance, we have included moral norms to capture the degree to which one feels morally obliged to act in a certain way. Recently it has also been recognized that the role of negative or positive emotions is neglected in pro-environmental behaviour studies stemming from a more general neglect of their role in cognitive psychology

and neuroscience throughout the twentieth century. Indeed, the position on the usefulness of emotions has evolved from the position where they were considered as a separate and undesirable part of thought to an integral and adaptive part of cognition that is stored and retrieved in the same way as and alongside with cognitive structures (Vining and Ebreo, 2002). However, the evidence is mixed regarding whether emotions mediate other predictors or the other way around (Carrus et al., 2008).

It has also been questioned whether TPB is suited to study continuance, i.e. keeping up with the desired behaviour. An initial adoption decision, which is likely to require deliberate thought, is argued to differ from continuance, which is likely to be determined by habit, and thus might require a different subset of antecedents (Limayem et al., 2007). However, Ajzen (2002) contends that routinization of behaviour is consistent with a reasoned action perspective. He says that the TPB does not propose that individuals actually review their behavioural, normative, and control beliefs prior to every enactment of a frequently performed behaviour. Instead, once formed and well-established, they are assumed to be activated automatically and to guide behaviour without the necessity of conscious thought. Hence, reasoning simply implies that conduct is guided by beliefs. Reasoning does not necessarily need to be effortful. Consequently, the fundamental difference in both views is that the habituation perspective asserts that routinized behaviour is under the control of stimulus cues, whereas the reasoned action perspective postulates that such behaviour is guided by automatically activated or spontaneous attitudes and intentions. The result of both views is identical: given the right conditions, routinized behaviour is performed in a largely automatic fashion with minimal conscious thought. In sum, this reflects the different views on the suitability of TPB to explain different types of behaviour on the continuum going from requiring actual effortful thought to behaviour that is fully automatic. Still, models that explicitly take habits into account have empirically been found to provide a better fit. This being said, we would like to remind the reader that section 1.1 serves to illuminate that the problem at hand is one of getting people to start bringing back battery packs faster and less one of motivating them to continue to do so.

1.3. Portable battery and waste electric and electronic equipment recycling

To the best of our knowledge, only a single, model-based socio-psychological study has specifically targeted recycling behaviour concerning spent portable batteries and it does not differentiate between battery types.

Hansmann et al. (2006) found that recycling knowledge, self-organization of recycling, and disagreement with justifications for non-recycling were positively related to self-reported battery recycling behaviour, while the more general attitude towards ecological waste disposal[1] was not directly related to Swiss respondents' self-reported battery recycling behaviour. The Swiss are excellent recyclers as proven by having the highest collection rate in Europe and have put in place legislation and a collection system which is very similar to that of Belgium (European Portable Battery Association, 2014). Other studies, such as Tang et al. (2011), at most consider battery recycling as an item in explaining the intention to recycle household waste. Furthermore, we note that little research has considered explaining the intention and enactment of (small) e-waste recycling using the TPB framework. However, batteries and waste electric and electronic equipment (WEEE) are clearly interconnected.

Le et al. (2013) constitute the exception and show that PBC and SN are stronger predictors of the intention to recycle e-waste than ATT for Vietnamese residents. Also, Ylä-Mella et al. (2015) have reported on the findings from a survey gauging Finnish consumers' awareness and perceptions towards mobile phone recycling and re-use. Similar to our case, they found that high awareness of the waste electrical and electronic equipment recovery system and proximity of collection points is inadequate in promoting their return. Mobile phones are an example of an up-to-date product, as defined by Cox et al. (2013). Such products are often discarded before the end of their functional lifetime and subsequently kept at home "as a spare", presumably out of attachment due to the fact that the devices are a representation of their identity and success in life, or because "they did not get round to it" rather than returned. Consequently, enormous resource potential is stored in homes waiting to be given new life, as shown by for example Saphores et al. (2009). A change in storing habits and the provision of additional information on who takes back these waste streams is considered needed in turning this evolution around.

[1] Attitude consisted of the following items: (a) the personal importance of ecologically positive waste disposal, (b) the acceptance of personal efforts in order to achieve ecologically positive waste disposal, and (c) the trust in administration and waste disposal companies concerning the appropriate use of the waste fragments that are separately collected

Our study adds to socio-psychological literature on recycling in two ways. First, we formulate recommendations for national battery producer responsibility organizations based on the insights gained from a integrative, TPB-based framework in order to facilitate behavioural change concerning battery pack collection. Second, we provide recommendations for future research based on insights from literature. The remainder of this paper contains the following sections. First, we discuss the method. In the next section we present the results. In section 4 we discuss these results. Section 5 holds the main findings of our work.

2. Method

2.1. Hypothesis development and model building

As was established in the introduction the TPB is the socio-psychological model that has been used most often to explain recycling. Yet, it has not been used to study batteries specifically, let alone the recycling intentions of battery packs. We aim to fill this gap viewing the resource potential that lies dormant. Furthermore, it has been argued that predictors might differ between (i) types of pro-environmental behaviour (Whitmarsh and O'Neill, 2010), (ii) waste management options (Barr, 2007), and (iii) studies focusing on recycling different products (Boldero, 1995). As the TPB only provides information about what relationships are likely of being relevant, empirical case studies provide the basis for their actual significance, sign and magnitude. The results of a literature review[2] focusing on TPB studies on recycling are displayed in Table 1. It displays the relative magnitude, sign, significance and measurement method of the relationship between the main effects of the three original TPB constructs and behavioural intention.

It can be concluded that quite generally, the more positive one's attitude, the more social pressure, and the more perceived behavioural control one has, the higher one's intention is towards performing the behaviour. This finding gives rise to hypothesis 1 (H1), 4 (H4), and 6 (H6), as can be seen in Table 2. Furthermore, it can also be realised that generally attitude outweighs the impact of perceived behavioural control which prevails over subjective norms. However, for the publications covering recycling behaviour, which requires travelling to a collection point, the order between attitude and perceived behavioural control is sometimes reversed. This

[2] The following query on the Web of Science, performed on 08/04/2015, resulted in finding 22 qualified peer-reviewed, English journal papers: TS=((“recycling” and “theory of planned behavio*”) or (“collection” and “theory of planned behavio*”)) AND TI=(“recycling”)

304 seems to indicate that having to transport materials can create a barrier. Hence, besides product type,
305 differences in predictors may also be caused by the way in which the waste is collected. Finally, the overview
306 shows that most diversity is found in how perceived behavioural control is conceptualised. Attitude is
307 generally measured directly on semantic differentials covering mainly affective judgements towards
308 performing the specific behaviour (Rhodes et al., 2015). Subjective norms are generally measured directly
309 using statements capturing the agreement with injunctive norms towards the specific behaviour upheld by
310 selected peers (Nigbur et al., 2010). Perceived behavioural control has not only captured control and difficulty,
311 but also situational constraints such as lack of facilities and personal constraints such as a lack of knowledge.
312 Though not mentioned in the table, intention was found to be measured by items measuring the degree to
313 which people "plan", "intend", "will", "want to" execute the desired behaviour. Note that due to our suspicion
314 of hoarding behaviour we introduced a time dimension into the equation. We want people to recycle their
315 battery packs as soon as possible. Therefore, intention statements measured the degree to which people intend,
316 plan, and want to drop-off battery packs to a Bebat collection point as soon as possible. For an overview of the
317 way we itemized the measurement models, we refer to Table 3 (section 2.2).
318

Table 1: Literature review on TPB-based studies investigating recycling behaviour

Reference	ATT	SN	PBC	Topic
Taylor and Todd (1995)	+, 1 (specific attitude)[d]	-,3 (referents)[d]	+,2 (control)[d]	Household waste recycling: sorting at home
Boldero (1995)	-, 1 (benefits, inconvenience, lack of conviction)[cm]	NS (referents)[cm]	NS (control)[d]	Wastepaper recycling: kerbside collection
Cheung et al. (1999)	+,1 (specific attitude)[cm]	+,2 (referents)[cm]	+,3 (control, difficulty)[cm]	Wastepaper recycling: not clearly specified
Tonglet et al. (2004)	+,1 (specific attitude)[d]	NS (referents)[d]	+,2 (inconvenience, facilities, knowledge)[d]	Household waste recycling: kerbside collection
Mannetti et al. (2004)	+,3 (specific attitude)[d]	+,3 (referents)[d]	+,1 (difficulty)[d]	Household waste recycling: differentiated collection
Chan (1998)	+, 1 (specific attitude)[d]	+,3 (referents, media)[d]	+,2 (difficulty)[d]	Household waste recycling: waste receptacles
Nigbur et al. (2010)	+,1 (specific attitude)[cm]	+,3 (descriptive SN)[d]	+,2 (control, difficulty)[cm]	Household waste recycling: kerbside collection
Chu and Chiu (2003)	**+,2 (specific attitude)[d]**	**+,3 (referents)[d]**	**+,1 (control)[d]**	**Household waste recycling: dump into disposal trucks**
Do Valle (2005)[a]	-,3 (specific attitude)[cm]	+,2 (referents)[cm]	1,+ (control, difficulty)[d]	Household waste recycling: selective collection
Knussen et al. (2004)	+,1 (specific attitude)[d]	NS (referents)[d]	NS (opportunity, difficulty)[d]	Household waste recycling: kerbside collection
Chen and Tung (2010)	**NS (specific attitude)[d]**	**-,1 (referents)[d]**	**+,2 (inconvenience, facilities, knowledge)d**	**Household waste recycling: bring to recycling facility**
Hansmann et al. (2006)[ab]	**NS (general attitude)[d]**	**NI**	**NI**	**Battery recycling: drop-off at collection points**
Ramayah et al. (2012)[a]	+,2 (benefits)[d]	+,1 (referents)[d]	NS (convenience, cost)[d]	Household waste recycling: recycling facility
Davis et al. (2006)	NS (specific attitude)[d]	NS (referents)[d]	NS (inconvenience, facilities, knowledge)[d]	Household waste recycling: kerbside collection
Chan and Bishop (2013)	NI (specific attitude)[d]	+,2 (referents)[d]	+,1 (inconvenience, facilities, knowledge)[d]	Household waste recycling: not clearly specified
Tang et al. (2011)[a]	**+,3 (specific attitude)[d]**	**+,2 (referents)[d]**	**+,1 (self-efficacy, situational factors)[d]**	**Household waste recycling: bring to collection depot**
Aguilar-Luzón et al. (2012)	+,1 (specific attitude)[d]	NS (referents)[cm]	+,2 (difficulty, control)[d]	Household waste recycling: glass sorting
Botetzagias et al. (2015)	**+,2 (specific attitude)[d]**	**NS (referents)[d]**	**+,1 (inconvenience, facilities, knowledge)[d]**	**Household waste recycling: drop-off in recycle bins**
Wan et al. (2014b)	**NS (specific attitude)[d]**	**+,2 (referents)[d]**	**+,1 (inconvenience, facilities, knowledge)[d]**	**Household waste recycling: bring to recycling facility**
White and Hyde (2012)	+,2 (specific attitude)[d]	+,1 (referents)[d]	NS (control, difficulty)[d]	Household waste recycling: kerbside recycling
Rhodes et al. (2015)	**+,1 (specific attitude)[d]**	**+,3 (referents)[d]**	**+,2 (control)[d]**	**Household waste recycling: bring to recycling depot**
Wan et al. (2014a)	**NS (specific attitude)[d]**	**+,2 (referents)[d]**	+,1 **(inconvenience, facilities, knowledge)[d]**	**Household waste recycling: bring to recycling facility**

Legend: NS = not significant; NI= not included; + = positive relationship; - = negative relationship; 1,2,3 = order of importance amongst ATT, SN, and PBC with 1 being more important than 3; () = how the measurement is operationalized; [a] Misses the intention-behaviour relationship and hence investigates the predictors of self-reported behaviour; [d] stands for direct measurement; [cm] stands for composite measurement; [b] Should have been excluded due to the non-compliance with the standard TPB framework, but was kept due to its importance regarding the topic

As recommended, additional variables are included in our model to be able to more adequately explain intentions. Hence, an integrative model is estimated (Bamberg and Möser, 2007). Firstly, past behaviour has often been hypothesized to affect recycling intention and behaviour, resulting in mixed evidence. Boldero (1995) failed to establish a significant relationship between past behaviour, measured by a self-report indicating whether the majority of newspapers (quantity) was recycled in the past (yes/no), and intention to recycle newspapers. On the other hand Cheung et al. (1999) found a positive relationship between past behaviour, indicated by the percentage of time (frequency) they performed the target behaviour within the 1-month period prior to the study, and intention. The same relationship applies for Terry et al. (1999), White and Hyde (2012) who used a quantity-based measurement of past behaviour. Tonglet et al. (2004) also concur, but use both questions on quantity and frequency to form paste behaviour. Consequently, hypothesis 2 (H2) says we expect a positive relationship between past behaviour and intention. Still, it should be noted that, while past behaviour has in some cases -which might reflect the influence of the operationalization- been found to be a powerful predictor of intention and future behaviour (e.g. see Conner and Armitage (1998)), it does not add to the theoretical understanding of what is driving that behaviour. It merely shows there is stability across time (Ajzen, 1991). In our study we have assumed that there might be a spill-over from the past recycling behaviour of other battery types on the intention to recycle battery packs in the future. Dispute has also arisen concerning whether past behaviour directly affects future actual behaviour or whether it is mediated by intention. This debate is interwoven with the habit issue discussed earlier (see section 1.2). If pro-environmental behaviour is thought to reasoned, then the frequency of prior behaviour should have only an indirect link to later behaviour, i.e. its effect should be mediated by intention. However, when added to the model, past behaviour is often found to significantly improve the prediction of later behaviour over and above the effects of intentions. Consequently, the behaviour might not be completely reasoned after all, but in part under the control of certain stimuli (Bamberg et al., 2003), which might reflect its semi-automatic nature.

Secondly, going into the debate evoked by the issues habits create for TPB models, Knussen et al. (2004) picked up on the use of past behaviour, operationalized by measuring its frequency, as a proxy for a habit. The reason for doing so was twofold. Reason number one was the disbelief in the frequency of past behaviour

346 being a good proxy on its own for the strength of a habit. Reason number two was the finding that the attitude–
347 intention relationship was stronger -and not weaker, which would actually match the findings of Ouellette and
348 Wood (1998)- for those who had recycled most of their recyclable waste, compared to those who had recycled
349 little or none of their recyclable waste. The latter found in a meta-analysis of TPB studies that if behaviour is
350 classified as habitual it decreases the strength of the attitude-intention relationship and increases the strength of
351 the past behaviour-intention relationship. Therefore, Knussen et al. (2004) reckoned that those who were not
352 recycling were those displaying habitual behaviour, which gave rise to the conception of a "lack of habit"
353 construct. Consequently, they aimed at verifying whether: (i) the attitude–intention relationship was weaker
354 for those with high scores on the lack of habit variable than for those with low lack of habit scores and (ii) the
355 past behavior–intention relationship was stronger for those with high lack of habit scores than for those with
356 low lack of habit scores. In other words, they expected the intention of those without a recycling habit to be
357 strongly related to past behavior and weakly related to attitudes. We will verify these hypotheses for a
358 recycling practice which requires the person to bring the waste to a collection point. The lack of habit
359 construct is considered appealing for our study as from the low collection levels of battery packs, it can be
360 deduced that most Belgians have adopted the custom of not bringing back their battery packs (to a Bebat
361 collection point), but in spite might have adopted a more prevailing alternative habit. Accordingly, the
362 construct "lack of habit" is hypothesized to moderate the relationship between attitude and intention and
363 between past behaviour and intention (Ouellette and Wood, 1998, Knussen et al., 2004). This will be tested in
364 hypothesis 7 and 8 (H7 and H8).
365
366

367 Table 2: Hypotheses

Nr	Hypothesis	Expected sign
H1	The more positive one's attitude, the higher the intention of dropping off used, removable battery packs at a Bebat collection point as soon as possible.	+
H2	The more one has recycled electronic waste streams in the past, the higher the intention of dropping off used, removable battery packs at a Bebat collection point as soon as possible.	+
H3	The more one feels morally obliged to recycle battery packs, the higher the intention of dropping off used, removable battery packs at a Bebat collection point as soon as possible.	+
H4	The more one perceives recycling battery packs as a socially desirable action by peers, the higher the intention of dropping off used, removable battery packs at a Bebat collection point as soon as possible.	+
H5	The more one perceives positive consequences of recycling battery packs as being present, the higher the intention of dropping off used, removable battery packs at a Bebat collection point as soon as possible.	+
H6	The more one perceived to be in able to carry out battery pack recycling, the higher the intention of dropping off used, removable battery packs at a Bebat collection point as soon as possible.	+
H7	The lack of a habit of dropping off battery packs at a Bebat collection point moderates the influence of attitude on the intention of dropping off used, removable battery packs at a Bebat collection point as soon as possible.	-
H8	The lack of a habit of dropping off battery packs at a Bebat collection point moderates the influence of past behaviour on the intention of dropping off used, removable battery packs at a Bebat collection point as soon as possible.	+
H9	The more people think that Bebat is highly effective in stimulating people to recycle battery packs, the lower the influence of being aware of the positive consequences of recycling battery packs on the intention of dropping off used, removable battery packs at a Bebat collection point as soon as possible.	-
H10	The more people think that Bebat is highly effective in stimulating people to recycle battery packs, the lower the influence of subjective norms on the intention of dropping off used, removable battery packs at a Bebat collection point as soon as possible.	-

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Thirdly, moral or personal norms have often been added to the TPB. Tonglet et al. (2004) hypothesized moral norms, measured by 7 7-point rating scales containing items such as "it would be wrong of me not to recycle waste", had a direct effect on intention to recycle household. No significant relationship was found. On the other hand, Nigbur et al. (2010) showed that personal norms, measured by 5 items adapted from Hopper and Nielsen (1991), had a positive direct effect on the intention to participate in a kerbside recycling program. Chu and Chiu (2003), Chen and Tung (2010), Chan and Bishop (2013), and Botetzagias et al. (2015) corroborate such findings. Hence, personal moral norms are expected to have a positive relationship with the intention to bring back battery packs (H3).

Fourthly, inspired by Schwartz's model of altruistic behaviour (Schwartz, 1970), the awareness of consequences has been added to a TPB model. Tonglet et al. (2004) unexpectedly found a negative relationship between consequences as distinct from community concern and outcomes, measured using 7-point rating scales using statements after Davies et al. (2002) capturing both personal and social benefits, and intention. The authors argue to capture the subjective knowledge-based (cognitive/instrumental) component of attitude. The anticipated positive relationship has been confirmed by Davis et al. (2006), Chen and Tung (2010), and Wan et al. (2014a, 2014b). Accordingly, hypothesis 5 (H5) says we expect a positive relationship between the awareness of consequences and intention.

Finally, the effectiveness of the recycling scheme and by consequence its organizer has been hypothesized to effect the intention to recycle. Such exploration goes back to Boldero (1995) who argued that the program's perceived inadequateness can be used to justify non-participation. The latter author, using a single 5-point rating scale ranging from a very bad to a very good evaluation, established a positive relationship between program evaluation and intention. Later, it has been picked up by Wan et al. (2014a, 2014b). Here, perceived policy effectiveness (PPE) captured an individual's favourable or unfavourable evaluation on the clarity, adequacy and facilitation of policy measures. It was measured using 5 7-point rating scales using statements such as "The government provides clear guidelines on recycling". They found that PPE not only has a direct

395 effect on intention, but also that it negatively moderates subjective norms and the awareness of consequences
396 (H9). An overview of the structural model and related hypothesis can be found in Figure 2.

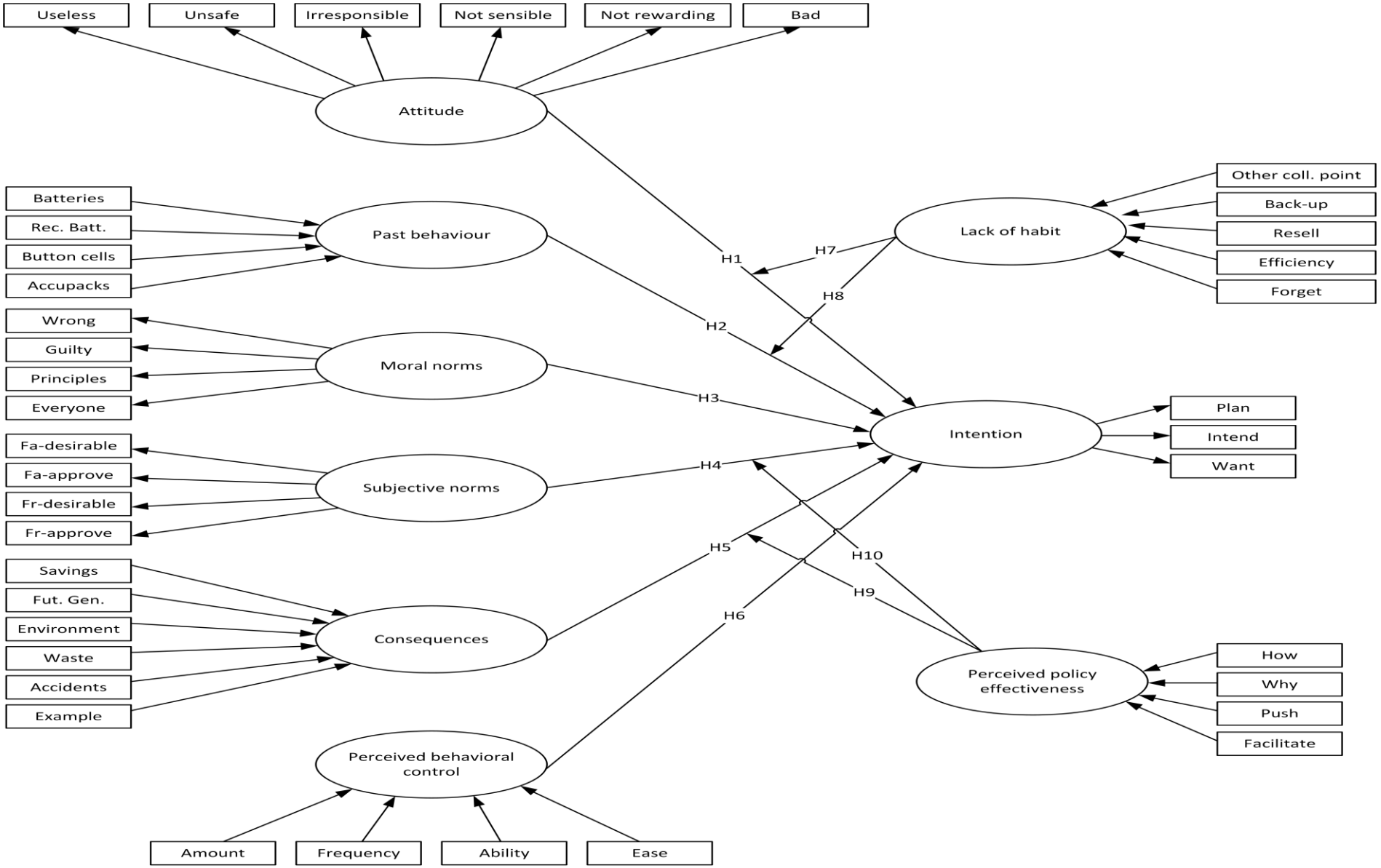

Figure 2. The structural equations model

2.2. Questionnaire design, measurement, and sampling

To gather the necessary data an online survey was designed in both Dutch and French. The survey consisted of an opening page, which introduced the topic and five survey sections. In the first section the respondents were profiled based on socio-demographic characteristics. In a second section the respondents were carefully explained what the desired behaviour entails. It was defined as: "dropping off spent, removable battery packs to a Bebat collection point as soon as possible". To assure full understanding, it was verified whether the provided definitions of 'spent' and 'removable' were memorized by the respondents. Spent signals that either the device or battery pack does not function properly anymore, or that the device has been replaced by a newer one. As we also strongly expected that respondents were unfamiliar with the word "battery packs", it was defined and examples of battery packs were presented. In case respondents did not reveal full understanding of the desired behaviour, the definitions provided earlier were repeated, before being able to continue.

In a third section the respondents were asked to fill in several 7-point semantic differentials or rating scales, see Table 3. Italic statements are changes to existing scales. The obtained scores give rise to the indicator variables (the rectangular shapes in Figure 2) that measure the latent variables under revision (the circles in Figure 2). Besides determining the measurement indicators, we also need to define the relationship between the latent variables and their indicators. Formative indicators are multidimensional in nature, whereas reflective indicators are unidimensional. In our study, the latent variables 'Past behaviour', 'Consequences', 'Perceived behavioural control', 'Perceived policy effectiveness", and 'Lack of habit' are measured on a formative scale, whereas the latent variables 'Attitude', 'Subjective norm', 'Moral norm', and Intention' are defined as being measured on a reflective scale. Using a test, based on principal component analysis of the correlation matrix, detailed in Sahmer et al. (2006) it could be verified that the reflective indicators are indeed unidimensional. An overview of the characteristics of reflective and formative latent variables is provided by Jarvis et al. (2003). It is important to correctly define the relationship between the latent variables and its indicators in order to avoid biased parameter and standard error estimates for the structural model and inflated type II errors (MacKenzie et al., 2005).

In a fourth section, respondents' objective knowledge on recycling batteries was verified. Here, respondents objective knowledge was tested regarding legal requirements, what they can bring to a Bebat collection point, where they can find Bebat collection points, and in what devices they can find removable battery packs. In the fifth and final section, respondents' pro-ecological worldview was assessed based on the scale developed by Dunlap et al. (2000).

429 Table 3: Measurement of latent variables

Latent variable	Tag	Indicator (mean – standard deviation)	Reference
Attitude (semantic differentials, reflective)	Useless	It is (useless-useful) to … (6.23 - 1.50)	Tonglet et al. (2004)
	Unsafe	*It is (unsafe-safe) to …* (6.20 - 1.51)	
	Irresponsible	It is (irresponsible-responsible) to … (6.22 - 1.51)	
	Not sensible	It is (not sensible-sensible) to … (6.22 - 1.53)	
	Not rewarding	It is (not rewarding-rewarding) to … (5.80 - 1.56)	
	Bad	It is (bad-good) to … (6.24 - 1.53)	
Past behaviour (rating scales: never-always, formative)	Batteries	How often do you recycle the typical non-rechargeable batteries (6.16 - 1.32)	Own work, inspired by Cheung et al. (1999)
	Rec. Batt.	How often do you recycle rechargeable batteries (5.66 - 1.75)	
	Button cells	How often do you recycle button cells (5.61 - 1.72)	
	Accupacks	How often do you recycle battery packs (5.31 - 1.85)	
Moral norms (rating scales: totally disagree-totally agree, reflective)	Wrong	It would be wrong of me not to … (5.80 - 1.48)	Tonglet et al. (2004)
	Guilty	I would feel guilty if I did not … (5.50 - 1.63)	
	Principles	It goes against my principles not to … (5.61 - 1.63)	
	Everyone	Everyone should share the responsibility to … (6.12 - 1.24)	
Subjective norms (rating scales: totally disagree-totally agree, reflective)	Fa-desirable	My family thinks it is desirable to … (5.53 - 1.68)	Taylor and Todd (1995) and Tonglet et al. (2004)
	Fa-approve	My family would approve of me … (5.93 - 1.33)	
	Fr-desirable	My friends think it is desirable to … (5.24 - 1.62)	
	Fr-approve	My friends would approve of me … (5.68 - 1.40)	
Awareness of consequences (rating scales: totally disagree-totally agree, formative)	Savings	I save money by … (4.15 - 1.85)	Tonglet et al. (2004)
	Fut. gen.	I create a better environment for future generations by … (6.20 - 1.18)	
	Environment	I protect the environment by … (6.35 - 1.09)	
	Waste	I reduce the amount of waste by … (6.05 - 1.30)	
	Accidents	*I reduce the likelihood of accidents in my house by …* (5.22 - 1.63)	
	Example	*I am an example for my kids by …* (6.17 - 1.24)	
Perceived behavioural control (semantic differentials and rating scales, formative)	Amount	How much control do you have over … (very few-a lot) (5.15 - 1.89)	Aguilar-Luzón et al. (2012) and Nigbur et al. (2010)
	Frequency	How many events out of your control could prevent you from (very few-a lot) (4.48 - 1.81)	
	Ability	If I want to, I can easily … (totally disagree-totally agree) (5.76 - 1.36)	
	Ease	It is (very hard-very easy) to … (5.65 - 1.48)	
Lack of habit (rating scales: totally disagree-totally agree, formative)	Other coll. point	I bring back electronic devices including battery pack, to the waste electric and electronic equipment recycling point (3.73 - 1.97)	Own work, inspired by Knussen et al. (2004)
	Back-up	I save the device as a spare before I … (4.51 - 1.80)	
	Resell	I try to salvage some economic value from my device before I ... (3.73 - 1.97)	
	Efficiency	The organization of battery pack collection could be more efficient (3.85 - 1.87)	
	Forget	I often forget to … even if battery packs have been removed from the devices (3.08 - 1.90)	
Perceived policy effectiveness (rating scales: totally disagree-totally agree, formative)	How	Bebat offers clear guidelines on … (5.31 - 1.47)	Wan et al. (2014a, 2014b)
	Why	Bebat clearly shows the benefits of … (5.38 - 1.45)	
	Push	Bebat stimulate me to … (5.23 - 1.52)	
	Facilitate	Bebat offers sufficient facilities in order for me to … (5.20 - 1.53)	
Intention (rating scales: totally disagree-totally agree, reflective)	Plan	I plan to … (5.93 - 1.26)	Cheung et al. (1999) and Chu and Chiu (2003)
	Intend	I intend to … (5.99 - 1.25)	
	Want	I want to … (5.87 - 1.28)	

The data was collected by a market research company. An online survey was taken from a panel of Belgian respondents during the 11/2014-01/2015 period. In total 1638 respondents aged between 18 and 64 participated in the survey. The primary sampling goal was to collect data that would subsequently allow investigating whether heterogeneity was an issue. We hypothesized that heterogeneity could be caused by the following self-reports: (1) whether the majority of battery packs was brought back to a Bebat collection point in the past (yes/no), (2) whether the living area is a rural or urban environment, and (3) what lifestage the respondent is in (young adult; family -12; family +12; medior; senior). As guidelines dictate that the minimum sample size is obtained by multiplying the maximum amount of arrowheads pointing at a latent variable times ten, 80 respondents are required per subgroup in our study (Barclay et al., 1995). Moreover, minimum sample size requirements based on power analysis also indicate that a sample of 1638 is sufficiently large. For example, given an α of 0.05 we need at least 174 respondents to achieve a statistical power of 80% for detecting R^2 values of at least 0.10 (and the number decreases as higher R^2 can be detected) (Hair et al., 2016). An overview of the obtained subgroup sample sizes is given in Table 4. Note that every categorization using only a single observed characteristic exceeds these requirements.

The descriptive statistics for the full sample (n=1638) can be found in Table 5. We can see that the sample is representative concerning gender, but is slightly dominated by older, more highly educated people having less kids compared to the Belgian population. The life stage variables were defined as follows: (1) “young adults” are people under 45 being single or in a relationship without kids (living at home); (2) “family -12” are families of which their oldest child has not reached the age of 12; (3) “family +12” are families of which their oldest child has passed the age of 12; (4) “mediors” are people falling in the age group of 45-60 being single or in a relationship without kids (living at home); (5) “seniors” are people having reached the age of 61 or older being single or in a relationship without kids (living at home). This categorization was maintained for reasons of consistency with prior research.

Table 4: Subgroup sample sizes (# respondents)

Battery pack = No			**Battery pack = Yes**		
	Living area			**Living area**	
Lifestage	*City*	*Rural*	**Lifestage**	*City*	*Rural*
Young adult	98	85	*Young adult*	69	73
Family -12	73	87	*Family -12*	54	67
Family +12	102	87	*Family +12*	100	94
Medior	86	88	*Medior*	93	91
Senior	50	62	*Senior*	89	90

458 Table 5: Descriptive statistics

Descriptive	Category	Proportion	Population [f]
Primary language	Dutch-speaking	57.39%	NA
	French-speaking	42.61%	NA
Region [a]	Flanders	59.77%	57.18%
	Walloon	32.30%	31.92%
	Brussels capital	7.94%	10.90%
Age [a]	18-24	13.61%	15.12%
	25-34	17.09%	12.79%
	35-44	15.32%	23.75%
	45-54	17.70%	25.73%
	55-64	36.26%	22.61%
Gender [a]	Male	50.18%	50.18%
	Female	49.82%	49.82%
Family size [b]	1	18.99%	16.70%
	2	41.64%	32.90%
	3	17.64%	20.50%
	4	13.92%	18.50%
	5	5.62%	7.40%
	>5	2.20%	4.00%
Life stage	Young adult	19.84%	NA
	Family -12	17.16%	NA
	Family +12	23.38%	NA
	Medior	21.86%	NA
	Senior	17.77%	NA
Education [c]	Primary and lower secondary	17.58%	29.50%
	Upper secondary	37.06%	37.80%
	Tertiary	45.36%	32.60%
Monthly net family income [d]	0-1499	20.52%	NA
	1500-2499	25.09%	NA
	2500-3499	19.78%	NA
	3500-4499	11.48%	NA
	4500-6000	3.24%	NA
	>6000	0.92%	NA
	Missing	18.97%	NA
Living area [e]	City	49.69%	NA
	Rural	50.31%	NA
Battery pack	Majority yes	49.94%	NA
	Majority no	50.06%	NA

459 [a] population data from Statbel (http://statbel.fgov.be/nl/statistieken/cijfers/) counted on 01/01/2015 for 18-64 years; [b] population data
460 obtained from Generation and Gender Program Belgium (http://www.ggps.be/); [c] population data from Eurostat
461 (http://ec.europa.eu/eurostat/data/database) counted on 01/01/2014 for 15-64 years; [d] the average net-adjusted monthly (yearly/12)
462 income in € (using a 0.95$/€ conversion rate) is about €2485 according to the 2015 OECD Economic Survey of Belgium
463 (http://www.oecdbetterlifeindex.org/countries/belgium/); [e] based on classification used by market research company, which is
464 dependent of both the Eurostat and OECD classification; [f] NA = Not available for comparison..

2.3. Estimation

Using structural equations modelling (SEM) the underlying relationships between latent variables, measured indirectly by indicator variables can be assessed. The term "structural equations model" generally refers to a combination of a "measurement model" that defines latent variables being measured by one or more observed indicator variables, and a "structural model" that links the latent variables together. The two parts of a structural equation model are linked together by a system of simultaneous regression equations. Within SEM one of two approaches can be chosen depending on the objectives of the research. Covariance based SEM is used to confirm or reject theories, whereas partial least squares structural equations modelling (PLS-SEM) is used when theory is less developed.

In this research, PLS-SEM is chosen, because no former socio-psychological study has been executed for our case and context. Additionally, PLS-SEM offers the following advantages: (1) it can handle formative, reflective, and single-item measurement scales, (2) it makes virtually no assumptions about the distribution of the data, (3) it does not require large sample sizes, (4) it allows for estimating higher order models, and (5) it works better for complex models, i.e. when the focus is on the interrelationships among a large set of factors and in case of many manifest variables (Chin and Newsted, 1999, Chin, 2010). PLS-SEM is an ordinary least squares (OLS) regression based method. The estimation procedure estimates the structural path coefficients that maximize the R^2 values of the target endogenous latent variables while accounting for measurement error. The effects of the perceived policy effectiveness of Bebat on the awareness of consequences and subjective norms and of a lack of habit on attitudes and past behaviour and attitude were investigated by means of the two-stage approach. Besides continuous moderators, PLS-SEM also allows testing for differences between identical models for different subsamples divided using a categorical variable (Hair et al., 2016). Hence, the goal of this research is not only to find out the latent drivers and barriers to battery pack drop-off intention, but also to reveal if and where heterogeneity in relationships is present. All SEM estimations are performed using the software program SmartPLS 2.0.

3. Results

3.1. PLS-SEM estimation results

Before being able to present the estimation results, the measurement models need to be evaluated. The full results of this evaluation can for brevity be found in Appendix A. For the reflective measurement models, all relevant criteria were met. For the formative measurement models it was found that the savings and efficiency indicator of the consequences and lack of habit construct do not meaningfully contribute and hence were dropped. Before proceeding with presenting the results of the regressions, we also demonstrate that the estimation is not biased due to multicollinearity. In order to verify whether this could be an issue, the tolerance and variance inflation factors (VIFs) are calculated as they do take indirect correlation into account. Tolerance levels below 0.2 or VIFs over 5 are considered to be indicative of multicollinearity (Hair et al., 2016). Using the latent variable scores, resulting from the previously validated measurement models, as input for a linear regression, we get the results shown in Table 6. Based on these results we conclude it is safe to proceed. The results of the estimation are shown in Figure 3. Path coefficients between round brackets are negative values.

Table 6: Checking for multicollinearity

Latent variable	VIF	Tolerance
Attitude	1.40	0.72
Subjective norms	2.46	0.41
Perceived behavioural control	1.76	0.57
Awareness of consequences	2.28	0.44
Moral norms	1.73	0.58
Past behaviour	1.55	0.65

The main focus in PLS-SEM analysis is on the predictive power in terms of variance explained, as well as on the significance of all path coefficients, while assuming that the model is correctly specified due to its grounding in theory. The structural model's predictive accuracy is evaluated using the R^2 values of the endogenous construct (i.e. intention), whereas its predictive relevance can be computed with Stone-Geisser's Q^2 which assesses the predictive relevance. According to Chin (1998) R^2 values of 0.67, 0.33 and 0.19 can be considered as respectively substantial, moderate and weak for social studies. Hence, the R^2 value of about 0.64 found by our study is considered to be moderate yet close to substantial. To test the R^2's significance, a bootstrap confidence interval is calculated by using the equation described in Tenenhaus et al. (2005). The R^2

90% bootstrap confidence interval amounts to [0.39,0.74]. To assess the hypotheses accompanying the structural model's path coefficients, again a bootstrapping procedure with 5000 draws is used to obtain their standard errors. From Figure 3 we can see that all direct effects are significant and have the anticipated sign, except for the relationship between attitude and intention. Hence, hypotheses H2 to H6 could be confirmed. Moreover, in diminishing order perceived behavioural control and moral norms are found to have the largest direct effect. The moderating effects of lack of habit and of perceived policy effectiveness on consequences are not significant, hence we disprove H7, H8 and H9. A negative moderating effect of perceived policy effectiveness on subjective norms was found, hence we can confirm H10. Additionally, it was found that the direct effects of lack of habit (-) and perceived policy effectiveness (+) perform as expected. A blindfolding procedure was used to assess the predictive relevance, of the structural model. The Q^2 value for intention amounts to +0.54 which signals that the model has predictive relevance for intention (Geisser, 1974). Finally, f^2 and q^2 effect sizes, which signal the importance of a single latent variable on the R^2 and Q^2 of an endogenous construct respectively, were found to be lacking (<0.02) or weak ([0.02-0.15]). An overview of the findings is provided in Table 7.

Table 7: Hypotheses: findings

Hypothesis	**H1**	**H2**	**H3**	**H4**	**H5**	**H6**	**H7**	**H8**	**H9**	**H10**
Expectation	+	+	+	+	+	+	-	-	-	-
Findings	NS	+	+	+	+	+	NS	NS	NS	-

*NS = not significant; sample size: n=1638

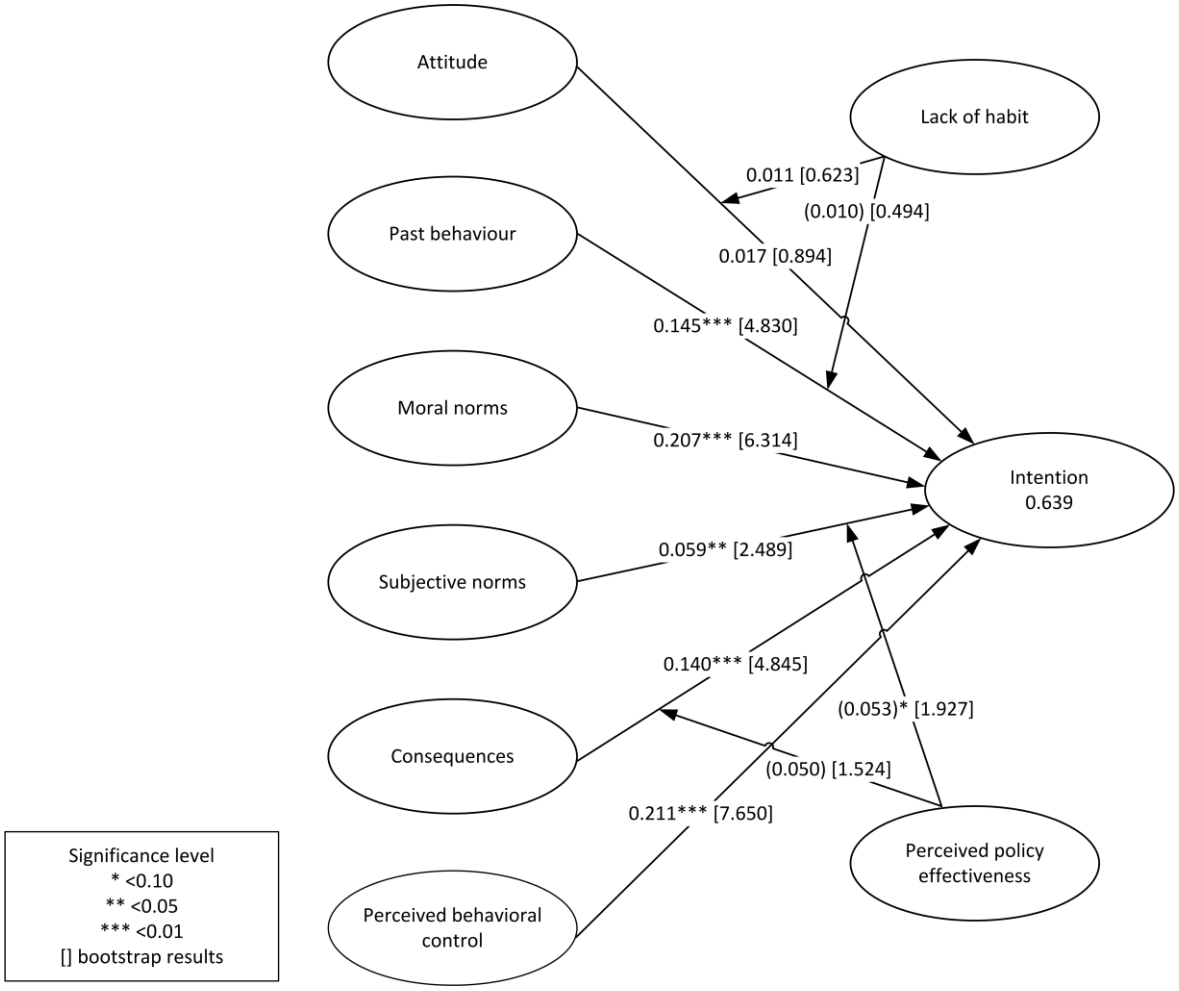

Figure 3: PLS-SEM estimation results

3.2 Evaluation of observed heterogeneity

A multi-group analysis (MGA) was used to assess the impact of observed (categorical) variables, such as lifestage, living area, and past drop-off behaviour, on the estimated path coefficients. Observed heterogeneity exists when significant differences are found between path coefficients when dividing the dataset into subgroups based on observed features. Seeing that PLS-SEM does not make any distributional assumptions, a non-parametric approach is used to test for differences between the strengths of the relationships amongst subgroups (Henseler, 2012). Such an analysis is meant to reveal the pitfalls of relying solely on the full sample's average results, which are presented in Figure 3. In Table 8 we show the results of the MGAs when dividing the dataset in subgroups based on a single feature. The p-values express the probability that the second subgroup has a larger population parameter than the first subgroup. Hence, if the path coefficient is positive, a p-value smaller than 0.10 signals that the first subgroup has the largest impact, whereas a value

larger than 0.90 indicates the opposite. In case the path coefficient is negative, a p-value smaller than 0.10 signals that the first subgroup has the smallest absolute impact, whereas a value larger than 0.90 indicates the opposite.

From Table 8 the following conclusions can be derived. First, there are only 2 groups without significant differences, being city-rural and young adult-family+12. The latter may be due to ambiguity in answering the profiling questions and resulting sorting, causing young adults to be sorted in the family + 12 and vice versa. Second, differences are most common in the susceptibility towards subjective norms, the lack of habit, moral norms, and awareness of consequences. Third, the characteristics causing most heterogeneity are: the pro-ecological worldview and the lifestage the respondent is in. Especially, respondents in a family with the oldest kid under the age of 12 are heterogeneous. Fourth, only the lower educated respondents display a positive relationship between attitude and intention, whereas the other display an insignificant relationship. Fifth, subjective norms have a stronger impact on intention for people bringing back less than half of their battery packs they have available for recycling to a Bebat collection point, for Dutch-speaking people, and for young adults and families with the oldest child over 12 compared to families with kids younger than 12. Sixth, lack of habit has a stronger impact on intention for people bringing back less than half of their battery packs they have available for recycling to a Bebat collection point, for people with a low pro-ecological worldview, and for mediors compared to young adults, families with the oldest child older than 12, and families with kids younger than 12. Seventh, moral norms have a stronger impact on intention for people having a high pro-ecological worldview, for females, and for young adults, families with the oldest child aged above 12, and seniors compared to families with kids younger than 12. Eighth, consequences have a stronger impact on intention for families with kids younger than 12 compared to all other lifestage categories. Ninth, the influence of perceived behavioural control on intention is larger for mediors than for seniors. This heterogeneity shows the importance of segmentation prior to behavioural change interventions as it has been argued that interventions should be tailored to the target group to avoid resistance (Klöckner, 2015).

566 Table 8: MGA test results

Observed variable	Subgroup[a]	Size	Significant difference	Sign[b]	p-value
Battery pack	Minority	818	Subjective norm -> Intention	+/NS	0.004
	Majority	820	Lack of habit -> Intention	NS/-	0.015
Education	Low	895	Attitude -> Intention	+/NS	0.049
	High	743			
Ecological world view	Low	835	Moral norm -> Intention	+/+	0.991
	High	803	Past behaviour -> Intention	+/+	0.082
			Lack of habit -> Intention	-/NS	0.965
Gender	Female	822	Moral norm -> Intention	+/+	0.090
	Male	816			
Language	Dutch	940	Subjective norm -> Intention	+/NS	0.025
	French	698	Past behaviour -> Intention	+/+	0.092
Living area	City	814	/	/	/
	Rural	824			
Lifestage	Young adult	325	Subjective norm -> Intention	+/NS	0.081
	Family -12	281	Moral norm -> Intention	+/+	0.042
			Consequences -> Intention	+/+	0.982
Lifestage	Young adult	325	/	/	/
	Family +12	383			
Lifestage	Young adult	325	Subjective norm -> Intention	+/NS	0.066
	Medior	358	Lack of habit -> Intention	NS/-	0.019
Lifestage	Young adult	325	Subjective norm -> Intention	+/NS	0.014
	Senior	291			
Lifestage	Family -12	281	Subjective norm -> Intention	NS/+	0.926
	Family +12	383	Moral norm -> Intention	+/+	0.904
			Consequences -> Intention	+/+	0.044
Lifestage	Family -12	281	Consequences -> Intention	+/+	0.037
	Medior	358	Lack of habit -> Intention	NS/-	0.075
Lifestage	Family -12	281	Moral norm -> Intention	+/+	0.965
	Senior	291	Consequences -> Intention	+/+	0.025
Lifestage	Family +12	383	Subjective norm -> Intention	+/NS	0.059
	Medior	358	Lack of habit -> Intention	NS/-	0.010
Lifestage	Family +12	383	Subjective norm -> Intention	+/NS	0.007
	Senior	291			
Lifestage	Medior	358	PBC -> Intention	+/+	0.090
	Senior	291	Lack of habit -> Intention	-/NS	0.952

567 [a] The first subgroup being the one first mentioned when reading from top to bottom; [b] NS = not significant.

568

4. Discussion

4.1. Reflection on the findings

In this study we have verified the drivers and barriers to battery pack drop-off intention using an integrative model based on the TPB. Seeing the R^2 our results support the use of such frameworks in understanding battery pack recycling intention for cases and contexts similar to ours. Yet, we expected attitude towards the specific pro-environmental behaviour to be a significant factor in driving battery pack recycling intention. However, our study points to the opposite conclusion, which can be considered surprising seeing the large empirical evidence on its role in predicting intentions. Chan and Bishop (2013), however, have previously found that moral norms and attitude, operationalized in the same way as in our study, exhibit convergent validity which signals that the constructs are not distinct, even if the indicators "bad" and "not responsible" are removed. Consequently, in accordance with Chen and Tung (2010) and Wan et al. (2014b), the additional constructs, awareness of consequences and moral norms, take over the predictive power from attitude seeing that in a basic TPB model attitude has the expected positive relationship with intention.

For past behaviour we have independently confirmed the findings of Knussen et al. (2004) to also be valid for battery pack recycling intention. Like for kerbside collection, the frequency of past behaviour (+) and lack of habit (-) made significant independent contributions to the intention to recycle. Consequently, past behaviour alone, operationalized using frequency measurements, does not confer habit. More recently, it became evident that there are three primary antecedents to habit development being: (i) frequent repetition of the behaviour in question, (ii) the extent of satisfaction with the outcomes of the repeated behaviour, and (iii) relatively stable contexts (Limayem et al., 2007). Unlike Knussen et al. (2004) we do not obtain evidence of significant moderation by lack of habit on the relationship between attitude and intention, most likely due to the above. Like Knussen et al. (2004) we do not find support for significant moderation by lack of habit on the relationship between past behaviour and intention, which is most likely signalling that the consistency between past behaviour and intention was not more marked for those presumed to have a strong alternative habit, than for those having the desired habit. The latter is supported by the fact that past behaviour is not identified as a latent variable with much heterogeneity.

Perceived behavioural control, moral norms and awareness of consequences were found to be significant factors in explaining intention, hence reconfirming the results found by Wan et al. (2014b) and Chen and Tung (2010). From the wider survey, however, some evidence was found supporting that perceived behavioural control is not a good proxy for actual behavioural control. Whereas people think to be quite able to bring back battery packs, they were found much less competent in identifying the devices containing them. Consequently, its effect on actual behaviour might be questionable (Carrington et al., 2010). Also, we did not add a mediating effect of moral norms on subjective norms. However, Nigbur et al. (2010) and have shown such an effect to be significant. Subjective (injunctive) norms were found to be least important in explaining intention. This is not surprising seeing that there is ample evidence showing that social pressure can become internalized over time Botetzagias et al. (2015). Furthermore, recycling battery packs is not a visible type of behaviour so there is few incentive to uphold such norms. Indeed, it has been argued that for social norms full impact to be revealed one should investigate both injunctive (i.e. what people approve) and descriptive (i.e. what people actually do in a given context) norms (Cialdini et al., 1990). For perceived policy effectiveness, we could not find statistical evidence of a moderating role on the awareness of consequences (Wan et al., 2014b). This signals that promotional campaigns in Belgium should not stop reminding people of the avoided costs and benefits of recycling batteries in spite of the good reputation Bebat maintains. On the other hand, we could establish a moderating role on subjective norms. This points out that for those with a weak perceived policy effectiveness a stronger, positive relationship exists between subjective norms and intention.

Besides offering the average results based on the full sample of 1638 respondents, we also performed a multi-group analysis (MGA) to assess the impact of observed demographical variables and pro-ecological worldview. Such an analysis is useful as empirical evidence on the effect of demographics is inconclusive (Arbués and Villanúa, 2016) and it allows nuancing the full sample's average results by serving as a means to create target groups that can be addressed using the same communication channel(s) and message(s). A downside of MGA is that it presumes measurement invariance, i.e. we suppose that the subgroups do not

622 require a different measurement model. However, ways to test this assumption empirically have yet to be
623 further developed (Henseler et al., 2016).
624
625 From the wider survey it was also found that on average respondents: (i) report to bring 7 to 8 used portable
626 batteries to a collection point 4-5 times per year, (ii) do not plan on changing this frequency, and (iii) agree the
627 least with the statement saying that they often forget to take battery packs to a collection point. Consequently,
628 we feel Bebat is facing the situation where people recycle batteries on a low frequency basis and do not
629 perceive any (easy) opportunity to bring back more of them. This lack in perceived opportunity is in contrast
630 to reality. Past research showed that people store used battery packs longer than they do other types of
631 batteries. At the root of the difference in recycling rates between types of batteries we presume, lies that that
632 (Belgian) people are more attached to higher-end electronics devices, which are more likely to contain battery
633 packs. Such devices are typical examples of up-to-date products. Consequently, people are more hesitant to
634 recycle such devices and their batteries (Jacoby et al., 1977) perhaps caused by anticipated feelings of regret
635 (Tsiros and Mittal, 2000) which then over time evolves into forgetting the devices are there. For instance, in a
636 follow-up qualitative study respondents noted not to have parted from a mobile phone because it contained
637 pictures of good times they once had. If they do part from their devices, our respondents preferred to look for
638 other interesting options, such as reselling or returning them for rebates, or to gift it to someone or donate it to
639 a charity, which is similar to American behaviour (Staples, 2014).

640 **4.2. Recommendations for national producer responsibility organisations**

641 From our findings the following recommendations can be drawn to reinforce the desired behaviour. National
642 producer responsibility organisations are advised to (continue) stress(ing) the added value of dropping-off
643 even a single battery (pack) in information campaigns. Also, if financially feasible, they are advised to reward
644 loyalty for instance by organising collection races, preferably asking for some form of prior commitment to
645 actually perform the behaviour (Burn and Oskamp, 1986). For instance, schools or companies could register to
646 participate in a local collection race of which the results are made public. Such activities help to prevent bad
647 habit formation or to relapse into them. The desired behaviour can be (re)activated by making consumers
648 aware of the consequences (or need) of assuming their responsibility of recycling all batteries. We do not

advocate raising awareness on recycling being a legal requirement in the top-performing countries as it might crowd out intrinsic motivation (Frey, 1994). Without any type of personal or public awareness, no norms can be activated whose defiance challenge both the ideal self-image and the ideal concept others have of me, which induces self-discrepancy (Higgins, 1987) and stimulates people to do what is right instead of what is economically rational.

Having touched ethics, it is also worth mentioning that a message intended to guilt someone into recycling in the future is expected to be less lasting than announcements that induce feelings of pride (Bissing-Olson et al., 2016). Hence, the message to persuade people to start recycling battery packs and to motivate others that have already started, should be framed in a positive and understandable manner. For more detail on how to design effective behaviour change interventions we refer to Bator and Cialdini (2000) for a thorough overview of general insights. Essential is that changing behaviour does not stop at making sure the message is well-received, it also involves making sure it is retrievable and that people are kept committed to the message. For literature investigating battery recycling slogans' most effective content we refer to Hansmann et al. (2009). In brief, they found that a factual slogan is more effective than a humorous one.

Increasing only the awareness of consequences is insufficient. Just because one provides ample reasons of why to adopt a new behaviour or continue the desired behaviour, does not mean one does not simply forget over time or is able or willing to. To avoid forgetting we recommend to use additional, more visible cues than the currently widely used battery collection bags. For instance national producer responsibility organisations could team up with apps for making grocery shopping lists to remind them of their recycling intention when they add new batteries or electric or electronic equipment containing battery packs to their shopping lists. The creation of a proper habit then still needs to be facilitated in order to avoid the feeling of learned helplessness and hence to generate satisfaction. Satisfactory experiences are key in developing new habitual behaviour (Aarts et al., 1997). Moreover, increasing people's feeling of competence and ease may contribute to an increase in the level of satisfaction which is experienced as behaviour is performed (Ronis et al., 1989). However, the battery collection process differs in difficulty across battery types and consequently so will the

perceived (and actual) behavioural control. Note that, in the case of portable batteries, the difference in difficulty in Belgium is not caused by how the system is organized as all portable batteries can be brought to the same Bebat drop-off point. One reason we suspect to be an issue is that people are unable to tell the difference between a removable battery pack and a built-in one. To remedy this barrier, people have to learn how to tell the difference. Only showing them how to do it in a commercial or on a website is expected to be less effective in the long run. A joint collection point having an instructor for separating wireless electrical and electronical waste and batteries could provide in a practical solution to help people by providing them with instructions while they do it. In a second stage collection campaigns targeting battery pack collection in specific target groups can be initiated to stimulate knowledge transfer further and to make learning a fun, social activity. It has been shown that people might induce themselves to carry out a mundane task by creating ways to perceive the task as more interesting and fun (Sansone and Harackiewicz, 1996). Intuitively, in the context of household chores a hedonic goal-frame is less expected. Indeed, our results confirm that in this context a normative goal-frame is most likely to be dominant without intervention (Miao and Wei, 2013).

For this approach to work the collection campaign needs to last long enough to allow unfreezing the old, unwanted and reinforcing or freezing the new, desired habit. These latter steps are important as information campaigns may stimulate a behavioral change, but tend to devote too little effort to feedback to support behavior repetition and the desired pro-environmental habit establishment (Dahlstrand and Biel, 1997). Respondents also indicated that a logo on the device would prove to be useful cue in stimulating the drop-off of battery packs. A stable context, which requires identical or similar situational cues, is alongside with satisfaction and frequent repetition conducive to habit development (Limayem et al., 2007).

We end with a word of caution as experimental studies would be required to validate these recommendations for our context. Such experimental studies are moreover important given that the costs of infomercials and collection campaigns vary significantly because they are a function of their length, quality, and coverage.

4.3. Limitations and routes for further research

The main limitation of our results is that they are based on self-reported intention statements, which are correlated with findings about self-reported behaviour. However, the latter do not necessarily have a high correlation with observed, actual behaviour. The strength of the relationship between actual and self-reported behaviour has been found to depend on the product under study, but typically one overestimates the degree to which one displays the desired behaviour when self-reporting (Huffman et al., 2014). Hence, further study based on objective measurements of actual behaviour of a representative sample is needed to verify whether our findings hold in such a context. These measurements would then allow to empirically verify whether a (lack of) habit significantly moderates the relationship between intention and actual behaviour and hence limits the predictive power of intentions on actual behaviour.

Based on the insights gained, we feel it would also be interesting to investigate the role of emotions, control, (lack of) habits and self-identity within the frame of the interlinkage between WEEE and battery packs using a multilevel structural equations model such as the one presented in Klöckner and Oppedal (2011) once before and once after interventions have taken place. This would allow to empirically quantify the existence and impact on spill-over effects in a context where recycling is normalized if the study were to take place in Belgium again. Previously, it has been argued that, due to normalization, positive spill-overs to other pro-environmental behaviours are less likely to occur, unless such conduct results from a pro-environmental identity (Thomas and Sharp, 2013). Still, the findings of Reams et al. (1996) who found that a positive effect might be limited to closely related behaviour, cause us to expect a positive spill-over. Nevertheless, such an effect is not guaranteed. Thøgersen (1999) found evidence of negative spill-over between pro-environmental behaviours. Most likely this is because people chose to act pro-environmentally in the domain where the costs are lowest, which is also known as limited behaviour (Gifford, 2011). In order to explain these mixed findings Truelove et al. (2014) developed a unifying theoretical framework which could be tested in such a follow-up study.

An interesting starting point is provided by Triandis' (1977) theory of interpersonal behaviour (TIB) and Klöckner and Blöbaum's (2010) comprehensive action determination model. Triandis' theory, although similar to TPB in that intention is a direct antecedent of actual behaviour, recognised the key role played by (i) social factors, which include norms, roles, and the self-concept, and emotions in forming intentions, (ii) the mediating influence of habits on actual behaviour, and (iii) the moderating influence by facilitating conditions on the influence of both intention and habits on actual behaviour. Consequently, actual behaviour is considered to be predicted by intention, habits, and situational constraints, whereas intention is formed by rational, social and affective antecedents. In a study by Bamberg and Schmidt (2003) it was shown that the TIB outperforms the TPB in terms of explanatory power of self-reported car use. Similarly, Klöckner and Blöbaum's comprehensive action determination model (CADM) incorporates intentional, normative, situational, and habitual influences on environmentally friendly behaviour based on the assumptions made respectively in the TPB, the norm activation model (NAM), the ipsative theory of behaviour (Tanner, 1999), and the definition of the concept of habit. A test of the comprehensive model showed that the CADM explained the greatest degree of variation as compared with the TPB and the NAM.

There is, however, a potential downside to the quest for socio-psychological models which explain more variation in the dependent variable(s). As more and more antecedents are added to such models there are diminishing increases in their predictive capacity while the increasing complexity renders them less easily amenable to practical application. If so, then perhaps one should consider turning to other methods. For instance, one could employ a method that operationalizes structuration theory (Giddens, 1984). The latter theory takes the middle ground in the debate on whether behaviour is driven by agency or by structure. Nevertheless, such an alternative has the potential downside of not being easily generalized across contexts. Alternatively, one could perform an experimental study. Although it has been said to evoke socially desirable responses due to the fact that respondents are aware of being in an experiment, the relative switch in behaviour displayed in experiments has been found to be consistent (Ariely et al., 2003).

Lastly, we admit that the proposed recommendations are mainly based on the average results and largely neglect the information provided by the multi-group analysis (MGA). This merely signals that our recommendations are more suited for mass media communication. We leave it to future studies to distinguish target groups that can be addressed using the same communication channel(s) and message(s).

5. Conclusion

Our results support the use of integrative, Theory of Planned based frameworks in understanding battery pack recycling intention, certainly for cases in which an actual, specific, desired habit has yet to be developed. Based on the size of the path coefficients we find that on average perceived behavioural control, moral norm, and the awareness consequences have the largest influence on the intention to drop-off battery packs as quickly as possible. Hence, national producer responsibility organisations are advised to (i) keep up with or start informational and promotional activities to familiarize people with the fact that this type of portable batteries is being collected by them and to decrease the (perceived) difficulty and banality of recycling battery packs in order to unfreeze the current lack of habit and (ii) to raise awareness on the need for and consequences of recycling battery packs in order to activate the ascription of responsibility and accordingly moral norms. Still, it should be taken into consideration that these findings and the derived recommendations are based on self-reported intention statements. Further study, using more comprehensive, integrative models which also incorporate objective measurements of actual behaviour of a representative sample, is needed to verify whether our findings hold in such a context. We recommend such a study to simultaneously investigate the presence of positive spill-overs or effect on spill-over of interventions using multilevel structural equation modelling.

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Appendices

Appendix A: Evaluation of the reflective and formative measurement models

When evaluating reflective measurement models, several aspects have to be tested. The indicator reliability specifies the part of an indicator's variance that can be explained by the underlying latent variable. At least 50% of an indicator's variance should be explained by the latent variable (i.e. loading above 0.70). For the construct reliability the composite reliability is used. Cronbach's alpha could also be used, but this measure is sensitive to the number of items in the scale and is more conservative. Values for the composite reliability above 0.60 are acceptable for exploratory research. The convergent validity measures the extent to which a measure correlates positively with alternative measures of the same construct. Both the outer loadings and average variance extracted (AVE) can be used to test this. The outer loadings should be higher than 0.70. The AVE is calculated as the sum of the squared loadings divided by the number of indicators. An AVE of less than 0.5 is considered insufficient, because more variance is due to error variance than to indicator variance. Finally, the discriminant validity represents the extent to which a construct is distinct from other constructs. The cross loadings may not exceed the indicators' outer loadings and the Fornell-Larcker criterion has to be met. The latter compares the square root of the AVE values with the latent variable correlations(Hair et al., 2016). It can be concluded that all criteria are met. An overview of the results of the reflective measurement models is provided in the Table A1.

Table A1: Estimation results and psychometric properties of reflective measurement models

Latent variable	Indicator	Loadings	Indicator reliability	Composite reliability	AVE	Discriminant validity
Attitude	Useless	0.852	0.726	0.942	0.729	yes
	Unsafe	0.855	0.731			
	Irresponsible	0.883	0.780			
	Not sensible	0.884	0.781			
	Not rewarding	0.770	0.593			
	Bad	0.874	0.764			
Moral norm	Wrong	0.891	0.794	0.933	0.776	yes
	Guilty	0.892	0.796			
	Principles	0.863	0.745			
	Everyone	0.879	0.773			
Subjective norm	Fa-desirable	0.825	0.680	0.908	0.711	yes
	Fa-approve	0.871	0.759			
	Fr-desirable	0.801	0.642			
	Fr-approve	0.874	0.764			
Intention	Planned	0.948	0.898	0.958	0.885	yes
	Probable	0.941	0.886			
	Desire	0.933	0.870			

Formative latent variables require a different evaluation of the measurement model as indicators are not supposed to be correlated. For formative measures we assessed the indicator reliability. Indicator reliability is examined by verifying whether high correlations exists between indicators. The variance inflation factor (VIF) is used to check whether multicollinearity poses a problem. The VIF did not exceed a value of 10. Using a bootstrapping procedure with 5000 draws it is also evaluated which indicators are significant and relevant. The null hypothesis, stating that an outer weight equals zero (i.e. has no significant effect), is rejected when the interval does not include zero. When it seems that indicators are not significant, these are further investigated. In case the outer loadings of these indicators are high (above 0.5), it was opted to keep the indicator in the model. The results of the overall formative measurement models are provided in 0. Based on the results, it is decided to keep all indicators in the measurement model, except for the savings indicator and efficiency indicator. In order to check for convergent validity it is suggested to use a general question, which might be considered reflective, related to each of the formative constructs in order to evaluate formative measurement model's validity. However, no question is taken into account in our survey as the questionnaire is already perceived as being quite long. As a consequence, the convergent validity of the formative constructs was not evaluated.

1114 Table A2: Results bootstrapping procedure formative measurement scales

Latent variable	Indicator	Outer weights (outer loadings)	Significance level (* .10 ** .05 ***.01)	Confidence interval (10%)
Past behaviour	Norm. batt.	0.580 (0.905)	***	[0.493;0.667]
	Rec. batt.	0.152 (0.732)	***	[0.072;0.232]
	Button cells	0.062 (0.733)	NS	[-0.023;0.147]
	Accupacks	0.396 (0.804)	***	[0.313;0.479]
Consequences	**Saving**	**0.010 (0.296)**	**NS**	**[-0.043;0.063]**
	Well-being	0.321 (0.925)	***	[0.196;0.446]
	Environment	0.305 (0.917)	***	[0.174;0.436]
	Waste	0.166 (0.795)	***	[0.079;0.253]
	Accident	0.164 (0.597)	***	[0.092;0.236]
	Example	0.228 (0.839)	***	[0.121;0.335]
Perceived behavioural control	Amount	0.136 (0.461)	***	[0.079;0.193]
	Frequency	0.053 (0.875)	*	[0.004;0.102]
	Ability	0.529 (0.868)	***	[0.446;0.612]
	Ease	0.537 (0.319)	***	[0.458;0.616]
Lack of habit	Other coll. Point	-0.390 (0.648)	***	[-0.472;-0.308]
	Back-up	0.269 (0.648)	***	[0.170;0.368]
	Resell	-0.108 (0.193)	**	[-0.191;-0.025]
	Efficiency	**0.091 (0.408)**	**NS**	**[-0.004;0.186]**
	Forget	0.760 (0.889)	***	[0.664;0.856]
Perceived policy effectiveness	How	0.223 (0.891)	**	[0.074;0.372]
	Why	0.244 (0.867)	***	[0.117;0.372]
	Push	0.355 (0.894)	***	[0.237;0.473]
	Facilitate	0.319 (0.853)	***	[0.223;0.415]

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