CATALYSING WATER SAVING BEHAVIOURS IN AUSTRALIAN URBAN HOUSEHOLDS

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To mum and dad,
for their love and support,
and Camellia, my PhD baby.

In Memoriam
Stanley Donald Kneebone
1928 - 2018

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Abstract

In response to population growth and fluctuations in freshwater availability caused by climate change, water managers around the world are implementing techniques to influence consumer use of water resources. These methods range from high-level policies around pricing structures, to community engagement communication strategies. In Australia, multifaceted programming applied during the millennium drought successfully encouraged householders in some regions to halve their daily water consumption. However, the country's growing population and climatic context means that new approaches to water demand management are essential to safeguard water supplies into the future.

Australia's householders consume a significant proportion of water resources and are an important stakeholder to engage with water conservation. There are many behaviours householders may adopt to reduce their water consumption, from curtailment of water usage practices, to adoption of efficient devices, to maintenance of water use systems. To facilitate the development of focussed and effective behaviour change interventions, water managers must select which behaviours to target. Such decision making requires frameworks to select priority behaviours, and methods of catalysing rapid behaviour adoption to maximise impact.

The spillover effect has been proposed as a way of accelerating behaviour change, leveraging additional behaviour adoption from participation in new or existing behaviours. This has the potential for creating more change in a shorter amount of time, ideal for applying to the complex global issues facing humanity, including water management. Previous research has explored a range of possible mechanisms that may influence the likelihood of spillover occurring, one of which is behavioural similarity. However, perceived similarity of behaviours is currently poorly understood.

Within this context, this PhD thesis aimed to *identify water conservation behaviours for adoption at a household level* for consideration by water managers, *develop and test a prioritisation tool to facilitate behaviour selection for behaviour change program design* and *identify potentially catalytic behaviours, to facilitate operationalisation of spillover theory*.

The first phase of the research began by identifying 46 household water conservation behaviours of potential use for future demand management programming. Second, householders and water professionals were asked to assess each of these behaviours on the perceived impact on water saving, the likelihood of behaviour adoption, the key barriers to adoption and existing participation rates. These data were used to develop and test a tool to facilitate behaviour selection and prioritisation, by mapping behaviours into a decision making frame, the impact-likelihood prioritisation matrix. The third phase of research explored householder perceptions of behavioural similarity, as an underlying mechanism of spillover effect. Finally, study data were synthesised, creating similarity-prioritisation maps to identify potentially catalytic behaviours, including pathways of multiple potential catalytic behaviours, providing guidance for water managers selecting optimal behaviours for demand management programming.

This thesis provides a practical approach for behaviour identification, prioritisation and selection of water conservation behaviours, while making a theoretical contribution to knowledge around perceived similarity and the spillover effect. Identification of catalytic behaviours could provide an important step for the operationalisation of spillover and the further investigation of this intriguing and potentially powerful approach to behaviour change.

Publications during enrolment

Academic publications

Kneebone, S., Smith, L., & Fielding, K. (2017). *The Impact-Likelihood Matrix: A policy tool for behaviour prioritisation*. Environmental Science & Policy, 70, 9-20.

Kneebone, S., Fielding, K., & Smith, L. (2018). *It's what you do and where you do it: Perceived similarity in household water saving behaviours*. Journal of Environmental Psychology, 55, 1-10.

Kneebone, S., Smith, L., & Fielding, K. (2018). Comparing perceptions – under review

Reports

Kneebone, S. & Smith, L. (2013) *Review: Behaviours for reducing individual and collective water footprints*. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.

Ramkissoon, H., Smith, L., & Kneebone, S. (2014). *Accelerating transition to water sensitive cities. Behaviour Assessment Database*. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.

Wright, P., Dean, A., Kneebone, S. & Smith, L. (2016). *Behavioural Roadmap: Prioritising water saving behaviours in households using measurements of impact and likelihood*. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.

Conference Presentations

Kneebone, S. (2015) *Can water saving behaviours spill over in Australian households through 'spillover'?* Poster presented at the 2nd Water Sensitive Cities Conference, Brisbane, Australia, 8-9 September, 2015.

Kneebone, S. (2016) *Ways to save water: Prioritising behaviours by impact and likelihood*. Making Cities Liveable Conference, Melbourne, Australia 27-28 June, 2016.

Kneebone, S. (2016) *Influencing Water Use: Using Behavioural Science To Manage Household Water Demand*. Presentation at the International Water Association World Water Congress & Exhibition. 9-13 October, 2016, Brisbane, Australia.

Kneebone, S., Fielding, K., & Smith, L. (2017). *They're all saving water, but how similar are they really? Assessing householder perceptions of similarity of water conservation behaviours.* Presentation to the Society of Australasian Social Psychologists Conference, 2017.

Other

Kneebone, S. (2017). The Impact Likelihood matrix. www.youtube.com/watch?v=89nX7_5iIlY

Kneebone, S. (2017). Similarity, spillover and water-saving behaviours. https://youtu.be/Rv-NwgwJAZQ

Thesis including Published Works General Declaration

I hereby declare that this thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

This thesis includes two original papers published in peer reviewed journals and one publication currently under review. The core theme of the thesis is the development of a process for identification and prioritisation of household water conservation behaviours to develop effective campaigns for water demand management. The ideas, development and writing up of all the papers in the thesis were the principal responsibility of myself, the candidate, working within the Monash Sustainable Development Institute under the supervision of Associate Professor Liam Smith and Associate Professor Kelly Fielding (University of Queensland).

The inclusion of co-authors reflects the fact that the work came from active collaboration between researchers and acknowledges input into team-based research.

In the case of chapters 3, 4 and 5 my contribution to the work involved the following:

Thesis chapter	Publication title	Publication status*	Nature and extent (%) of students contribution
3	Kneebone, S., Smith, L., & Fielding, K. (2017). The Impact-Likelihood Matrix: A policy tool for behaviour prioritisation. Environmental Science & Policy, 70, 9-20.	Published	Formulation of the research problem, research design, data collection and analysis, interpretation of results, writing the paper: 90%
4	Kneebone, S., Smith, L., & Fielding, K. (2018). Whose view do we use? Comparing expert water professional and lay householder perspectives on water saving behaviours. Urban Water Journal.	Under review	Formulation of the research problem, research design, data collection and analysis, interpretation of results, writing the paper: 90%
5	Kneebone, S., Fielding, K., & Smith, L. (2018). It's what you do and where you do it: Perceived similarity in household water saving behaviours. Journal of Environmental Psychology, 55, 1-10.	Published	Formulation of the research problem, research design, data collection and analysis, interpretation of results, writing the paper: 90%

I have not renumbered sections of submitted or published papers in order to generate a consistent presentation within the thesis.

Student signature: [redacted] **Date:** 5th July 2018

The undersigned hereby certify that the above declaration correctly reflects the nature and extent of the student and co-authors' contributions to this work.

Main Supervisor signature: [redacted] **Date:** 5th July 2018

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Chapter 1: Introduction

1.0 Motivation: The global water context and the need for catalytic behaviour change

> *Don't be distracted by the myth that* "every little helps."
> *If everyone does a little, we'll achieve only a little.*
> *We must do a lot.*
> David MacKay (2008)

Water is essential to life on earth, supporting healthy ecosystems, human health and economic development (Connor, 2015). Clean water underpins most, if not all, of the 17 Sustainable Development Goals (SDGs) adopted by the 193 members of the UN General Assembly in September 2015. Without clean water and sanitation, and protection of aquatic ecosystems, we may not be able to achieve progress in ensuring an equitable society and economic development (Folke et al., 2011). However, the risks to water access are numerous (United Nations, 2018). Climate change impacts on rainfall patterns are predicted to increase global water scarcity and affect water access for millions of people (Gosling & Arnell, 2016). Recent drought conditions have reduced the harvest, creating economic losses in California (Howitt et al., 2014), driven mass water-consumption reduction campaigns in South Africa (Brick, Martino & Visser, 2017), and exacerbated the effect of civil war in Syria and Yemen (Gleick & Heberger, 2014).

Global population growth drives increasing exploitation of water supplies through direct and indirect consumption of water resources. Growing numbers of households consume water directly for drinking, food preparation, and bathing, which are essential for health (WHO/UNICEF, 2017). The need for food and fuel drives indirect water consumption through production processes (e.g. Endo, Tsurita, Burnett, & Orencio, 2017; Leck, Conway, Bradshaw & Rees, 2015). Developing tools and methods to assist countries to manage their water resources, despite climatic change and ensure adequate supplies for growing populations, is therefore of utmost importance.

The development of new technologies has expanded water supply options (Rutherford & Finlayson, 2011), but none of these is risk-free (see section 1.4). Managing consumption of water supplies to ensure their sustainability is vital (Gleick, 1996; Vörösmarty et al., 2000). To this end, policy-makers must incorporate demand control measures, ensuring effective use of water supplies (Baroudy, 2005) and offsetting requirements for potentially costly large supply schemes (Rutherfurd & Finlayson, 2011). It is within this context that water managers have been applying techniques from behavioural science to design and implement interventions that influence the behaviour of water consumers to assist the sustainable use of water resources (e.g. Hamilton, 1985; Renwick & Archibald, 1998; Howarth & Butler, 2004; Walton & Hume, 2011; LaFrance, 2018).

Behaviour change program design usually calls for the identification of individual behaviours to target, to enable selection of the appropriate theoretical approaches and intervention types (Johnston & Dixon, 2008; Michie, Van Stralen & West, 2011). Some water demand management programs have adopted this approach to create highly targeted interventions (e.g. Manning et al., 2013). However, this approach has been criticised for being slow and inefficient, creating at best incremental change and modest improvements in existing situations (Crompton, 2008; Pelletier et al., 1999). The geographic and temporal scale of the water security issue, and indeed many of the issues described within the Sustainable Development Goals, means that change is needed urgently (Griggs et al., 2013). Achieving such change requires wholescale shifts in patterns of consumer behaviour (Oskamp, 2000; Jackson, 2005). Programs must be efficient and effective and overcome barriers to behaviour participation (Gifford, 2011). Policies developed around behaviour change must be designed to maximise meaningful outcomes to address the key social, environmental and economic challenges of the era (Dolan & Galizzi, 2015).

The need for accelerated behaviour change to tackle such significant problems has resulted in increasing interest within the literature into ‘catalytic’ behaviours and mechanisms (e.g. Nilsson, Bergquist, & Schultz, 2017; Lacasse, 2016; Carrico, Raimi, Truelove & Eby, 2017). Catalytic behaviours are those that increase the likelihood of subsequent behaviour adoption through the spillover effect (Thøgersen, 1999; Thøgersen & Ölander, 2003, Thøgersen, 2004). The spillover effect describes the phenomenon whereby participation in a behaviour creates a (psychological) change which further triggers the uptake of additional behaviour(s) beyond those initially targeted (Thøgersen, 1999; Thøgersen & Ölander, 2003). The premise is that by identifying and promoting catalytic behaviours which generate further behaviour change by the consumer, policy makers and practitioners can speed-up the adoption of pro-environmental behaviours (Thøgersen & Crompton, 2009; Austin, Cox, Barnett & Thomas, 2011; Truelove et al., 2014). Accelerated change is essential given the scale and urgency of tackling global problems. In particular, the spillover effect presents an opportunity to create impactful behavioural solutions to the issues of water security, consumption and conservation of resources (Crompton, 2008; Dolan & Galizzi, 2015). The identification of catalytic behaviours could provide policy-makers with a framework to apply and promote the rapid change needed (Crompton, 2009; Dolan & Galizzi, 2015).

The spillover effect is proposed to occur when consumer participation in an initial behaviour catalyses additional behaviours. Various underpinning mechanism have been suggested, including ‘foot-in-the-door’ (Freedman & Fraser, 1966), changes in self-perception (Bem, 1967), coupled with a desire for consistency (Thøgersen, 2004; Thøgersen, 2012, Thøgersen & Noblet, 2012), increased knowledge or skills (Bandura, 1977; Thøgersen & Crompton, 2009), or activation of personal values (Thøgersen & Ölander, 2003; Verplanken & Holland, 2002; Carrico et al., 2017). Thus far, the psychological mechanisms that invoke spillover-type behavioural change have undergone only limited empirical investigation (Austin, Cox, Barnett & Thomas, 2011; Poortinga, Whitmarsh & Suffolk, 2013, Thøgersen & Crompton, 2009; Thøgersen & Noblet, 2012). Researchers acknowledge that further research is required, both to investigate the concept of spillover, the existence of catalytic behaviours, and the mechanism(s) that facilitate spillover from one behaviour to another (Thøgersen & Crompton, 2009; Austin et al., 2011, Truelove et al., 2014; Nilsson, Bergquist & Schultz, 2017).

This thesis discusses how spillover can be used to tackle issues around water consumption to ensure sustainability of supplies. First, spillover and its underpinning mechanisms will be presented, including the potential role of perceived similarity in identifying catalytic behaviours. Second, the water context will be further explored, with the research objectives emerging from this background. Finally, the research questions and research approach will be established along with the overall thesis structure.

1.1 Spillover and its mechanisms

The spillover effect relates to behaviours being triggered (or not in the case of negative spillover) due to participation in a previous behaviour. Positive spillover increases the likelihood of a second (or additional) behaviours being adopted following engagement with an initial behaviour (Thøgersen, 1999; Thøgersen & Olander, 2003). It is proposed as a means to facilitate and accelerate participation in additional (pro-environmental) behaviours to create greater change and thus could be useful as a tool to address the water demand management issues outlined above. However, the spillover effect may work in the opposite direction. Negative spillover occurs when adoption of a behaviour decreases the likelihood of additional participation and therefore reduces the desired outcome overall (e.g. Thøgersen & Olander, 2003; Thøgersen & Crompton, 2009; Truelove et al., 2014). Both types of spillover are described and explanatory mechanism discussed below.

1.1.1 Positive spillover

The mechanisms underpinning positive spillover have undergone investigation since its proposal. The range of mechanisms are illustrated in Figure 1, identifying the proposed mediators between 'Behaviour A' and 'Behaviour B' (Thøgersen, 2012). Although considerable work has been and is still being undertaken to better understand the role of potential spillover mechanisms, the diagram is theoretical, describing possible relationships whilst not being wholly based on empirical evidence. However, it provides a useful summary from which to further explore the theoretical basis for positive spillover (Nash et al., 2017).

The first mechanism suggested, priming or activating pro-environmental goals and values, has been shown to increase pro-environmental attitudes and related decision making (Schultz & Zelezny, 1998; 1999). Goals themselves are in turn influenced by personal needs, desires, attitudes and values (Austin & Vancouver, 1996), and vary in both their intensity (i.e. their perceived importance or commitment to them) and type (i.e. difficulty, specificity, complexity) (Locke & Latham, 2002). They can be defined within a hierarchy, from abstract concepts, e.g. ‘be more environmentally friendly’ to more concrete, specific actions, such as ‘take a 4 minute shower’ (Carver & Scheier, 2001). Participation in behaviours that contribute to goal achievement is more likely for goals that are specific and challenging, and produce immediate clear feedback on how the behaviour contributes towards goal attainment (Locke & Latham, 2013). As an individual participates in behaviour(s) that help achieve a goal, the goal itself may increase in salience (Homburg & Stolberg, 2006) and potentially encourage the adoption of additional behaviours that will also contribute towards goal attainment (Verplanken & Holland, 2002; Glasman & Albarracín, 2006), resulting in spillover.

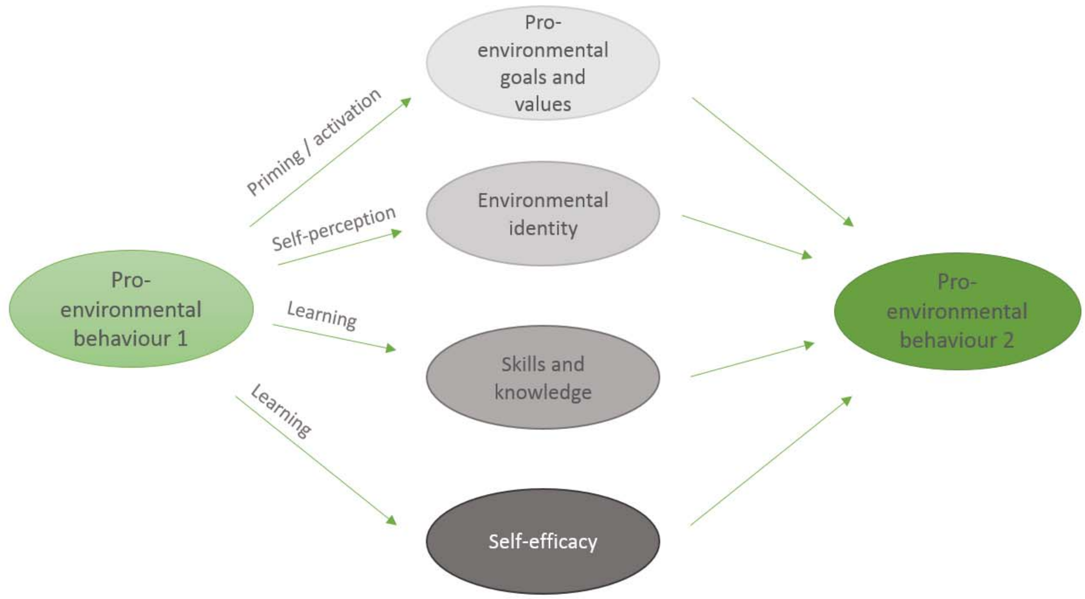

Figure 1: Psychological mechanisms proposed to underpin positive spillover effect (adapted from Thøgersen, 2012)

The second mechanism illustrated in Figure 1 involves self-perception and environmental identity. Self-perception encompasses the mechanism of self-identity but self-efficacy could also be thought of as an aspect of self-perception as well (Lauren, Smith, Louis & Dean, 2017). Environmental self-identity impacts on the likelihood of engaging in environmental behaviours (Whitmarsh & O'Neil, 2010) and reminders of past performance of environmental behaviour have been found to influence environmental self-identity (van der Werff, Steg & Kaiser, 2014). Recent work on environmental self-identity and spillover supports this idea; study participants reminded of previous participation in pro-environmental behaviours reported an increase in environmental self-identity (Lacasse, 2016). In addition, participants labelled as 'environmentalists' within the study conditions reported even stronger environmental self-identity and indicated increased support for climate change-related policy (Lacasse, 2016). Similar findings emerge from a study where students reminded of previous engagement in pro-environmental behaviours, reported an increase in their environmental self-identity and increased levels of intention to perform pro-environmental behaviours (Lauren et al., 2017). Some research has shown that political identity may moderate the effects of self-identity. In a study examining spillover from water bottle recycling to support for an environmental fund, Republican participants exhibited negative spillover between the two behaviours (Truelove, Yeung, Carrico, Gillis & Faimi, 2016). Self-identity is therefore a complex area of relevance to investigations of both positive and negative spillover.

The third hypothesised route within Figure 1 involves the interaction between gaining skills and knowledge necessary to enact a behaviour and self-efficacy (i.e. the belief that one is able to enact a behaviour). An important part of acquiring skills and knowledge is ensuring that the information required for successful participation in target behaviours is easily accessible and cognitively available. This 'cognitive accessibility', relates to the frequency of reflection or thought about the process of behaviour participation (Schley & Dekay, 2015), and impacts the adoption of further pro-environmental behaviours through spillover (Sintov, Geisler & White, 2017). In addition to access to adequate information provision, participation in some pro-environmental activities may require a skill that improves with practice. As individuals become more competent at performing a behaviour, the perceived ability to carry out another may be increased, through increased motivation and cognitive ability (Bandura, 1977; Bandura, 2002). For example, consumers are more likely to adopt a new eco-label if they are already practiced in using other eco-labels (Thøgersen, Haugaard, & Olesen, 2010). Gaining and utilising competence in behaviour performance has been suggested as an important motivator for additional behaviour adoption (De Young, 2000; Bandura, 2002). Research into past performance of water saving behaviours has found that personal perceptions of competence, i.e. self-efficacy, can act as a mediator between easy past behaviours and the intention and self-reported adoption of more difficult (and impactful) future behaviours, independent of pro-environmental identity (Lauren, Fielding, Smith & Louis, 2016).

The mechanisms relating to self-perception and consistency are of particular interest in this thesis and are the focus of further discussion. The foot-in-the-door (FITD) effect (Freedman and Fraser, 1966), linked to both self-perception theory (Bem, 1967), as discussed above, and the drive for individuals to see themselves, and be seen by others, as consistent (Festinger, 1957). Foot-in-the-door was initially investigated by researchers interested in the idea that compliance with a small request may catalyse compliance with a more demanding request (Freedman and Fraser, 1966). They found that householders who agreed to an initial small request to sign a petition or display a notice, about road safety or reducing littering, were more than twice as likely to agree to a second more substantial request, to display a large sign in their garden, than the control group (48% versus 17%) (Freedman & Fraser, 1966). The highest level of compliance was obtained when the two requests were similar in some way, either by the topic selected or the type of task requested.

The core idea within the theory of self-perception, a potential explanation for FITD, is that an individual may observe their behaviour and extrapolate from their behaviours to learn about their attitudes and values, as noted above. Self-perception theory was developed in response to Festinger's cognitive dissonance theory to help explain when and how feelings of dissonance arise (Bem, 1967). Further work suggests that individual's knowledge of their previous experience could act as a motivator for decisions about future behaviour, i.e., they could use awareness of their own actions as a heuristic to simplify future decision-making (Taylor, 1975). It has also been suggested that participants' perceptions of past behaviours also affects decisions about whether to repeat behaviours in the future (Albarracín & Wyer, 2000).

From a water conservation or pro-environmental perspective in general, self-perception theory allows for the development of pro-environmental attitudes from engagement in pro-environmental behaviours (Cornelissen, Dewitte, Warlop & Yzerbyt, 2007). More positive pro-environmental or water saving attitudes may then, in turn, influence future behaviour (Cornelissen, Pandelaere, Warlop, & Dewitte, 2008). That is, engaging in one behaviour may shift individuals' perception of themselves from '*I am someone who does not engage in pro-environmental behaviours'*, to '*I am someone who does engage in pro-environmental behaviours*'. It may also increase the ongoing enactment of that behaviour so that it becomes persistent or, if taking place within a stable context, habitual (Oulettte & Wood, 1998; Holland, Verplanken & Van Knippenberg, 2002).

Another potential mechanism to explain spillover also originates from cognitive dissonance theory. This model evolved from the observation that individuals in situations where they held conflicting personal beliefs, attitudes and/or behaviours, often altered one or all of these; ostensibly in an effort to reduce a sensation of discomfort triggered by these discrepancies (Festinger, 1957). Festinger argued that "*[t]he holding of two or more inconsistent cognitions arouses the state of cognitive dissonance, which is experienced as an uncomfortable tension. This tension has drive-like properties and must be reduced*" (quoted in Cooper, 2007, p. 7). In other words, people generally prefer consistency within, or between, their personal beliefs, attitudes and/or behaviours, to inconsistency in their thoughts and behaviours (Cooper, 2007). Acting inconsistently with previous behaviours or values generates a feeling of tension or unease. This sensation of tension has been shown to be a physiologically measurable state of arousal (Croyle & Cooper, 1983) that is discomforting, or feels unpleasant (Eliott & Devine, 1994). Studies into the feeling of cognitive dissonance have found that this unpleasant feeling can provide a motivation for changing attitudes and beliefs (Festinger & Carlsmith, 1959), and behaviours (Stone et al., 1994).

Cognitive dissonance has been utilised as a theory for behaviour change, particularly in the health and environmental fields. Researchers have triggered the tension of dissonance in study participants by creating a perceived inconsistency, or sensation of hypocrisy, between participants' personal attitudes and behaviours undertaken through the course of the study (Dickerson, Thibodeau, Aronson, & Miller 1992; Fointiat, 2004; Stone et al., 1994). For example, in one study promoting safe sex, researchers asked sexually active university students to present a speech on safe sex for use as a teaching tool. The students were then reminded of explanations given for not using condoms and asked to think of past experiences of not using condoms; thus inducing a feeling of hypocrisy. Following this, they were invited to purchase condoms before leaving. Over 80% of participants from the induced-hypocrisy condition bought condoms, compared with less than 50% of participants in non-hypocrisy conditions (Stone et al., 1994).

In another example, at a public swimming pool, researchers used a multiple condition approach whereby swimmers were randomly allocated to one of four conditions. In the '*mindful*' condition, swimmers were asked about their water saving values and which of their prior personal actions might have led to water waste. In the '*commitment*' condition, participants were asked to sign a pledge committing to help water conservation efforts through turning their shower off while 'soaping up'. In the '*hypocrisy*' condition, participants received the questions and the petition; i.e. being asked to remember previous behaviours that did not match with their stated values. Participants in the hypocrisy condition were more likely to turn the shower off when soaping up, as per their pledge, than participants in the other conditions (Dickerson et al. 1992).

Cognitive dissonance has therefore been successfully operationalised as a model or method of behaviour change, when a feeling of hypocrisy can be induced under particular conditions (e.g. studies from Kantola, Syme & Campbell, 1984; Dickerson et al., 1992; Stone et al., 1994; Fointiat, 2004;). However, the dissonance experienced, and thus the motivation for change, may vary from individual to individual, depending on personal preference for consistency (Cialdini, Trost & Newsome, 1995; Guadagno, Demaine, & Cialdini, 2001).

1.1.2 Negative spillover

The mechanisms described above have been suggested to explain positive spillover, a potential tool to facilitate adoption of additional (pro-environmental) behaviours to create greater change and thus address the water demand management issues outlined (Section 1.0). However, the spillover effect may also work in the opposite direction. Negative spillover occurs when adoption of a behaviour decreases the likelihood of adopting other behaviours and therefore reduces the desired outcome overall (e.g. Thøgersen & Olander, 2003; Thøgersen & Crompton, 2009; Truelove et al., 2014). Research on Danish shoppers, for example, found they were less likely to reduce their consumption of packaging when they recycled at home (Thøgersen, 1999). Likewise, consumer purchases of organic food correlated with lower personal participation in public transport (Thøgersen & Olander, 2003). It has been suggested that the co-occurrence of negative spillover alongside positive spillover could explain the slow progress of pro-environmental behaviour adoption (Thøgersen & Olander 2003).

Negative spillover has also been explained through a number of different mechanisms, such as the contribution ethic, single action bias, moral licensing effects and rebound effects. Contribution ethic describes the situation whereby having performed one behaviour an individual may feel they have ‘done their bit’, e.g. for the environment, and thus resist further engagement (Thøgersen & Crompton, 2009). The contribution ethic may have implications for the maintenance of behaviour change in the long term; once consumers have participated in a behaviour for a given period, they may consider their contribution sufficient. Certainly, longitudinal studies on interventions to encourage adoption of water conservation behaviours have found participation rates decrease over time (Fielding et al., 2013). In one example, water savings initially produced from using a shower alarm decreased until water consumption returned to pre-installation levels (Stewart, Willis, Panuwatwanich & Sahin, 2012,).

Contribution ethic may also affect the pattern or order in which behaviours are adopted. As consumers seem to prefer to engage with simple or easy, potentially low impact, behaviours ahead of more difficult (and meaningful) behaviours (Diekmann & Preisendörfer, 1998), the contribution ethic could preclude high impact behaviours from ever being adopted (Thøgersen, 2012). The single action bias is akin to contribution ethic, and applies where non-participation is justified when two activities with the same end goal are seen as equivalent and substitutable.

This means the consumer does not feel obligated to participate in multiple contributory behaviours, even when multiple behaviours would be appropriate (Weber, 2006; Truelove et al., 2014; Nash et al., 2017).

Similar to contribution ethic and single action bias, moral licensing refers to the discounting of the moral obligation to perform in a certain (e.g. pro-environmental) way, through adoption of a particular behaviour perceived to be 'moral' (Thøgersen & Crompton, 2009). That is, people do not feel obliged to act morally once that have already enacted a moral activity. One study in Sweden examining householders' purchase and use of electric vehicles found they actually increased, rather than decreased, their mileage overall, and their ownership of an electric vehicle reduced their sense of moral obligation to decrease their car use (Klöckner, Nayum, & Mehmetoglu, 2013).

The rebound effect, otherwise known as Jevon's paradox, describes when investment in a resource consumption system produces efficiencies, leading to lowered prices for accessing the resource, resulting in increased consumption of the resource overall (Gillingham, Kotchen, Rapson & Wagner, 2013). This has been observed in households when the installation of energy efficient infrastructure is followed by an increase in energy consumption (Hertwich, 2005). Within the water sector, households with water efficient washing machines have been found to use significantly more water in clothes washing (17%) than households without the efficient device (Fielding, Russell, Spinks & Mankad, 2012). A potential rebound effect has also been observed among household recipients of a free water efficiency kit, found to have increased water consumption, compared to households who had bought and installed their own water efficiency devices (Campbell, Johnson & Hunt Larsen, 2004).

The occurrence and risk of negative spillover has been discussed in some comprehensive reviews (e.g. Thøgersen & Crompton, 2009; Truelove et al., 2014; Nash et al., 2017), and is an important aspect to be considered and assessed throughout attempts to utilise spillover to achieve a specific goal.

1.2 The role of similarity in spillover theory

Many of the factors used to help explain positive spillover, such as foot-in-the-door, self-perception and cognitive dissonance, relate directly to the need for consistency, performing behaviours that align with, or are similar to, previously held attitudes, values, or enacted behaviours. One review of the foot-in-the-door effect and self-perception theory suggested that the perceived similarity of requests was an important component to facilitate compliance, i.e., that one action led to the other when they were seen as similar (Burger, 1999). Further work in this area has also suggested that individuals may be more likely to perform behaviours to achieve a goal or meet personal values if they are seen as similar in some way (Bratt, 1999; Thøgersen, 2004; Thøgersen & Noblet, 2012; Truelove et al., 2014). Work investigating the transference of a particular behaviour from one context to another found greater success when the contexts themselves were similar, i.e., in terms of content and process (Frey, 1993; Littleford, Ryley & Firth, 2014). Certainly, similarity has been identified as a moderating factor for spillover, which may affect the likelihood of spillover taking place (Nilsson, Bergquist & Schultz, 2017). Indeed, perceived similarity of behaviours could have an impact on other proposed mechanisms. Similar behaviours might promote sensations of self-efficacy, potentially requiring similar skills for adoption, clearly contribute towards the same goal, tap into the same value set or self-identity as well as promote a feeling of consistency and avoiding cognitive dissonance. However, until we understand behavioural similarity or have a process through which we can diagnose behavioural similarity, these hypotheses cannot be tested.

Investigation of the perceptual relationship between behaviours and the dimensions of similarity used by consumers could assist in the identification of catalytic behaviours and thus increase the likelihood of spillover taking place, triggering faster, or more effective, uptake of additional behaviours (Thøgersen, 2004; Nilsson, Bergquist & Schultz, 2017). However, assessment of similarity has been challenging (Burger, 1999). The original Freedman & Fraser (1966) study relied on the researchers' own subjective perceptions of whether the requests made of householders were similar, rather than a definitive measure to determine the requests' similarity.

If, as suggested, perceived similarity of behaviours is an important aspect of 'catalysing' further behaviour change, investigating perceptions of similarity between behaviours, and gaining an understanding of which characteristics of behaviours affects perceptions of similarity, is important (Nilsson, Bergquist & Schultz, 2017). Potentially, if individuals do not perceive two behaviours as subjectively similar, the mechanisms for spillover may not be triggered and thus spillover may not occur (Thøgersen, 2004). Understanding individual perceptions of similarity (or dissimilarity) between existing and target behaviours is therefore central to the development of spillover-focussed interventions and thus the operationalisation of spillover theory (Truelove et al., 2014).

Householder perceptions are not the only ways to investigate similarity. A more objective assessment of similarity between two behaviours could be carried out based on the presence or absence of behavioural characteristics. Ajzen and Fishbein (1980) defined behaviours as ‘observable acts studied in their own right’, each with specific, defining elements or characteristics including action, target, context and time (Ajzen & Fishbein, 1980). Behaviours may therefore be grouped into categories on the basis of one or more of these objective characteristics (Thøgersen, 2004; Thøgersen & Crompton, 2009). Another characteristic of interest may be the cost of behaviour participation, including the actual or perceived temporal, physical and cognitive effort involved in adopting a behaviour (Steg & Vlek 2009).

Research on energy conservation behaviours suggests behaviour type might form a useful categorisation structure, depending on whether behaviours involve installation of new technology or systems (efficiency) or modification of the frequency or length of resource use (curtailment) (Karlin et al., 2014). Stern’s (1999) categorisation of pro-environmental behaviours, assessing activities in terms of impact, from influence to activism, could be another route to understanding similarity. This categorisation has also been suggested as a way for an individual to track their ‘progress’ via adoption of specific behaviours, towards more meaningful pro-environmental action (Thøgersen & Crompton, 2009). Research has suggested that perceptions of similarity may differ markedly from one individual to another (Thøgersen, 2004) and may be affected by personal levels of knowledge or identity relating to the behavioural context (Austin et al., 2011; Truelove et. al., 2014).

In general, relatively little research has been carried out on similarity assessments of any behaviours, including pro-environmental behaviours (Thøgersen, 2012). Even less is known about perceptions of similarity of water-saving behaviours in particular, and thus which might be considered as catalysts for encouraging behavioural spillover. Investigation into how such behaviours are perceived is needed before the impacts of similarity on spillover can be assessed (Truelove et al., 2014). Understanding perceptions of behavioural similarity is therefore an important step towards the operationalisation of spillover (Poortinga, Whitmarsh & Suffolk, 2013; Truelove et al., 2014; Nilsson, Bergquist & Schultz, 2017).

If catalytic behaviours increase the likelihood of behavioural spillover, they would be ideal targets to prioritise for accelerated behaviour change. Gaining an insight into which behaviours are seen as similar could therefore provide a clear pathway for behavioural selection. From a broader perspective, this could also provide a vital step into the further investigation of spillover as a behaviour change tool. Considering the need for wholescale shifts in human behaviours to tackle, not just water security, but many complex issues, understanding catalytic behaviours and processes could make an important contribution to achievement of the sustainable development goals. Within the water context, developing a process to assess behavioural similarity and identify catalytic behaviours could have significant benefits for water managers needing to develop behvaiour change programs for demand management. The research described in this thesis therefore aims to examine water conservation behaviours and identify leverage or catalytic behaviours through investigating perceived similarity of household water saving behaviours.

1.3 Context for the study: Water in Australia

Australia is the driest inhabited continent on earth and rainfall patterns can be unpredictable and unreliable (Pigram, 2007; Potter, Mackinnon, McKenzie & McKay, 2007; Prosser, 2011). High average temperatures mean precipitation runoff rates in Australia are some of the lowest in the world; only 9-12% of total rainfall volume remains to recharge aquifers or rivers and thus become available for human consumption (Heberger, 2011; Prosser, 2011). Australia's exposure to El Niño and La Niña climatic events results in cyclical drought and flood conditions (Chiew, Piechota, Dracup & McMahon, 1998). For example, from 1996 – 2010 large areas of the country, including the south Murray-Darling basin, Victoria, South West Australia, and South East Queensland, were afflicted by severe drought (Bureau of Meteorology, 2015).

This drought event, known as the 'Big Dry', or 'Millennium Drought' (Heberger, 2011), saw rainfall decrease by 13% in some areas, reducing streamflow by up to 44% (CSIRO 2010). By April 2007, the dams supplying populous South East Queensland were at 19.5% capacity (Walton & Hume 2011), while Melbourne's water storages reached a record low of 25.6% in June 2009 (Melbourne Water, 2009). The drought eventually broke, in some areas with damaging flooding (Van den Honert & McAneney, 2011). However, Australia's climate means future drought events are expected, indeed at the time of writing, central and western New South Wales and northwest Victoria are experiencing much lower rainfall than expected (Bureau of Meteorology, 2018)

Climate projections suggest average temperatures will increase by 0.5 – 1.8^{o}C by 2090, with more frequent, and hotter, hot days, more intense extreme rainfall events, fewer wet years and more dry years (CSIRO & Bureau of Meteorology, 2014). Increased evapotranspiration is also predicted, leading to reduced runoff, lower river levels, and decreased water avaliability for human consumption (Sherwood & Fu, 2014). Western Australia, in particular around Perth, has already experienced fundamental ‘step changes’ in rainfall patterns since records began, with long-term decreases in annual precipitation (Delworth & Zeng, 2014).

In addition, Australia’s population is forecast to increase from 24 million to 46 million people by 2075 (Australian Bureau of Statistics, 2013a), essentially doubling the population of Sydney, Melbourne, Perth and Adelaide (Gregory & Hall, 2011). More residents will require more water, placing increasing demands on water supplies (Gregory & Hall, 2011) and amplifying the potential reduction in water supply from climate change (Sherwood & Fu, 2014).

Australia has traditionally met its growing population’s water requirements with dam and reservoir construction or through tapping into existing groundwater aquifers (Cathcart, 2010; National Water Commission, 2012). This approach has resulted in the highest water storage capacity per person in the world (Australian Bureau of Statistics, 2010). However, the economic and environmental costs of dams (Pigram, 2007; Kingsford, 2000; Kingsford & Thomas, 2004) and their vulnerability to decreased stream flow (Water Services Association of Australia, 2013) limits their further utility. Groundwater reserves are still relatively poorly understood (Herczeg, 2011) and aquifer recharge is also predicted to be negatively affected by reduced runoff resulting from climate change (Barron et al., 2010).

New technologies have expanded water supply options to include desalination, the capture and reuse of stormwater, and recycling sewage wastewater (Rutherford & Finlayson, 2011). However, the roll-out of these methods is restricted by their high economic cost and energy requirements (Kenway et al., 2008; Cook, Hall & Gregory, 2012), the potential for environmental degradation (e.g. Flower, Mitchell & Codner, 2007; Kingsford, 2000; Kingsford & Thomas, 2004), the need for largescale infrastructure changes (Palmer, 2010), and perceived (un)acceptability of the water produced by household consumers (e.g. Po, Nancarrow, & Kaercher, 2003; Dolnicar & Hurlimann, 2010a). These limitations should not be underestimated. In Toowoomba, Queensland, the community rejected a $23 million wastewater recycling scheme that would fulfil their potable water requirements, despite having empty reservoirs at the time of the referendum (Hurlimann & Dolnicar, 2010).

1.4 Water consumption by Australian households

The limitations of water supply diversification, and the need for resource management, support the need for research into reducing water consumption. Currently, Australia's agricultural system is the greatest consumer of water, using 58% of total extracted freshwater in 2015-2016 (Australian Bureau of Statistics, 2017), see Figure 2. This is followed by the water supply industry (including water supply, sewerage and drainage) utilising 12% of total extracted water. Mining, manufacturing, energy production and other industries combined use 18% of the total. Households are the joint second largest consumer of water in Australia. Over nine million households consumed 1,899GL of water, 12% of the total freshwater supply, in 2015-2016 (Australian Bureau of Statistics, 2017). In cities, households consume 70-80% of water supplies (Gregory & Hall, 2011). The significance of Australian households, both in terms of the proportion of freshwater resource use and the impact created by continuing population growth, means that they are a particularly important stakeholder in water management planning.

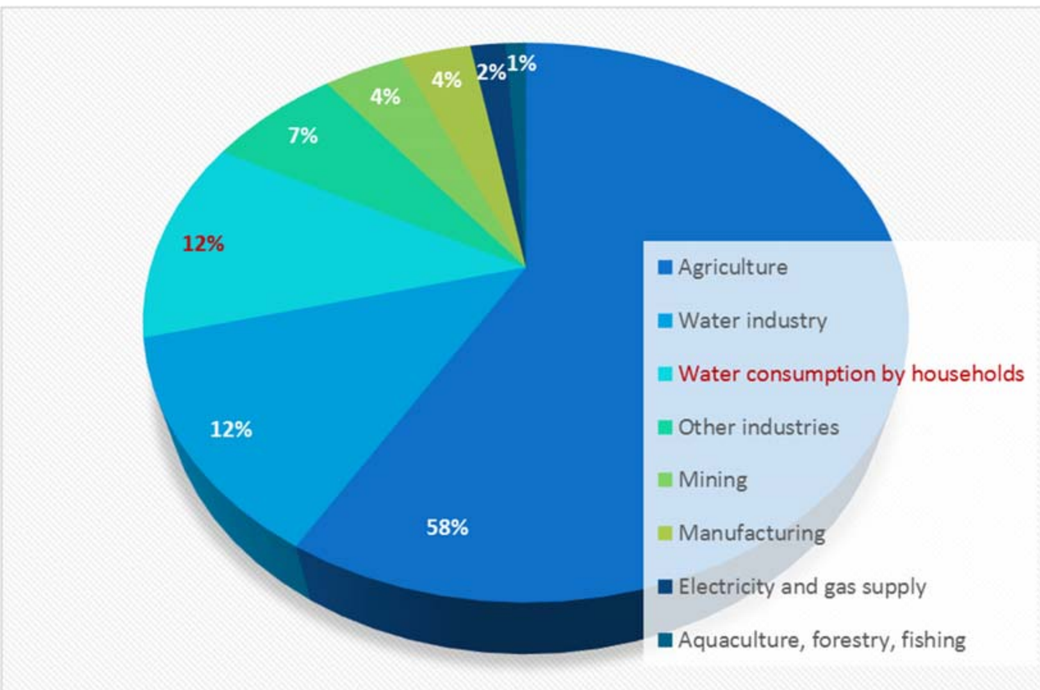

Figure 2: Water consumption in Australia by sector (2015-2016) (Australian Bureau of Statistics, 2017)

Australian household water use patterns have varied greatly over time, from a relatively modest 100 litres per person per day (lpppd) in the mid-nineteenth century to 400 lpppd in the 1940s

(Davison, 2008). Consumption declined up until the 1990s before peaking again with an average household water use of 328 lpppd in 2000-2001. Changes in water availability wrought by the Millennium Drought provided a powerful context for water conservation action. A combination of successful multi-media campaigns promoting voluntary water saving behaviours, water restrictions, policy change and provision of incentives resulted in significant reductions of water consumption by Australian households from 2003 to 2009, see Figure 3 (Turner, White, Beatty & Gregory, 2005; Turner et al., 2010; Grant et al., 2013). In Queensland, daily household consumption dropped from 180 lpppd to 129 lpppd (Walton & Hume, 2011) and Melbourne consumption reduced to under 155 lpppd (Low et al., 2015). The reduction in water consumption seems to have been generated through adoption of a range of different water saving behaviours, rather than the universal adoption of one particularly effective behaviour (Australian Bureau of Statistics, 2013; Ramkissoon, Smith & Kneebone, 2014). This suggests that the water demand management campaigns were not significantly affected by negative spillover, (e.g. through contribution ethic, rebound effects or moral licensing) otherwise the savings realised would presumably not have been achieved.

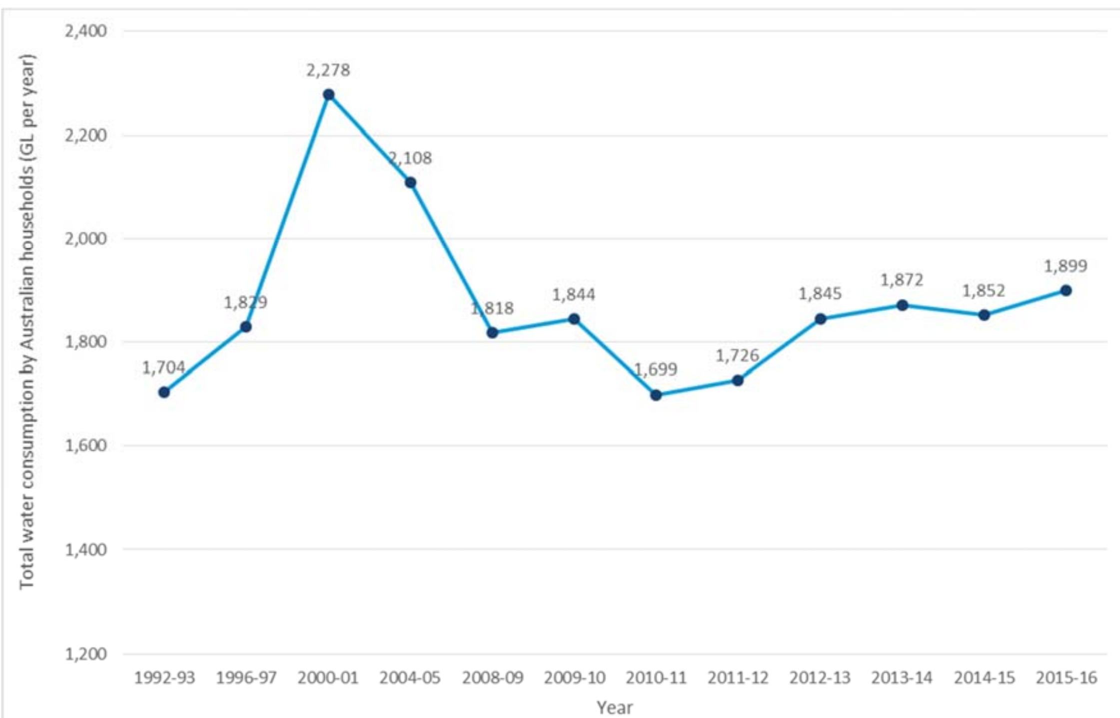

Figure 3: Changes in total water consumed by Australian households over time (GL per year) (Australian Bureau of Statistics, 2017)

Figure 3 illustrates that the amount of water being consumed by households across Australia has increased post-drought. Work from South East Queensland suggests that the removal of restrictions and the cessation of social marketing programs at the end of the drought created a rebound effect, with household water consumption increasing, particularly through increased consumption in the outdoor space, (Beal, Makki & Stewart, 2014). However, the ‘rebounded’ water consumption rates are still not at pre-drought levels. Indeed, much of the increase in household water consumption across the country has been linked to growth in Australia's population and the number of households consuming water overall, rather than individual households increasing their water consumption (see Figure 4) (Australia Bureau of Statistics, 2017). This suggests that, despite changes in the social, environmental and legislative landscape around water consumption, householders may still engage with some demand management activities, compared with their pre-drought water use practices. The need to understand the adoption and continuation, or cessation, of water use practices demonstrates why research into end-use water consumption patterns on an individual household scale is required.

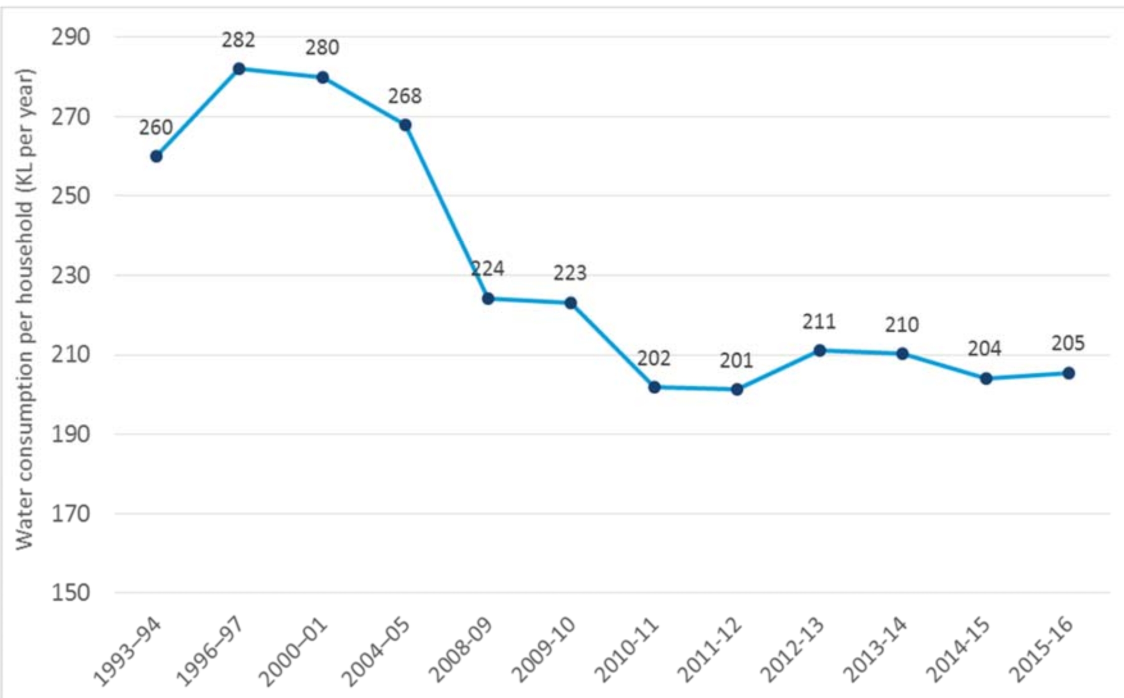

Figure 4: Changes in average annual household water consumption over time (KL per year) (Australian Bureau of Statistics, 2017)

End-use water consumption studies provide valuable insight into how householders allocate water to particular uses, fulfilling particular needs (Giurco et al., 2008; Gan & Redhead, 2013; Loh & Coglan, 2003; Water Corporation, 2010; Willis et al., 2013). This is particularly important in monitoring for the appearance of negative spillover, for example through the rebound effect, contribution ethic and so on, as described in section 1.1. One study examining potential rebound effect through increased water consumption following installation of water efficient washing machine also found that most of the other water efficient technologies investigated, such as low-flow showerheads, low-flow taps, plumbed rainwater tank, pool cover and greywater system resulted in a reduction of water use (although the volume was not necessarily significant) (Fielding, Russell, Spinks & Mankad, 2012). This is clearly an area where more work could be carried out to investigate the presence and impact of negative spillover on water conservation behaviours.

With close examination it is possible to see that indoor water-consumption behaviours use a fairly consistent proportion of total water volume (see Table 1). Showering accounts for the highest proportion of indoor water use, followed by either running a washing machine, turning on taps or toilet flushing. In contrast, water consumed in the outdoor space varies considerably by geographic location. A greater proportion of total water volume is used outside in areas with high temperatures and low rainfall, such as Perth (44% of consumption) and Alice Springs (68% of consumption), as illustrated in Table 1.

Outdoor water consumption has increased through the evolution of the Australian ‘back yard’, from a utilitarian location for the laundry, vegetables and chickens, to a grassed ‘*retreat from the public world*’ (Murphy, 2000), with accompanying changes in perception of the ‘*good life*’ in the 1970’s resulting in a 52% increase in outside water use (Davison, 2008). The high-visibility of water used in the outdoor space has resulted in it being identified as an important target for water conservation campaigns (Syme, Shao, Po & Campbell, 2004; Head, 2008), with the potential to influence social norms more readily than more private and unknown indoor behaviours (Cary, 2008; Miller & Buys, 2008).

Table 1: Proportion (%) of household water consumed, by activity and location.

	Location				
	Melbourne (winter 2010)[1]	**Melbourne (summer 2012)[2]**	**Gold Coast (winter 2010)[3]**	**Perth (winter & summer 2008-2009)[4]**	**Alice Springs (2012)[5]**
Indoor water consumption					
Shower	29.8	26.1	33	25	8
Washing machine	19.7	13	19	7	6
Toilet	17.5	13.1	13	9	6
Taps	16.4	16.3	17	6	5
Bath	2.1	2	4	N/A	N/A
Evaporative air conditioner	0.6	5.2	N/A	4	7
Leaks	5.8	4.3	1	4	N/A
Dishwasher	1.2	0.8	1	1	N/A
Unidentified	3.6	0.4	N/A	N/A	N/A
Proportion of water used indoors (%)	**96.7**	**81.2**	**88**	**56**	**32**
Outdoor water consumption					
Irrigation	3.3	18.3	12	39	65
Hand watering	N/A	N/A	N/A	3	N/A
Pool and spa	0	0.5	N/A	2	3
Proportion of water used outdoors (%)	**3.3**	**18.8**	**12**	**44**	**68**

Domestic water consumption does not occur within a vacuum; household patterns of water use are affected by a substantial list of social, technological and cultural factors (Supski & Lindsay, 2013). Research into the variables impacting water consumption cover three main categories: who is using water (household demographics, personal history, and attitudes), where water is being used (characteristics of the house, location, and neighbourhood) and how water is used (what water-related behaviours householders participate in). For example, larger households use more water in total, but use less water per head than smaller households (Arbués, Villanúa, & Barberán, 2010; Domene & Saurí, 2006). Households with young children have fewer showers (Roberts, 2005; Roberts, 2014), but more baths and clothes washing (Willis et al., 2013; Beal, Stewart, Huang & Rey, 2011), whereas households with teenagers use more water

[1] Gan & Redhead, 2013
[2] Gan & Redhead, 2013
[3] Beal et al., 2011
[4] Water Corporation, 2010
[5] Department of Land Resource Management, 2013

for showers and clothes washing (Beal et al., 2011; Makki, Stewart, Panuwatwanich & Beal, 2013; Willis et al., 2013).

Wealthier households may use more water as a whole (Makki, Stewart, Beal & Panuwatwanich, 2015; Beal et al., 2011), but can also afford to install efficiency devices, thus saving water consumed in the washing machine or through irrigation (e.g. Willis et al., 2013; Guhathakurta & Gober, 2007), and get leaks fixed (Nauges & Thomas, 2000). Households in wealthy neighbourhoods with home owner associations, tend to have larger properties, with larger areas of lawn and high rates of water-using devices such as swimming pools, irrigation systems and evaporative cooling (Mayer et al., 2000; Supski & Lindsay, 2013; Rathnayaka et al., 2014; Landon, Kyle & Kaiser, 2016). Householder attitudes and knowledge have also been linked with water use, with positive attitudes towards the environment and greater knowledge about water generally leading to decreased water consumption and increased participation in water conservation behaviours (Willis et al., 2013; Dean, Fielding & Newton, 2016; Dean et al., 2016), as well as the current context of water availability (Gilbertson, Hurlimann & Dolnicar, 2011).

Differences in household water use practices, involving specific behaviours around water consumption, are an obvious source of variability in water demand. Water consumption is affected by behaviour frequency, i.e. the number of times a behaviour is performed per day, the duration of use, i.e. the time in minutes water is used for that purpose, the volume of water used, and the efficiency of the appliance being used (Stewart et al., 2013). Household water use patterns seem to be consistent with Shove's (2003) pragmatic perspective on household water consumption for "*comfort, cleanliness and convenience*". This means that consumers desire the services water provides, rather than the water itself, to clean clothes and homes, remove waste and create pleasant green landscapes (Gregory & Hall, 2011). Decreasing demand for water therefore relies on maintaining these important services, whilst reducing the volume of water required to do so. Such changes may be brought about through increasing efficiency of use via three main routes: modification to system design, adoption of new technology, or behaviour change (Gregory & Hall, 2011). It is these latter two that are of particular interest within this research project.

1.5 Engaging households with water conservation

As discussed, Australia's current climate, the impact of climate change and the effects of a growing population threaten the sustainability of water supplies. Although a diversification of supply through development of other sources is underway, each option has limitations, whether economic, environmental or in terms of acceptability to consumers. Encouraging the efficient use of water, regardless of the source, is recommended to protect and ensure sustainability of supply (Bates, Kundzewicz, Wu, & Palutikof, 2008). Over the past fifteen years, Australia has utilised a broad array of water-focused policies to engage with all levels of water users to reduce water consumption (England, 2009). As households are one of the major consumers of extracted freshwater in Australia they are an important stakeholder for water demand management programming (Mercer, Christesen & Buxton, 2007; Isler, Merson & Roser, 2010; Dolnicar, Hurlimann, & Grün, 2012).

Methods to influence household water use have typically encompassed top-down policy initiatives such as water restrictions and pricing policies; encouraging household adoption of water efficient appliances, devices and technologies; and initiatives focussed on reducing water consumption through habitual behaviours (Cahill & Lund, 2013; Syme, 2008; Dolnicar, Hurlimann & Grün, 2012). Water restrictions in Australia impose a legal obligation on domestic consumers to change their behaviour in regard to water consumption, with a focus on visible, i.e. outdoor, water use (Cooper, Burton & Crase, 2011). Restrictions are normally imposed on communities when water storage levels reach pre-determined (low) levels; each level determines a particular set of restrictions (Brennan, Tapsuwan & Ingram, 2007). The regulations may include allocating specific days for garden irrigation, compulsory changes in irrigation method (for example, from a hose or sprinkler to hand watering), bans on washing a car or filling a swimming pool with potable water, and prohibiting irrigation at times of the day when evaporation rates are highest (Willis, Pearce, Mamerow, Jorgensen, & Martin, 2013). The universal application of such restrictions has been criticised; domestic consumers who particularly value their gardens and gardening may face welfare costs over and above other residents when water restrictions are imposed (Syme, Shao, Po & Campbell, 2004; Brennan, Tapsuwan & Ingram, 2007). This has been principally found to affect older people who value their garden more, but are less able to maintain it through alternate collection and application of grey water, and thus are more adversely affected than other consumers (Willis et al., 2013). In addition, broad scale application of such policies tends to be difficult to police, so authorities may often rely on social pressure to motivate adherence to restrictions and encourage community members to report non-compliance (Cooper, Burton & Crase, 2011).

Most consumers adhere to restrictions, leading to significant water savings (Randolph & Troy, 2008). Some demonstrate their dislike of water restrictions through stated willingness to pay to avoid them (Brennan, Tapsuwan & Ingram, 2007; Hensher, Shore & Train, 2006), whereas others simply refuse to comply (Beal, Stewart, Huang, & Rey, 2011; Pearce, Willis, Mamerow, Jorgensen, & Martin, 2013). One study into consumer perceptions of water use found that high water users tended to water their gardens more often than permitted, despite restrictions (Pearce et al., 2013). In Sydney, although 75% of residents reported water restrictions affected their behaviour, nearly one quarter of residents still watered the garden more often than permitted (Randolph & Troy, 2008). Watering outside of specified times has also been recorded from consumers in the Sunshine and Gold Coasts (Beal et al., 2011). These issues of welfare, inequality, consumer non-compliance and apparent lack of consequences mean that, although frequently used, water restriction policies may not present the optimal solution for domestic water consumption. Pricing tools are another strategy that may be more economically efficient alternative.

Currently, the majority of Australian urban water suppliers use a domestic water pricing structure known as ‘Inclining Block Tariffs’ (Edwards, 2011). These set an initial low charge for a given volume of water (for example, 100 KL) and increase the charge per volume of water used in stages, with rising charges as consumers utilise larger volumes through a series of ‘block’ volumes of water (Edwards, 2011). This policy rewards low volume users by charging them less per litre of water used, but may result in the volumetric portion of a household’s bill as less than half of all charges. For example, water charges for residents in Adelaide and Perth make up less than one quarter of their overall water bill. The remaining 75% of the charges cover supply costs or wastewater treatment charges. Within a certain ‘block’ volume of water consumption, there is therefore relatively little financial incentive to save water. The OECD (Organisation for Economic Cooperation and Development) has also expressed concern over the impact of pricing reforms on equitable water provision. They recommend that water prices should “[B]etter reflect the actual consumption and treatment costs, including water abstraction and supply as well as treatment of wastewater to avoid pollution.” (Parker & Speed, 2010). Therefore, pricing should incorporate treatment and distribution costs, capital costs of infrastructure and future development and opportunity cost of the water (for use and non-use elsewhere) (Olmstead & Stavins, 2009).

The political and social implications of restrictions and pricing policies means that other policy strategies, such as encouraging efficiency or curtailment water-saving behaviours may be more appealing to decision-makers (Olmstead & Stavins, 2009). More palatable methods include water demand management programs involving consumer education and engagement (Boyes & Stanisstreet, 2011; Chawla & Cushing, 2007), promotion of social norms (Schultz et al., 2007), provision of incentives (Gneezy, Meier & Rey-Biel, 2011; Stern, 1999), encouraging commitment and goal-setting (Lokhorst et al., 2013), and so on. Such approaches have had notable successes, particularly through multi-pronged water conservation campaigns conducted during the Millennium Drought (Walton & Hume, 2011). Whatever strategy is seen as most appropriate, future policies and programs should utilise existing evidence to realise their aims (Syme, Nancarrow & Seligman, 2000; Syme & Hatfield-Dodds, 2007; Johnston & Dixon, 2008), including the latest findings from behaviour change research.

Households may adopt two main types of behaviour to reduce water consumption: install devices to use water supplies more efficiently (efficiency behaviours) or limit the performance of water use activities (curtailment behaviours) (Gardner & Stern, 1996; Syme, 2008). The one-off installation of a water efficient appliance produces ongoing water savings for domestic consumers, whereas modification of regular water consumption behaviours, such as taking a shorter shower or reducing the frequency of toilet flushing, comprise curtailment behaviours. Gaining insight into the relative savings made, in terms of volume of water, from adoption of different types of behaviour may be useful to identify areas for investment to facilitate demand management (Ravandi, Mok & Chignell, 2009). For example, shower timers, water volume feedback displays and goal-setting strategies have all been used to reduce shower-related water consumption in households (Hobson, 2006; Kappel & Grechenig, 2009; Willis et al., 2010; Makki, Stewart, Panuwatwanich & Beal, 2013). Other approaches have focused on incorporating efficiency technologies, for example, low-flow showerheads, tap aerators, dual flush toilet cisterns, and low water use dishwashers and washing machines, to enable water conservation (e.g. Stewart et al., 2013; Carragher, Stewart & Beal, 2012).

The adoption of water efficient appliances by households in Australia has grown steadily over the last 20 years (see Figure 5). An international review of the impact of replacing and retrofitting efficient appliances found water savings of 35-50% (Inman & Jeffrey, 2006). One Australian study found that households with more efficient appliances had a 25% lower peak water demand than households with less efficient fixtures (Carragher, Stewart & Beal, 2012). Similarly, a study of 151 households in the Gold Coast found a 30% water consumption reduction through installation of low-flow showerheads, efficient washing machines and rainwater tanks, compared with households without such devices (Willis et al., 2013). In 2013, 34% of Australian households had a more water-efficient front-loading washing machine, and between 62-75% had installed water-saving showerheads (depending on house age) (Australian Bureau of Statistics, 2007; 2013b).

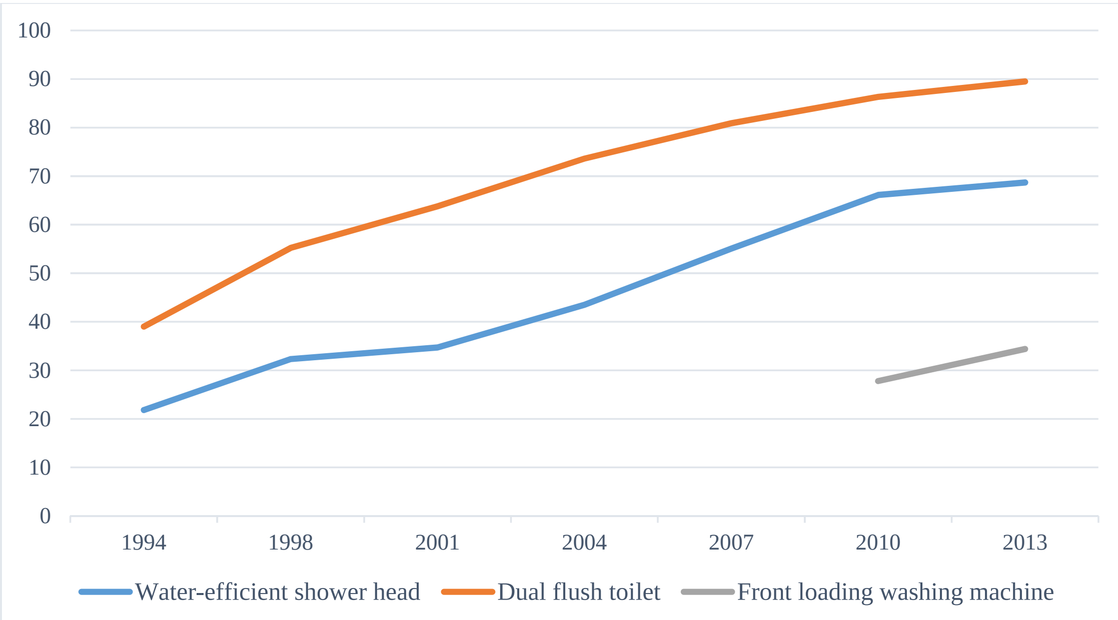

Figure 5: Graph illustrating the increase in the percentage of domestic households with water efficient appliances installed. (Australian Bureau of Statistics, 2007; 2013b)

Clearly, installation of water-efficient devices is not yet universal; there tends to be higher adoption levels in younger, more educated households with a higher income and larger number of members (Willis et al., 2013). The requirement of a high income for the adoption of efficiency technologies resonates with data suggesting householders perceive such devices as expensive to install (Roseth, 2006). The financial cost involved has been found to prevent uptake of efficiency devices (Clarke & Brown, 2006), and thus reduces household ability to save water, even if they want to. Such findings support the use of government rebate schemes, for example the Victorian rainwater tank subsidy (Pigram, 2007) or the provision of free low-flow showerheads (Sarac, Day & White, 2003) to encourage household adoption of such devices.

As discussed previously (see section 1.1.2), some research into the installation of efficiency devices suggest that they may not automatically lead to water conservation; rather, installation of efficiency devices instead triggers changes in behaviour that offset savings (Olmstead & Stavins, 2009). This '*rebound effect*' is linked with work on negative spillover and has particularly been investigated in energy consumption (e.g. Sorrel, 2007; Saunders, 2013). In response to this, some researchers have called for further work investigating the promotion of curtailment behaviours, to ensure that the installation of efficient devices is supported by good practice to deliver the water savings required by water managers (Beal et al., 2011; Beal, Makki & Stewart, 2014).

Curtailment behaviours comprise many of the practices involved with high volume end-use activities, such as taking showers, flushing the toilet, washing dishes and filling the dishwasher or washing machine (Aitken, Duncan & McMahon, 1991; Aitken, McMahon, Wearing & Finlayson, 1994). Many curtailment behaviours are habitual, i.e. automatic regularly or frequently occurring behaviours, under stable circumstances which an individual is motivated and able to repeat (Ouellette & Wood, 1998; Verplanken & Wood, 2006). For daily water-related practices, the habit itself, such as the duration of a shower or the choice of toilet flush type, determines the volume of water consumed (Aitken et al., 1994). Households reporting participation in water-saving habits, such as reducing the number of showers and number of washing machine loads, tend to have lower water consumption (Gregory & Leo, 2003). Reducing the volume of water consumed through habitual behaviours requires the modification of habits, including self-monitoring and adjustment of behaviour on a regular (daily) basis to produce an aggregate impact over time (Jansson, Marell & Nordlund, 2010).

Water-use habits can be useful predictors of future water-related behaviour. People who habitually carry out a specific behaviour have been found to be more likely to repeat it in the future (Ouellette & Wood, 1998; Jorgensen, Martin, Pearce & Willis, 2013). The successful manipulation of water related habits may therefore help ensure long-standing behaviour change; however such stable, habitual behaviours are also notoriously difficult to influence (Verplanken & Wood, 2006). Although habitual, curtailment-type behaviours do not incur a financial cost, they require frequent effort and may involve some level of discomfort for compliers (Ritchie & McDougal, 1985). They may involve an impact on lifestyle, making them less attractive for adoption by householders (Gardner & Stern, 1996). These challenges mean that curtailment behaviours may offer limited potential for water-demand management solutions, unless their adoption can assist in further, more impactful, water conservation behaviour change, potentially such as that proposed through spillover.

Overall, many Australians are already participating in water conservation behaviours, potentially continuing habitual practices started during the drought context. This could provide an ideal start point for investigating spillover, as existing behaviours could provide leverage for additional behaviour adoption.

1.6 Research problem

To ensure the sustainability of water supplies, despite a growing population and the impact of climate change on water sources, Australia's water managers will need to manage consumer demand. As one of the most significant consumers of water, householders are an important audience to consider in water use planning. Many researchers view engagement with householders as an essential part of sustainable water use in Australia (Mercer, Christesen & Buxton, 2007; Isler, Mercer & Roser, 2010; Dolnicar, Hurlimann, & Grün, 2012). The on-going efforts by researchers to investigate more effective and efficient methods to decrease household water consumption levels reflect this view (e.g. Aitken, Duncan & McMahon, 1991; Barrett, 2004; Hurlimann, Dolnicar & Meyer, 2009; Lindsay, Dean & Supski, 2017). A substantive proportion of research within a large Australian water research initiative, the CRC for Water Sensitive Cities (CRCWSC) was dedicated to examining these questions (CRCWSC, 2018). The specific research described within this thesis was developed to contribute to these efforts.

The CRCWSC is a multidisciplinary, multi-institute program, established in 2012 and funded through the Australian Commonwealth Government's Cooperative Research Centre program. The initiative aims to improve water resource management in urban areas, building city resilience, protecting and rejuvenating natural ecosystems and benefiting inhabitants (watersensitivecities.org.au). Understanding how to engage with key audiences, including householders, to help water managers influence patterns of consumption and promote efficient use of water supplies is an important aspect of creating more water sensitive cities. The research project described in this thesis aims to facilitate the development of demand management programs by water managers. The overall objective is to simplify the decision-making process by developing a method to identify and prioritise water saving behaviour for household adoption, and consider how to select catalytic behaviours that increase the chances of spillover taking place.

1.6.1 Identifying household water saving behaviours

Water practitioners turning to behavioural solutions for management of water resources benefit from being able to identify behaviours for promotion in future demand management programs. As with any behaviour change intervention, the identification and prioritisation of target behaviours is an important first step (Stern, 2000; McKenzie-Mohr, 2000; McKenzie-Mohr, Lee, Kotler & Schultz, 2011). Selection of a target behaviour permits investigation for a better understanding of behaviour characteristics; the more that is known about the behaviour at hand, the better in order to select appropriate theoretical approaches and intervention type (Johnston & Dixon, 2008; Michie, Van Stralen & West, 2011). Identification of a specifically defined, priority behaviour therefore becomes an integral part of any behaviour change or intervention design process (Stern, 2000; Darnton, 2008; Gifford, Kormos & McIntyre, 2011).

Although numerous studies have tested and evaluated a variety of intervention approaches for water conservation (e.g. Syme, 2000; Olmstead & Stavins, 2009; Willis et al., 2013; Fielding et al., 2013; Liu, Giurco & Mukheibir, 2016), relatively little work has been carried out on the <u>process</u> of behaviour identification (Johnston & Dixon, 2008; Inskeep & Attari, 2014; Department of Environment, Food and Rural Affairs, 2008). As has been discussed (section 1.6), householders may engage with a plethora of behaviours to save water around the home (e.g. Manning et al., 2013). However, the sheer number means a detailed investigation into each one is untenable. It is therefore important to generate a usable list of water saving behaviours, a subset of all those possible, as a first step in the research program, therefore the first objective of the research is:

Objective 1: Identify water conservation behaviours for adoption at a household level.

1.6.2 Selecting behaviours to target

Some behavioural issues, such as reducing tax avoidance or increasing organ donor registration, lend themselves to single solutions and, potentially, more directed intervention design options (Hallsworth, 2014; Behavioural Insights Team, 2013). However, complex issues, such as environmental or resource conservation, may present a huge range of solutions and associated practices for enactment by audiences (Gardner & Stern, 2008). Identifying behaviours to address these challenging problems may involve discussion with multiple stakeholders, such as academics, industry experts, community members and policy makers (e.g. Hargroves, Desha & Reeve, 2010; Boudet, Flora & Armel, 2016; Manning et al., 2013).

Engagement and discussion with stakeholders may result in long lists of solution-related activities for consideration. For example, within the household energy conservation field, one USA study obtained 100 types of energy conservation behaviours from householders (Woods, 2008), an Australian project considered 240 behaviours for household adoption (Hargroves, Desha & Reeve, 2010), and a categorisation study commenced with an initial list of 500 behaviours, reduced to a more-manageable 261 for investigation (Boudet, Flora & Armel, 2016). Within the popular literature, a guide to personal carbon emission reduction identifies the carbon footprint of over 100 everyday products and activities (Berners-Lee, 2011). Similarly, those wanting to live a more environmentally-friendly lifestyle can select from 500 different ways to ‘make a difference’ (Neff, 2018). Long lists of potential behaviours pose a practical challenge for the researcher or practitioner seeking to evaluate uptake and impacts with limited time and budget. They are also problematic for the well-intentioned householder wishing to change their behaviour, but unsure of which of the many options to enact and paralysed by choice.

Choice overload, or the ‘paradox of choice’, explains how provision of multiple offerings, whether which water-saving behaviour to adopt or which type of jam to buy, leads to poor decision making (Iyengar & Lepper, 2000). Too much choice has been found to trigger consumer paralysis, and indecision, to the point of becoming overwhelming and negatively impacting on consumer wellbeing (Iyengar & Lepper, 2000; Schwartz, 2004; Botti & Iyengar, 2006). Providing audiences, such as householders, with numerous behavioural options is thought to be confusing and potentially result in adoption of the simplest, possibly least effective, behaviour offered (Gardner & Stern, 2008; Thøgersen & Crompton, 2009). For example, when asked to select the best behaviours for water conservation from a range, individuals tend to identify curtailment-type behaviours for personal adoption, despite greater savings being achievable through the selection of efficiency behaviours (Kempton, Harris, Keith & Weihl, 1985; Inskeep & Attari, 2014).

The number of water-saving behaviours available for promotion to householders (e.g. Manning et al., 2013) presents water managers with a challenge when developing demand management programming for the future. Prioritising behaviours for householders to adopt avoids many of the potential pitfalls created through a ‘shopping list’ approach (Gardner & Stern, 2008). For example, promoting high impact water saving behaviours could prevent householders from selecting more visible, easy to adopt but less impactful behaviours (Inskeep & Attari, 2014). Encouraging adoption of just a couple of behaviours may also prevent the single action bias, or contribution ethic, whereby adoption of one behaviour precludes adoption of further behaviours (Weber, 1997; Wagner, 2011). Providing a focussed target also prevents the confusion and paralysis triggered by choice overload (Botti & Iyengar, 2006). From a practical water manager’s perspective, a specific approach means limited time, personnel and funds can be concentrated on a clear course of action, whilst from a theoretical perspective, understanding a single behaviour may provide a greater chance of success through targeted intervention design (McKenzie-Mohr et al., 2011).

Decision makers currently have a range of tools available to assist in the selection of a few priority behaviours from a long list of potential activities. Assessment of behavioural characteristics may be used to distinguish and select between each behaviour under consideration. For example, Community Based Social Marketing (CBSM) endorses a ranking system, whereby behaviours are considered and scored in terms of their impact, for example volume of water saved, likelihood of adoption, and existing penetration within the target audience (McKenzie-Mohr, 2000; McKenzie-Mohr et al, 2011; McKenzie-Mohr & Schultz, 2014). This produces a single score outcome, with priority behaviours selected from those with the optimal scores. When a more nuanced approach is required, a matrix framework may be applied to evaluate behaviours against more than one criterion at a time. Matrices have been extensively used in the risk management sector to map risks in terms of their severity and probability of occurring (Hopkin, 2017). Once risks are prioritised, resources can be allocated to mitigate those with the greatest severity and highest probability of occurrence (Hopkin, 2017).

The matrix approach can be combined with the CBSM behaviour criteria to build a decision making frame for behaviour selection. Scores allocated, for example to the potential impact and likelihood of adoption, allow a behaviour to be mapped onto a 2x2 grid which can act as a decision-making guide (see Figure 4). Activities scored as low likelihood of adoption and low impact on the issue are placed into the bottom left quadrant. This location identifies them as low priority; they are unlikely to be adopted by the target audience and do little to mitigate the issue. By comparison, behaviours scored as high likelihood of adoption and high impact on the issue appear in the upper right quadrant, as first priority ‘low-hanging fruit’ (Attari, Dekay, Davidson & de Bruin, 2011). These first priority behaviours may appear optimal for selection for behaviour change programming, however, their utility may indicate previous program success, resulting in high participation rates and thus little opportunity for additional change.

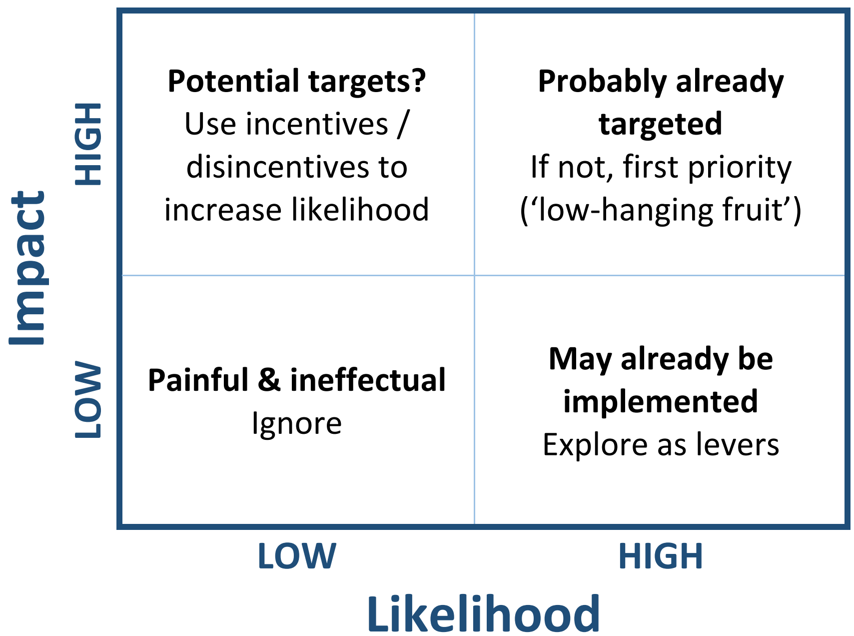

Figure 6: The Impact-Likelihood matrix for behaviour prioritisation. (Adapted from Smith, 2012)

The need to make a significant difference means that it may therefore be necessary to select behaviours appearing in other quadrants. Behaviours mapping into the upper left quadrant, indicating high impact on the issue but low likelihood of adoption, may be useful, but require investment in intervention design to overcome barriers to adoption (see Chapter 3). Alternatively, behaviours appearing in the lower right quadrant, with a high likelihood of adoption but low impact on the issue, offer an interesting prospect. Such behaviours may be relatively easy to engage the target audience in, requiring little additional resources, or indeed may already be performed. If the audience experience shifts in their self-perception from performing such behaviours, they may be willing or able to adopt additional behaviours, through the spillover effect (Thøgersen, 1999; Thøgersen & Ölander, 2003; Truelove et al., 2014), as discussed in section 1.1 above.

As has been discussed, there are many ways in which householders are able to reduce their water consumption, through modification of practices in the indoor and outdoor space, installing water-efficient devices or adoption of curtailment behaviours. Selection of a single behaviour is best practice for effective intervention design, but far from straightforward as behaviours vary by type, impact on water saving, effort required for adoption and likelihood of adoption. If water managers are to plan for future drought occurrences it is important to know which of these behaviours should be targeted in order to determine behaviour change approaches by which behaviour change can be brought about. Prioritising behaviours for householders to adopt avoids many of the potential pitfalls created through a 'shopping list' approach (Gardner & Stern, 2008). For example, promoting only high impact water saving behaviours could help prevent householders from selecting more visible, easy to adopt, less impactful behaviours (Inskeep & Attari, 2014).

Encouraging adoption of just a couple of behaviours may also prevent the single action bias, or contribution ethic, whereby adoption of one behaviour precludes adoption of further behaviours (Weber, 1997; Wagner, 2011). Providing a focussed target also prevents the confusion and paralysis triggered by choice overload (Botti & Iyengar, 2006). From a practical water manager's perspective, a specific approach means limited time, personnel and funds can be concentrated on a clear course of action, whilst from a theoretical perspective, understanding a single behaviour may provide a greater chance of success through targeted intervention design (McKenzie-Mohr et al., 2011).

Therefore, the second area of interest for this research program is to develop and test a tool to aid water managers with behaviour selection for demand management campaigns:

Objective 2: Develop and test a prioritisation tool to facilitate behaviour selection for behaviour change program design.

1.6.3 Maximising water conservation through accelerating behaviour change

Given the global and Australian context of this study (section 1.0 and 1.4), a further consideration for the research was how to maximise the potential for change. Spillover theory could provide an opportunity to increase the effectiveness of any behaviour change program by increasing the likelihood of further behavioural adoption and thus accelerating change (Truelove et al., 2014; Van der Werff, Steg & Keizer, 2014; De Young, 2000; Thøgersen, 2004). If they are able to increase the likelihood of behavioural spillover, catalytic behaviours could be ideal targets to prioritise for water managers in future campaigns. Creating and testing a method to prioritise water saving behaviours, incorporating perceptions of similarity to allow the operationalisation of spillover theory, is an essential prerequisite for optimal behaviour selection. Therefore, the third objective of the research project is:

Objective 3: Identify potentially catalytic behaviours, to facilitate operationalisation of spillover theory.

1.7 Research approach

The research program is designed to address each of the three key research objectives, aiming to develop practical processes of utility to water managers seeking to select optimal behaviours to target in future demand management programs. This will include identification of potentially catalytic behaviours through investigation of perceptions of behavioural similarity. The study followed an iterative, step-wise design, addressing each of the three key objectives through answering specific research questions.

Objective 1: Identify water conservation behaviours for adoption at a household level.

Research Question 1.1: What household water-saving behaviours could be considered for investigation?

Identification of behaviours plays an important role in behaviour change programming. In order to maximise the efficiency of the research, it is important to have a workable list of water conservation behaviours to focus on. The process used for behaviour identification is detailed in Chapter 2, while Table 2 provides a summary of the data sources and research approach.

Table 2: Research approach and data sources for Objective 1.

Objective 1: Identify water conservation behaviours for adoption at a household level.	
1.1 What household water-saving behaviours could be considered for investigation?	
Research approach	Investigation of existing grey literature and recommendations targeted at householders from campaigns mounted during the Millennium Drought
Sources of data	Websites and other campaign materials; Long list of behaviours assessed for validity and relevance by water industry professionals
Data analysis methodology	External audit by water industry professionals to aid confirmation and categorisation.
Output	Full method details in Chapter 2. List of 46 behaviours for use in all subsequent phases of the study

Objective 2: Develop and test a tool for prioritising water saving behaviours to be targeted in future behaviour change programming.

Research Question 2.1: What are the criteria for behaviour prioritisation, and how can water saving behaviours be prioritised for future demand management programs?

Having produced a shortlist of behaviours to investigate, the next step in the research programme is to trial a practical tool that water managers could use to aid with prioritising water saving behaviours to target in campaigns. The second research question therefore relates to investigating the utility of a decision-making frame, using data from householders and water professionals to prioritise the water-saving behaviours identified in Chapter 2.

Research Question 2.2: Do householders and water professionals differ in their perceptions of the household water saving behaviours?

If stakeholder perceptions of the criteria used for behaviour prioritisation differ, different behaviours could emerge as priorities. Therefore, analysis of perception data from householders and water professionals will be undertaken to ascertain whether expert opinion (Walton, 2010) provides a usable data source for behaviour prioritisation. The approach and data sources for the investigation are listed in Table 3 while the detailed method and results comprise Chapter 3.

Table 3: Research approach and data sources for Objective 2.

Objective 2: Develop and test a prioritisation tool to facilitate behaviour selection for behaviour change program design.	
2.1: What are the criteria for behaviour prioritisation, and how can water saving behaviours be prioritised for future demand management programs?	
Research approach	Data collected from key stakeholders to gain insight on the impact and likelihood of adoption of water saving behaviours to inform the prioritisation decision-making process.
Sources of data	1) Online survey distributed to householders (n=151) and water professionals (n=18) across Australia eliciting perceptions through quantitative scoring of behaviour characteristics: impact on water saving, effort required for behaviour adoption (cognitive, physical and financial) and existing participation rates. 2) Existing data from national online survey of knowledge about and participation in water sensitive behaviours (n=5194).
Data analysis methodology	1) Mean scores, from water professionals for behaviour impact and from householders on the effort required for behaviour adoption, used to map each water saving behaviour onto a two-dimensional prioritisation framework. 2) Prioritisation matrix combined with self-reported rates of behaviour participation to provide an indication of opportunity for further behaviour adoption.
Output	Chapter 3: Publication 1: *The Impact-Likelihood Matrix: A policy tool for behaviour prioritisation*
2.2 Do householders and water professionals differ in their perceptions of the household water saving behaviours?	
Research approach	Comparative analysis of the existing survey data from 'lay' householders and 'expert' water professional stakeholders
Sources of data	1) Householder generated behaviour perception scores on current participation rates, impact of behaviour on water conservation and effort required for behaviour adoption (cognitive, physical and financial), from the original online survey (used in paper 1). 2) Online survey redistributed to water professional to obtain a larger sample size. Quantitative scores obtained on water professional perceptions of current participation rates, impact of behaviour on water conservation and effort required for behaviour adoption (cognitive, physical and financial)
Data analysis methodology	Independent sample T-tests used to identify if, and where, significant differences arose in scores obtained from 'lay' householders compared with 'expert' water professional perspectives.
Output	Chapter 4: Publication 2: *Whose view do we use? Comparing expert water professional and lay householder perspectives on water saving behaviours*

Objective 3: Identify potentially catalytic behaviours, to facilitate operationalisation of spillover theory.

The third objective focuses on identifying potentially catalytic behaviours that may be of utility in operationalisation of spillover theory. Behavioural similarity has been proposed as a potentially important aspect of catalytic behaviours, therefore this element of the research will focus on investigating the perceived similarity of water saving behaviours. The following research questions will be used to guide investigation:

Research Question 3.1: Which of the water saving behaviours under investigation are perceived as similar by householders?

Research Question 3.2: Why are they seen as similar; specifically, what criteria do householders use to determine perceptions of similarity?

Research Question 3.3: How can the results from behaviour prioritisation matrix and similarity assessment be combined to identify potentially catalytic behaviours?

These questions will be investigated through a novel application of a data analysis categorisation method for behaviour, see Table 4 for the summary.

Table 4: Research approach and data sources for Objective 3

Objective 3: Identify potentially catalytic behaviours, to facilitate operationalisation of spillover theory	
3.1: Which of the water saving behaviours under investigation are perceived as similar by householders?	
Research approach	Multiple Sort Procedure
Sources of data	Study participants (n=32) sort cards describing 44 water saving behaviours into groups, based on personal perceptions of behavioural similarity.
Data analysis methodology	1) Behaviour co-occurrence in groups investigated through Multidimensional Scaling Analysis to create a visual representation, with behaviours mapped according to their perceived similarity. 2) Cluster analysis of the groups created to identify patterns within the sort procedure results and thus which behaviours are seen as similar.
Output	Chapter 5: Publication 3: *It's what you do and where you do it: Perceived similarity in household water saving behaviours.*
3.2: Why are the behaviours seen as similar; specifically, what criteria do householders use to determine perceptions of similarity?	

Research approach	Descriptions and explanations of groups generated through Multiple Sort Procedure.
Sources of data	Study participants (n=32) creating groups out of water behaviour cards gave explanations as to why the cards had been sorted in a particular manner
Data analysis methodology	1) Content analysis of explanations provided to understand why behaviours are seen as similar. 2) Categorical Principal Components Analysis used to combine the dimensions of similarity with the MDS biplot.
Output	Chapter 5: Publication 3: *It's what you do and where you do it: Perceived similarity in household water saving behaviours.*
Research Question 3.3: How can the results from behaviour prioritisation matrix and similarity assessment be combined to identify potentially catalytic behaviours?	
Research approach	Combination of data sets and findings from investigations into all other research questions
Sources of data	1) Online survey data from householders on perceptions of behaviour characteristics (paper 1) 2) Online survey data from larger sample of water professionals on perceptions of behaviour characteristics (paper 2) 3) Cluster analysis and multidimensional scaling analysis outputs indicating perceptually similar behaviours (paper 3)
Data analysis methodology	Recombine householder and water professional data to create new impact-likelihood matrices. Overlay with similar behaviour clusters to produce a similarity/prioritisation map with pathways for catalytic behaviour identification.
Output	Chapter 6: Synthesis of results

It is anticipated that the study findings will be used by industry water managers to guide future community level interventions aimed at encouraging domestic water consumers to engage in multiple water conservation behaviours within their home and thus help reduce urban household water consumption.

1.8 Thesis structure

This thesis by publication is structured around three academic papers reporting the main outcomes and findings from the research project, rather than a traditional monograph. Each research paper includes a literature review, methodological details, results and discussion; therefore some of the content of the thesis body may seem repetitive. In particular, there may be redundancy in content regarding the need for behaviour prioritisation and the methods currently available to do so (Chapter 3), the potential difference in stakeholder perspectives of water saving behaviours (Chapter 4), and the importance of perceptual similarity and the role of similarity in spillover theory (Chapter 5). Much of the detail in Chapter 1 has been included in order to provide context and explanation for the research program and to position the papers within the broader water and behaviour change literature.

This introductory chapter provided a rationale for the research project, the need for accelerated behaviour change to achieve the widescale shifts in behaviours needed to address the pressing environmental, social and economic issues of the era including around water resource management. It describes the mechanisms behind spillover theory and explores the role of similarity in identification of catalytic behaviours. It also provides details about the study context, regarding water in Australia, household water consumption and participation in water saving. The objectives for this piece of research emerge from the literature around the study context. The research objectives give rise to specific questions for investigation and the proposed research approach is outlined.

Objective 1: Identify water conservation behaviours for adoption at a household level.

Objective 2: Develop and test a tool for prioritising water saving behaviours to be targeted in future behaviour change programming.

Objective 3: Identify potentially catalytic behaviours, to facilitate operationalisation of spillover theory.

Chapter 2 details the mixed method approach, combining literature review and expert opinion, used to identify a list of potential water saving behaviours for consideration within the research program. Chapters 3, 4 and 5 consist of two peer-reviewed journal publications and one manuscript submitted for publication. Chapter 3 comprises the first journal publication, '*The Impact-Likelihood matrix: A policy tool for behaviour prioritisation*'. This paper, published in the Journal of Environmental Science and Policy (2017), describes the development and testing of a tool that allows the visualisation of behaviours for decision making. Chapter 4 contains the second journal article '*Whose view do we use? Comparing expert water professional and lay householder perspectives on water saving behaviours*' (submitted and under review with Urban Water Journal), an investigation of stakeholder perceptions of water saving behaviours. Chapter 5 includes the journal publication, '*It's what you do and where you do it: Perceived similarity in water saving behaviours*' (published in the Journal of Environmental Psychology, 2018). This chapter details an investigation into householder perceptions of similarity of water-saving behaviours. The relationship between objectives and publications is in Table 5.

The findings generated from the research are synthesised and summarised in Chapters 6 and 7. Chapter 6 describes a synthesis of the outcomes from each study to describe a process for the identification of potentially 'catalytic' behaviours that increase the likelihood of spillover occurring. The thesis concludes with Chapter 7, which includes a summary of outcomes, discussion of the research contribution to literature and theory, outlines limitations of the study and describes implications for practice and future research.

Table 5: Relationship between research objective, results chapters and publications

Research Objective	Addressed in Chapter	Publication
Objective 1	2	Identifying water conservation behaviours
Objective 2	3	Publication 1: *The Impact-Likelihood Matrix: A policy tool for behaviour prioritisation.* Published: Journal of Environmental Science and Policy
	4	Publication 2: *Whose view do we use? Comparing expert water professional and lay householder perspectives on water saving behaviours.* Under review: Urban Water Journal
Objective 3	5	Publication 3: *It's what you do and where you do it: Perceived similarity in household water saving behaviours.* Published: Journal of Environmental Psychology
	6	Synthesis of results for identification of catalytic behaviours

References

Aitken, C. K., Duncan, H., & McMahon, T. A. (1991). A cross-sectional regression analysis of residential water demand in Melbourne, Australia. *Applied Geography*, 11(2), 157-165.

Aitken, C. K., McMahon, T. A., Wearing, A. J., & Finlayson, B. L. (1994). Residential water use: Predicting and reducing consumption. *Journal of Applied Social Psychology*, 24(2), 136-158.

Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behaviour*. Englewood Cliffs, NJ: Prentice-Hall.

Albarracín, D., & Wyer Jr, R. S. (2000). The cognitive impact of past behavior: influences on beliefs, attitudes, and future behavioral decisions. *Journal of Personality and Social Psychology*, 79(1), 5.

Arbués, F., Villanúa, I., & Barberán, R. (2010). Household size and residential water demand: an empirical approach. *Australian Journal of Agricultural and Resource Economics*, *54*(1), 61-80.

Attari, S. Z., DeKay, M. L., Davidson, C. I., & de Bruin, W. B. (2011). Changing household behaviors to curb climate change: How hard can it be? *Sustainability: The Journal of Record*, *4*(1), 9-11.

Austin, A., Cox, J., Barnett, J., Thomas, C. (2011). *Exploring catalyst behaviours: Summary report to the Department for Environment, Food and Rural Affairs*. London: Brook Lyndhurst for Defra.

Austin, J. T., & Vancouver, J. B. (1996). Goal constructs in psychology: Structure, process, and content. Psychological Bulletin, 120(3), 338-375. doi: 10.1037/0033-2909.120.3.338

Australian Bureau of Statistics. (2007). *Environmental Issues: People's Views and Practices, Mar 2007* (cat. no. 4602.0). Retrieved from: www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/4602.0

Australian Bureau of Statistics. (2010). *Environmental Issues: Water use and Conservation, Mar 2010* (cat. no. 4602.0.55.003). Retrieved from: www.abs.gov.au/AUSSTATS/abs@.nsf/Previousproducts/4602.0.55.003

Australian Bureau of Statistics. (2013a). *Regional population growth: Australia,2011-2012* (cat. no. 3218.0). Retrieved from: www.abs.gov.au/ausstats/abs@.nsf/Products/3218.0~2011-12

Australian Bureau of Statistics. (2013b). *Environmental Issues: Water use and Conservation, March 2013* (cat.no. 4602.0.55.003). Retrieved from: www.abs.gov.au/ausstats/abs@.nsf/Lookup/4602.0.55.003

Australian Bureau of Statistics (2017) 4610.0 - Water Account, Australia, 2015-16. Retrieved from: www.abs.gov.au/ausstats/abs@.nsf/mf/4610.0

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, 84, 191-215.

Bandura, A. (2002). Environmental Sustainability by Sociocognitive Deceleration of Population Growth. In P. Schmuck et al. (Eds), *Psychology of sustainable development* (pp. 209-238). Springer, Boston, MA.

Baroudy, E., Lahlou, A., Attia, B. (2005). *Managing water demand: policies, practices and lessons from the Middle East and North Africa forums*. Cornwell, USA: IWA Publishing

Barrett, G. (2004). Water conservation: The role of price and regulation in residential water consumption. *Economic papers: A journal of applied economics and policy*, 23(3): 271-285.

Barron, O., Crosbie, R., Dawes, W., Pollock, D., Charles, S., Mpelasoka, F., Aryal, S., Donn, M. & Wurcker, B. (2010). *The impact of climate change on groundwater resources: The climate sensitivity of groundwater recharge in Australia.* CSIRO: Water for a Healthy Country, Report to National Water Commission.

Bates, B., Kundzewicz, Z. W., Wu, S., Palutikof, J. (2008). *Climate change and water*. Intergovernmental Panel on Climate Change, Technical Paper VI. Geneva: IPCC. Retrieved from www.ipcc.ch/pdf/technical-papers/climate-change-water-en.pdf

Beal, C. D., Makki, A., & Stewart, R. A. (2014). What does rebounding water use look like? An examination of post-drought and post-flood water end-use demand in Queensland, Australia. *Water Science and Technology: Water Supply*, 14(4), 561-568.

Beal, C., Stewart, R., Huang, T., & Rey, E. (2011). South East Queensland residential end use study. *Journal of the Australian Water Association,* 38(1): 80-84.

Behavioural Insights Team, (2013). *Applying behavioural insights to organ donation: Preliminary results from a randomised controlled trial*. London: Cabinet Office.

Bem, D. J. (1967). Self-perception: An alternative interpretation of cognitive dissonance phenomena. *Psychological Review*, 74(3), 183.

Bennear, L., Lee, J., and Taylor, L. (2011). Participation incentives, rebound effects and the cost-effectiveness of rebates for water-efficient appliances. *Duke Environmental Economics Working Paper*. No. 11-10, 2011.

Berners-Lee, M. (2011). *How bad are bananas? The carbon footprint of everything.* London: Greystone Books.

Botti, S. and S. S. Iyengar (2006). The dark side of choice: when choice impairs social welfare. *Journal of Public Policy & Marketing*, 25(1): 24-38.

Boudet, H. S., Flora, J. A., & Armel, K. C. (2016). Clustering household energy-saving behaviours by behavioural attribute. *Energy Policy*, 92, 444-454.

Boyes, E., & Stanisstreet, M. (2011). Environmental education for behaviour change: Which actions should be targeted? *International Journal of Science Education*, 34(10), 1591-1614.

Bratt, C. (1999). Consumers' environmental behavior: generalized, sector-based, or compensatory? *Environment and Behavior*, 31(1), 28-44. doi: 10.1177/00139169921971985

Brennan, D., Tapsuwan, S., & Ingram, G. (2007). The welfare costs of urban outdoor water restrictions. *Australian Journal of Agricultural and Resource Economics*, 51(3), 243-261.

Brick, K., De Martino, S. & Visser, M. (2017) Behavioural nudges for water conservation: Experimental evidence from Cape Town. *Under review*: DOI: 10.13140/RG.2.2.25430.75848

Bureau of Meteorology, (2015). *Recent rainfall, drought and southern Australia's long-term rainfall decline*. Retrieved from www.bom.gov.au/climate/updates/articles/a010-southern-rainfall-decline.shtml

Bureau of Meteorology, (2018). *Monthly drought report, May 2018*. Accessed May 2018, retrieved from http://www.bom.gov.au/climate/drought/

Burger, J. M. (1999). The foot-in-the-door compliance procedure: A multiple-process analysis and review. *Personality and Social Psychology Review*, 3, 303-325.

Cahill, R. and J. Lund (2013). Residential water conservation in Australia and California. *Journal of Water Resources Planning and Management*, 139(1): 117-121.

Cahill, R., & Lund, J. (2013). Residential water conservation in australia and california. Journal of Water Resources Planning and Management, 139(1), 117-121. doi: 10.1061/(ASCE)WR.1943-5452.0000225

Campbell, H.E., Johnson, R.M. and Hunt Larsen, E. (2004). Prices, devices, people or rules: The relative effectiveness of policy instruments in water conservation. *Review of Policy Research*, 21(5), 637-662.

Carragher, B. J., Stewart, R. A., & Beal, C. D. (2012). Quantifying the influence of residential water appliance efficiency on average day diurnal demand patterns at an end use level: A precursor to optimised water service infrastructure planning. *Resources, Conservation and Recycling*, 62, 81-90.

Carrico, A. R., Raimi, K. T., Truelove, H. B., & Eby, B. (2017). Putting your money where your mouth is: an experimental test of pro-environmental spillover from reducing meat consumption to monetary donations. *Environment and Behavior*, 0013916517713067. doi: 10.1177/0013916517713067

Carver, C. S., & Scheier, M. F. (2001). *On the self-regulation of behavior*: Cambridge University Press.

Cary, J. W. (2008). Influencing attitudes and changing consumers' household water consumption behaviour. *Water Science & Technology: Water Supply, 8*(3), 325-330.

Cathcart, M. (2010). *The water dreamers: The remarkable history of our dry continent*. Melbourne: Text Publishing.

Chawla, L., & Cushing, D. F. (2007). Education for strategic environmental behavior. *Environmental Education Research*, 13(4), 437-452.

Chiew, F. H., Piechota, T. C., Dracup, J. A., & McMahon, T. A. (1998). El Nino/Southern Oscillation and Australian rainfall, streamflow and drought: Links and potential for forecasting. *Journal of Hydrology*, *204*(1), 138-149.

Cialdini, R. B., Trost, M. R., & Newsom, J. T. (1995). Preference for consistency: The development of a valid measure and the discovery of surprising behavioral implications. *Journal of Personality and Social Psychology*, 69(2), 318.

Clarke, J. M., & Brown, R. R. (2006). Understanding the factors that influence domestic water consumption within Melbourne. *Australian Journal of Water Resources*, *10*(3), 261.

Commonwealth Scientific and Industrial Research Organisation (CSIRO), Bureau of Meteorology (2014). *State of the Climate 2014*. Collingwood, VIC: CSIRO. Retrieved from www.csiro.au/Outcomes/Climate/Understanding/State-of-the-Climate-2014.aspx

Commonwealth Scientific and Industrial Research Organisation (CSIRO) (2010). *Climate variability and change in South-Eastern Australia: A synthesis of findings from phase 1 of the South Eastern Australian climate initiative* (SEACI). Canberra; ACT, CSIRO**:** 31.

Connor, R. (2015). *The United Nations world water development report 2015: Water for a sustainable world* (Vol. 1). pp. 2 – 4. UNESCO Publishing.

Cook, S. Hall. M. and Gregory, A. (2012) *Energy use in the provision and consumption of urban water in Australia: an updat*e. CSIRO Water for a Healthy Country Flagship, Australia. Prepared for the Water Services Association of Australia.

Cooper, B., Burton, M., & Crase, L. (2011). Urban water restrictions: Attitudes and avoidance. *Water Resources Research*, 47(12).

Cooper, J. (2007). *Cognitive dissonance: 50 years of a classic theory*. UK: Sage.

Cornelissen, G., Dewitte, S., Warlop, L., & Yzerbyt, V. (2007). Whatever people say I am, that's what I am: Social labelling as a social marketing tool. *International Journal of Research in Marketing*, 24(4), 278-288.

Cornelissen, G., Pandelaere, M., Warlop, L., & Dewitte, S. (2008). Positive cueing: Promoting sustainable consumer behavior by cueing common environmental behaviors as environmental. *International Journal of Research in Marketing*, 25(1), 46-55.

CRC Water Sensitive Cities, (2018) *Introduction to the Cooperative Research Centre for Water Sensitive Cities*. Retrieved from: https://watersensitivecities.org.au/, accessed May 2018

Crompton, T. (2008). *Weathercocks and signposts: the environment movement at a crossroads.* World Wide Fund for Nature, UK: World Wide Fund for Nature.

Croyle, R. T., & Cooper, J. (1983). Dissonance arousal: Physiological evidence. *Journal of Personality and Social Psychology*, 45(4), 782.

Darnton, A. (2008). *GSR behaviour change knowledge review: Reference report*: An overview of behaviour change models and their uses. London: Centre for Sustainable Development, University of Westminster.

Davison, G. (2008). Down the gurgler: Historical influences on Australian domestic water consumption, In Troy, P. (Ed). *Troubled Waters: Confronting the Water Crisis in Australia's Cities*. Canberra, Australia: Australian National University Press.

Dean, A. J., Fielding, K. S., & Newton, F. J. (2016). Community knowledge about water: Who has better knowledge and is this associated with water-related behaviors and support for water-related policies? *PloS one*, *11*(7), e0159063.

Dean, A. J., Lindsay, J., Fielding, K. S., & Smith, L. D. G. (2016). Fostering water sensitive citizenship – Community profiles of engagement in water-related issues. *Environmental Science & Policy*, 55, Part 1, 238-247. doi: http://dx.doi.org/10.1016/j.envsci.2015.10.016

De Young, R. (2000). New ways to promote proenvironmental behavior: Expanding and evaluating motives for environmentally responsible behavior. *Journal of Social Issues*, 56(3), 509-526. doi: 10.1111/0022-4537.00181

Diekmann, A., & Preisendörfer, P. (1998). Environmental behavior: Discrepancies between aspirations and reality. *Rationality and Society*, 10(1), 79-102.

Delworth, T. L. and F. Zeng (2014). Regional rainfall decline in Australia attributed to anthropogenic greenhouse gases and ozone levels. *Nature Geoscience*, **7**: 583.

DEFRA. (2008). *Framework for pro-environmental behaviours*. London: Department for Environment, Food and Rural Affairs.

Department of Land Resource Management (2013) *How we use our water – Central Australia* [Fact sheet]. Alice Springs, NT: Northern Territory government. Retrieved from: www.lrm.nt.gov.au/__data/assets/pdf_file/0011/214787/How-we-use-our-water_CA.pdf

Dickerson, C. A., Thibodeau, R., Aronson, E., & Miller, D. (1992). Using cognitive dissonance to encourage water conservation. *Journal of Applied Social Psychology*, 22(11), 841-854.

Dolan, P., & Galizzi, M. M. (2015). Like ripples on a pond: Behavioral spillovers and their implications for research and policy. *Journal of Economic Psychology*, 47(0), 1-16. doi: http://dx.doi.org/10.1016/j.joep.2014.12.003

Dolnicar, S., & Hurlimann, A. (2010a). *Desalinated versus recycled water: what does the public think?* In C. E. Isabel & I. S. Andrea (Eds.), Sustainability Science and Engineering (Vol. Volume 2, pp. 375-388): Elsevier.

Dolnicar, S., & Hurlimann, A. (2010b). Australians' water conservation behaviours and attitudes. *Australian Journal of Water Resources*, *14*(1), 43-53.

Dolnicar, S., Hurlimann, A., & Grün, B. (2012). Water conservation behavior in Australia. *Journal of Environmental Management*, *105*, 44-52.

Domene, E. & Saurí, D. (2006). Urbanisation and water consumption: influencing factors in the metropolitan region of Barcelona. *Urban Studies*, 43(9): 1605-1623. doi: 10.1080/00420980600749969

Elliot, A. J., & Devine, P. G. (1994). On the motivational nature of cognitive dissonance: Dissonance as psychological discomfort. *Journal of Personality and Social Psychology*, 67(3), 382.

Endo, A., Tsurita, I., Burnett, K., & Orencio, P. M. (2017). A review of the current state of research on the water, energy, and food nexus. Journal of Hydrology: Regional Studies, 11, 20-30. doi: https://doi.org/10.1016/j.ejrh.2015.11.010

England, P. (2009). Managing urban water in Australia: The planned and the unplanned. *Management of Environmental Quality* 20(5): 592-568.

Festinger, L. (1957). *A theory of cognitive dissonance* (Vol.1). USA: Stanford University Press.

Festinger, L., & Carlsmith, J. M. (1959). Cognitive consequences of forced compliance. *The Journal of Abnormal and Social Psychology*, 58(2), 203.

Fielding, K. S., Spinks, A., Russell, S., McCrea, R., Stewart, R., & Gardner, J. (2013). An experimental test of voluntary strategies to promote urban water demand management. *Journal of Environmental Management*, 114(0), 343-351.

Fielding, K. S., Russell, S., Spinks, A., & Mankad, A. (2012). Determinants of household water conservation: The role of demographic, infrastructure, behavior, and psychosocial variables. *Water Resources Research*, 48(10).

Flower, D. J. M., Mitchell, V. G., & Codner, G. P. (2007). The potential of water demand management strategies to reduce the greenhouse gas emissions associated with urban water systems. *Combined International Conference of Computing and Control for the Water Industry CCWI2007 and Sustainable Urban Water Management*, De Montfort, Leicester SUWM2007 593-600

Fointiat, V. (2004). "I know what I have to do, but..." when hypocrisy leads to behavioral change. *Social Behavior and Personality*, 32(8), 741-746.

Folke, C., Jansson, Å., Rockström, J., Olsson, P., Carpenter, S.R., Stuart Chapin III, F., Crépin, A.S., Daily, G., Danell, K., Ebbesson, J. & Elmqvist, T. (2011). Reconnecting to the biosphere. *AMBIO: A Journal of the Human Environment*, 40(7), pp.719-738.

Freedman, J. L., & Fraser, S. C. (1966). Compliance without pressure: The foot-in-the-door technique. *Journal of Personality and Social Psychology*, 4(2), 155-202.

Frey, B. S. (1993). Motivation as a limit to pricing. *Journal of Economic Psychology*, 14(4), 635-664. doi: http://dx.doi.org/10.1016/0167-4870(93)90014-C

Gan, K., & Redhead, M. (2013). *Melbourne residential water use studies*. City West Water, South East Water, Yarra Valley Water. Melbourne, VIC: SmartWater Fund. Retrieved from: www.yvw.com.au/yvw/groups/public/documents/document/yvw1004065.pdf

Gardner, G. T., & Stern, P. C. (1996). *Environmental problems and human behavior*. Needham Heights, MA, USA: Allyn & Bacon.

Gardner, G. T. and P. C. Stern (2008). The short list: The most effective actions US households can take to curb climate change. *Environment: Science and Policy for Sustainable Development*, 50(5): 12-25.

Gifford, R. (2011). The dragons of inaction: psychological barriers that limit climate change mitigation and adaptation. American Psychologist, 66(4), 290.

Gifford, R., Kormos, C., & McIntyre, A. (2011). Behavioral dimensions of climate change: drivers, responses, barriers, and interventions. *Wiley Interdisciplinary Reviews: Climate Change*, 2(6), 801-827.

Gilbertson, M., Hurlimann, A., & Dolnicar, S. (2011). Does water context influence behaviour and attitudes to water conservation? *Australasian Journal of Environmental Management*, *18*(1), 47-60.

Gillingham, K., Kotchen, M. J., Rapson, D. S., & Wagner, G. (2013). Energy policy: The rebound effect is overplayed. Nature, 493(7433), 475.

Giurco, D., Carrard, N., McFallan, S., Nalbantoglu, M., Inman, M., Thornton, N., & White, S. (2008). *Residential end-use measurement guidebook: A guide to study design, sampling and technology*. Institute for Sustainable Futures, UTS and CSIRO. Melbourne, VIC: Smart Water Fund.

Glasman, L. R., & Albarracín, D. (2006). Forming attitudes that predict future behavior: A meta-analysis of the attitude-behavior relation. *Psychological Bulletin*, 132(5), 778-822. doi: 10.1037/0033-2909.132.5.778

Gleick, P. H. (1996). Basic water requirements for human activities: Meeting basic needs. *Water International*, *21*(2), 83-92.

Gleick, P. H., & Heberger, M. (2014). Water and conflict. In, *The World's Water* (pp. 159-171). Island Press, Washington, DC.

Gneezy, U., Meier, S., & Rey-Biel, P. (2011). When and why incentives (don't) work to modify behavior. *The Journal of Economic Perspectives*, 25(4), 191-209.

Gosling, S. N. and N. W. Arnell (2016). A global assessment of the impact of climate change on water scarcity. *Climatic Change*, 134(3): 371-385.

Grafton, R. Q., & Ward, M. B. (2008). Prices versus rationing: Marshallian surplus and mandatory water restrictions. *Economic Record*, 84(s1), S57-S65.

Grafton, R. Q., Ward, M. B., To, H., & Kompas, T. (2011). Determinants of residential water consumption: Evidence and analysis from a 10-country household survey. *Water Resources Research*, 47(8), W08537.

Grant, S.B., Fletcher, T.D., Feldman, D., Saphores, J.D., Cook, P.L., Stewardson, M., Low, K., Burry, K. and Hamilton, A.J. (2013). *Adapting urban water systems to a changing climate: Lessons from the Millennium Drought in southeast Australia*. 10727-10734.

Gregory, A., Hall, M. (2011). Urban water sustainability. In I. P. Prosser (Ed.), *Water: Science and solutions for Australia* (pp. 75-88). Melbourne, Vic: CSIRO

Gregory, G. D., & Leo, M. D. (2003). Repeated behavior and environmental psychology: The role of personal involvement and habit formation in explaining water consumption. *Journal of Applied Social Psychology*, 33(6), 1261-1296.

Griggs, D., Stafford-Smith, M., Gaffney, O., Rockström, J., Öhman, M.C., Shyamsundar, P., Steffen, W., Glaser, G., Kanie, N. and Noble, I., 2013. Policy: Sustainable development goals for people and planet. Nature, 495(7441), p.305.

Guadagno, R. E., Demaine, L. J., & Cialdini, R. B. (2001). When saying yes leads to saying no: Preference for consistency and the reverse foot-in-the-door effect. *Personality and Social Psychology Bulletin*, 27(7), 859-867.

Guhathakurta, S., & Gober, P. (2007). The impact of the Phoenix urban heat island on residential water use. *Journal of the American Planning Association*, 73(3), 317-329.

Hamilton, L. C. (1985). Self-reported and actual savings in a water conservation campaign. Environment and Behavior, 17(3), 315-326.

Hallsworth, M. (2014). The use of field experiments to increase tax compliance. *Oxford Review of Economic Policy*, 30(4), 658-679.

Hargroves, K., Desha, C., & Reeve, A. (2010). *Identification and assessment of homeowner behaviours related to reducing residential energy demand: Report to the Townsville CitySolar community capacity building program*. The Natural Edge Project, Griffith University.

Head, L. (2008). Nature, networks and desire: Changing cultures of water in Australia. In P. Troy, (Ed.), *Troubled Waters*, pp 67-80.

Heberger, M. (2011). Australia's Millennium Drought: Impacts and responses. In P. Gleick (Ed.), *The world's water, volume 7: The biennial report on freshwater* (pp. 97-125). California: Pacific Institute for Studies in Development, Environment, and Security

Hensher, D., Shore, N. & Train, K. (2006). Water supply security and willingness to pay to avoid drought restrictions. *Economic Record*, 81, 56–66.

Herczeg, A. (2011). Groundwater. In I. P. Prosser (Ed.), *Water: Science and solutions for Australia* (pp. 47-60). Melbourne, Vic: CSIRO

Hertwich, E. G. (2005). Consumption and the rebound effect: An industrial ecology perspective. *Journal of Industrial Ecology*, 9(1-2), 85-98.

Hobson, K. (2006). Bins, Bulbs, and Shower Timers: On the 'Techno-Ethics' of Sustainable Living. *Ethics, Place & Environment*, 9(3): 317-336.

Holland, R. W., Verplanken, B., & Van Knippenberg, A. (2002). On the nature of attitude–behavior relations: The strong guide, the weak follow. *European Journal of Social Psychology*, 32(6), 869-876.

Homburg, A., & Stolberg, A. (2006). Explaining pro-environmental behavior with a cognitive theory of stress. *Journal of Environmental Psychology*, 26(1), 1-14. doi: http://dx.doi.org/10.1016/j.jenvp.2006.03.003

Hopkin, P. (2017). *Fundamentals of risk management: Understanding, evaluating and implementing effective risk management*. Kogan Page Publishers

Howarth, D., & Butler, S. (2004). Communicating water conservation: how can the public be engaged? Water Science & Technology: Water Supply, 4(3), 33-44.

Howitt, R., Medellín-Azuara, J., MacEwan, D., Lund, J. R., & Sumner, D. (2014). *Economic analysis of the 2014 drought for California agriculture*. University of California, Davis, CA: Center for Watershed Sciences.

Hurlimann, A., & Dolnicar, S. (2010). When public opposition defeats alternative water projects–the case of Toowoomba, Australia. *Water research*, *44*(1), 287-297.

Hurlimann, A., Dolnicar, S., & Meyer, P. (2009). Understanding behaviour to inform water supply management in developed nations. A review of literature, conceptual model and research agenda. *Journal of Environmental Management*, 91(1), 47-56.

Inman, D., & Jeffrey, P. (2006). A review of residential water conservation tool performance and influences on implementation effectiveness. *Urban Water Journal*, 3(3), 127-143.

Inskeep, B. D., & Attari, S. Z. (2014). The water short list: The most effective actions US households can take to curb water use. *Environment: Science and Policy for Sustainable Development*, 56(4), 4-15.

Isler, P. L., Merson, J., & Roser, D. (2010). Drought proofing Australian cities: Implications for climate change adaptation and sustainability. *World Academy of Science, Engineering and Technology*, 70, 352-360.

Iyengar, S. S. and M. R. Lepper (2000). When choice is demotivating: can one desire too much of a good thing? *Journal of Personality and Social Psychology*, 79(6): 995-1006.

Jackson, T. (2005). Live better by consuming less?: is there a “double dividend” in sustainable consumption?. Journal of Industrial Ecology, 9(1‐2), 19-36.

Jansson, J., Marell, A., & Nordlund, A. (2010). Green consumer behavior: Determinants of curtailment and eco-innovation adoption. *Journal of Consumer Marketing*, 27(4), 358-370.

Johnston, M., & Dixon, D. (2008). Current issues and new directions in psychology and health: What happened to behaviour in the decade of behaviour? *Psychology and Health*, 23(5), 509-513.

Jorgensen, B. S., Martin, J. F., Pearce, M., & Willis, E. (2013). Some difficulties and inconsistencies when using habit strength and reasoned action variables in models of metered household water conservation. *Journal of Environmental Management*, 115(0), 124-135

Kantola, S. J., Syme, G. J., & Campbell, N. A. (1984). Cognitive dissonance and energy conservation. Journal of Applied Psychology, 69(3), 416.

Kappel, K. and T. Grechenig (2009). "Show-me": Water consumption at a glance to promote water conservation in the shower. *Proceedings of the 4th International Conference on Persuasive Technology*. Claremont, California, ACM: 1-6.

Karlin, B., Davis, N., Sanguinetti, A., Gamble, K., Kirkby, D., & Stokols, D. (2014). Dimensions of Conservation: Exploring Differences Among Energy Behaviors. Environment and Behavior, 46(4), 423-452. doi: 10.1177/0013916512467532

Kempton, W., Harris, C. K., Keith, J. G., & Weihl, J. S. (1985). Do consumers know "What works" in energy conservation? *Marriage & Family Review*, 9(1-2), 115-133.

Kenway, S. J., Priestley, A., Cook, S., Seo, S., Inman, M., Gregory, A., & Hall, M. (2008). *Energy use in the provision and consumption of urban water in Australia and New Zealand*. Water Services Association of Australia (WSAA): Sydney, Australia.

Kingsford, R. T. (2000). Ecological impacts of dams, water diversions and river management on floodplain wetlands in Australia. *Austral Ecology*, *25*(2), 109-127.

Kingsford, R. T., & Thomas, R. F. (2004). Destruction of wetlands and waterbird populations by dams and irrigation on the Murrumbidgee River in arid Australia. *Environmental Management*, *34*(3), 383-396.

Klöckner, C. A., Nayum, A., & Mehmetoglu, M. (2013). Positive and negative spillover effects from electric car purchase to car use. *Transportation Research Part D: Transport and Environment*, 21, 32-38. doi: 10.1016/j.trd.2013.02.007

Lacasse, K. (2016). Don't be satisfied, identify! Strengthening positive spillover by connecting pro-environmental behaviors to an “environmentalist” label. *Journal of Environmental Psychology*, 48, 149-158.

LaFrance, D. B. (2018). Day Zero, Defeat Day Zero. Journal - American Water Works Association, 110 (3), 10-10. doi: doi:10.1002/awwa.1027

Landon, A. C., Kyle, G. T., & Kaiser, R. A. (2016). Predicting compliance with an information-based residential outdoor water conservation program. *Journal of Hydrology*, 536, 26-36.

Lauren, N., Fielding, K. S., Smith, L., & Louis, W. R. (2016). You did, so you can and you will: Self-efficacy as a mediator of spillover from easy to more difficult pro-environmental behaviour. *Journal of Environmental Psychology*, 48, 191-199.

Leck, H., Conway, D., Bradshaw, M., & Rees, J. (2015). Tracing the water–energy–food Nexus: description, theory and practice. Geography Compass, 9(8), 445-460.

Lindsay, J., Dean, A. J., & Supski, S. (2017). Responding to the Millennium Drought: comparing domestic water cultures in three Australian cities. *Regional Environmental Change*, *17*(2), 565-577.

Littleford, C., Ryley, T. J., & Firth, S. K. (2014). Context, control and the spillover of energy use behaviours between office and home settings. *Journal of Environmental Psychology*, 40, 157-166.

Liu, A., Giurco, D., & Mukheibir, P. (2016). Urban water conservation through customised water and end-use information. *Journal of Cleaner Production*, 112, 3164-3175.

Locke, E. A., & Latham, G. P. (2002). Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. American Psychologist, 57(9), 705-717. doi: 10.1037/0003-066X.57.9.705

Locke, E. A., & Latham, G. P. (2013). Goal setting theory 1990. In E. A. Locke & G. P. Latham (Eds.), New developments in goal setting and task performance (pp. 4-15). Hoboken: Routledge.

Loh, M., Coghlan, P. (2003). *Domestic water use study: In Perth, Western Australia, 1998-2001*. Perth: Water Corporation. Retrieved from www.water.wa.gov.au/PublicationStore/first/42338.pdf

Lokhorst, A. M., Werner, C., Staats, H., van Dijk, E., & Gale, J. L. (2013). Commitment and behavior change: A meta-analysis and critical review of commitment-making strategies in environmental research. *Environment and Behavior*, 45(1), 3-34

Low, K.G., Grant, S.B., Hamilton, A.J., Gan, K., Saphores, J.D., Arora, M. & Feldman, D.L. (2015). Fighting drought with innovation: Melbourne's response to the Millennium Drought in Southeast Australia. *Wiley Interdisciplinary Reviews: Water*, *2*(4), pp.315-328.

MacKay, D. (2008). Every big helps. In Sustainable Energy without the Hot Air. Ch 19, pp.114. Accessed from www.withouthotair.com.

McKenzie-Mohr, D. (2000). New ways to promote proenvironmental behavior: Promoting sustainable behavior: An introduction to community-based social marketing. *Journal of Social Issues*, 56(3), 543-554.

McKenzie-Mohr, D., Lee, N. R., Kotler, P., & Schultz, P. W. (2011). *Social marketing to protect the environment: What works?* Sage Publications.

McKenzie-Mohr, D. & Schultz, P. W. (2014). Choosing effective behavior change tools. *Social Marketing Quarterly*, 20(1): 35-46.

Makki, A. A., Stewart, R. A., Beal, C. D., & Panuwatwanich, K. (2015). Novel bottom-up urban water demand forecasting model: Revealing the determinants, drivers and predictors of residential indoor end-use consumption. *Resources, Conservation and Recycling*, *95*, 15-37.

Makki, A. A., Stewart, R. A., Panuwatwanich, K., & Beal, C. (2013). Revealing the determinants of shower water end use consumption: enabling better targeted urban water conservation strategies. *Journal of Cleaner Production*, 60, 129-146.

Manning, C., Hargroves, K., Walker, M., Lange, J., Igloi, S., Bruce, G., & Desha, C. (2013). Dry Tropics water smart: A community based approach to residential outdoor water consumption. *Australian Water Association Conference*. Perth.

Manning, C., Hargroves, K., Walker, M., Lange, J., Igloi, S., Bruce, G., & Desha, C. (2013). *Dry Tropics water smart: A community based approach to residential outdoor water consumption.* Australian Water Association Conference. Perth.

Mayer, P. W., DeOreo, W. B., Opitz, E. M., Kiefer, J. C., Davis, W. Y., Dziegielewski, B., & Nelson, J. O. (1999). *Residential end uses of water*: AWWA Research Foundation and American Water Works Association.

Mayor, B., Hardy, L., and Lopez-Gunn, E. (2012). *Is the rebound effect / Jevon's Paradox a useful metaphor for water management?* Stockholm World Water Week, Stockholm, August 26-31, 2012.

Melbourne Water (2009) *Melbourne Water Annual Report 2008-2009* Melbourne, Vic: Melbourne Water. Retrieved from www.melbournewater.com.au

Mercer, D., Christesen, L., & Buxton, M. (2007). Squandering the future: Climate change, policy failure and the water crisis in Australia. *Futures*, 39(2), 272-287.

Michie, S., Van Stralen, M. M., & West, R. (2011). The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implementation Science*, 6(1), 42.

Miller, E., & Buys, L. (2008). The impact of social capital on residential water-affecting behaviors in a drought-prone Australian community. *Society & Natural Resources, 21*(3), 244-257.

Murphy, J. (2000). *Imagining the fifties: Private sentiment and political culture in Menzies' Australia*, (pp. 27) Thomas Telford. Sydney: University of New South Wales Press

Nash, N., Whitmarsh, L., Capstick, S., Hargreaves, T., Poortinga, W., Thomas, G., Sautkina, E. and Xenias, D. (2017). Climate‐relevant behavioral spillover and the potential contribution of social practice theory. *Wiley Interdisciplinary Reviews: Climate Change*, 8(6), p.e481.

National Water Commission. (2012). *Groundwater Essentials*. Canberra, ACT: NWC. Retrieved from: www.nwc.gov.au/__data/assets/pdf_file/0020/21827/Groundwater_essentials.pdf

Nauges, C., & Thomas, A. (2000). Privately operated water utilities, municipal price negotiation, and estimation of residential water demand: The case of France. *Land Economics*, 68-85.

Neff, M. (2018). *Simple acts to save our planet: 500 ways to make a difference*. USA: Adams Media.

Nilsson, A., Bergquist, M., & Schultz, W. P. (2017). Spillover effects in environmental behaviors, across time and context: A review and research agenda. *Environmental Education Research*, 23(4), 573-589. doi: 10.1080/13504622.2016.1250148

Olmstead, S. M., & Stavins, R. N. (2009). Comparing price and nonprice approaches to urban water conservation. *Water Resources Research*, 45(4).

Oskamp, S. (2000). A sustainable future for humanity? How can psychology help? American Psychologist, 55(5), 496.

Ouellette, J. A., & Wood, W. (1998). Habit and intention in everyday life: The multiple processes by which past behavior predicts future behavior. *Psychological Bulletin*, 124(1), 54-74

Palmer, M. A. (2010). Water resources: Beyond infrastructure. *Nature*, 467(7315): 534-535.

Parker, S. & Speed, R. (2010). *Agricultural Water Pricing: Australia*. OECD Joint Working Party on Agriculture and the Environment of the Committee for Agriculture and the Environment Policy Committee. Brisbane: Australia.

Pearce, M., Willis, E., Mamerow, L., Jorgensen, B., & Martin, J. (2014). The prestige of sustainable living: implications for water use in A ustralia. The Geographical Journal, 180(2), 161-174.

Pelletier, L. G., Dion, S., Tuson, K., & Green-Demers, I. (1999). Why Do People Fail to Adopt Environmental Protective Behaviors? Toward a Taxonomy of Environmental Amotivation1. Journal of Applied Social Psychology, 29(12), 2481-2504. doi: 10.1111/j.1559-1816.1999.tb00122.

Pigram, J. (2007). Australia's water resources - wet and dry. In J. Pigram, (Ed.) *Australia's water resources: From use to management* (pp. 19-40). Collingwood, Victoria: CSIRO Publishing

Po, M., Nancarrow, B. E., & Kaercher, J. D. (2003). *Literature review of factors influencing public perceptions of water reuse* (pp. 1-39). Victoria: CSIRO Land and Water.

Poortinga, W., Whitmarsh, L., & Suffolk, C. (2013). The introduction of a single-use carrier bag charge in Wales: Attitude change and behavioural spillover effects. *Journal of Environmental Psychology*, 36, 240-247.

Potter, E., Mackinnon, A., McKenzie, S., McKay, J. (2007). *Fresh Water: New Perspectives on Water in Australia*: Carlton, Vic.: Melbourne University Press.

Prosser, I. P. (2011). Current water availability and use. In I.P Prosser (Ed.) *Water: Science and solutions for Australia* (pp 1-16). Melbourne, Vic: CSIRO Publishing.

Ramkissoon, H., Smith, L., & Kneebone, S. (2014). *Accelerating transition to water sensitive cities. Behaviour Assessment Database*. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.

Randolph, B., & Troy, P. (2008). Attitudes to conservation and water consumption. *Environmental Science & Policy*, 11(5), 441-455. doi: http://dx.doi.org/10.1016/j.envsci.2008.03.003

Rathnayaka, K., Maheepala, S., Nawarathna, B., George, B., Malano, H., Arora, M., & Roberts, P. (2014). Factors affecting the variability of household water use in Melbourne, Australia. *Resources, Conservation and Recycling*, 92(Supplement C), 85-94. doi: https://doi.org/10.1016/j.resconrec.2014.08.012

Ravandi, M., Mok, J., & Chignell, M. (2009) *Development of an emotional interface for sustainable water consumption in the home.* 13th International Conference on Human-Computer Interaction, HCI International 2009: Vol. 5612 LNCS (pp. 660-669). San Diego, CA.

Renwick, M. E., & Archibald, S. O. (1998). Demand Side Management Policies for Residential Water Use: Who Bears the Conservation Burden? Land Economics, 74(3), 343-359.

Ritchie, J. B., & McDougall, G. H. (1985). Designing and marketing consumer energy conservation policies and programs: Implications from a decade of research. *Journal of Public Policy & Marketing*, 4(1), 14-32.

Roberts, P. (2005). *Yarra Valley Water: 2004 residential end use measurement study*. (pp. 1-77). Melbourne: Yarra Valley Water.

Roberts, P. (2014). Factors affecting the variability of household water use in Melbourne, Australia. *Resources, Conservation and Recycling*, 92, 85-94.

Roseth, N. (2006). Community views on water shortages and conservation. *Water, 33*(8), 62-66.

Rutherfurd, I., & Finlayson, B. L. (2011). Whither Australia: Will availability of water constrain the growth of Australia's population? *Geographical Research, 49*(3), 301–316.

Sarac, K., Day, D., & White, S. (2003). What are we saving anyway? The results of three water demand management programs in NSW, Australia. *Water Supply*, 3(3), 215-222.

Saunders, H. (2013). Is what we think of as "rebound" really just income effects in disguise? *Energy Policy*, 57(0), 308-317.

Schultz, P. W., Nolan, J. M., Cialdini, R. B., Goldstein, N. J., & Griskevicius, V. (2007). The constructive, destructive, and reconstructive power of social norms. *Psychological Science*, 18(5), 429-434.

Schultz, P. W., & Zelezny, L. C. (1998). Values and proenvironmental behavior: A five-country survey. *Journal of Cross-Cultural Psychology*, 29(4), 540-558.

Schultz, P. W., & Zelezny, L. (1999). Values as predictors of environmental attitudes: Evidence for consistency across 14 countries. *Journal of Environmental Psychology*, 19(3), 255-265.

Schwartz, B. (2004). *The paradox of choice: Why more is less*. (Vol. 6). New York: HarperCollins.

Sherwood, S. and Q. Fu (2014). A drier future? *Science*, 343(6172): 737-739.

Shove, E. (2003). Converging conventions of comfort, cleanliness and convenience. *Journal of Consumer Policy*, 26(4), 395-418.

Sintov, N., Geislar, S., & White, L. V. (2017). Cognitive accessibility as a new factor in proenvironmental spillover: results from a field study of household food waste management. *Environment and Behavior*, 0013916517735638.

Smith, L.D.S. (2012). *Accelerating transitions to Water Sensitive Cities by influencing behaviour*. Research Project Proposal, CRC Water Sensitive Cities.

Sorrell, S. (2007). *The rebound effect: An assessment of the evidence for economy-wide energy savings from improved energy efficiency*. London, UK: UK Energy Research Centre.

Steg, L., & Vlek, C. (2009). Encouraging pro-environmental behaviour: An integrative review and research agenda. *Journal of Environmental Psychology*, 29(3), 309-317. doi: http://dx.doi.org/10.1016/j.jenvp.2008.10.004

Stern, P. C. (1999). Information, incentives, and proenvironmental consumer behavior. *Journal of Consumer Policy*, 22(4), 461-478.

Stewart, R. A., Beal, C. D., Gardner, J., Spinks, A. B., McCrae, R., & Fielding, K. S. (2013). Mind or machine: Examining the drivers of residential water end-use efficiency. *Water: Journal of the Australian Water Association*, 40(3), 66.

Stewart, R. A., Willis, R. M., Panuwatwanich, K., & Sahin, O. (2013). Showering behavioural response to alarming visual display monitors: longitudinal mixed method study. *Behaviour & Information Technology*, 32(7), 695-711.

Stone, J., Aronson, E., Crain, A. L., Winslow, M. P., & Fried, C. B. (1994). Inducing hypocrisy as a means of encouraging young adults to use condoms. *Personality and Social Psychology Bulletin*, 20(1), 116-128.

Supski, S., & Lindsay, J. (2013). *Australian domestic water use cultures: A literature review*. Melbourne, Australia: CRC for Water Sensitive Cities.

Syme, G. (2008). Urban water: Is efficiency enough? *Australian Economic Review*, 41(4): 435-440.

Syme, G. J., & Hatfield-Dodds, S. (2007). *The role of communication and attitudes research in the evolution of effective resource management arrangements*. In Hussey, K. & Dovers, S. (Ed.) Managing water for Australia: The social and institutional challenges. Ch 2, pp. 11-22.

Syme, G. J., Nancarrow, B. E., & Seligman, C. (2000). The evaluation of information campaigns to promote voluntary household water conservation. *Evaluation Review*, 24(6), 539-578. doi: 10.1177/0193841x0002400601

Syme, G. J., Shao, Q., Po, M., & Campbell, E. (2004). Predicting and understanding home garden water use. *Landscape and Urban Planning, 68*(1), 121-128.

Taylor, S. E. (1975). On inferring one's attitudes from one's behavior: Some delimiting conditions. *Journal of Personality and Social Psychology*, 31(1), 126.

Thøgersen, J. (1999). Spillover processes in the development of a sustainable consumption pattern. *Journal of Economic Psychology*, 20(1), 53-81

Thøgersen, J. (2004). A cognitive dissonance interpretation of consistencies and inconsistencies in environmentally responsible behavior. *Journal of Environmental Psychology*, 24(1), 93-103.

Thøgersen, J. (2012). *Pro-environmental spillover: Review of research on the different pathways through which performing one pro-environmental behaviour can influence the likelihood of performing another*. Report (unpublished) produced for BehaviourWorks Australia.

Thøgersen, J., & Crompton, T. (2009). Simple and painless? The limitations of spillover in environmental campaigning. *Journal of Consumer Policy*, 32(2), 141-163.

Thøgersen, J., Haugaard, P., & Olesen, A. (2010). Consumer responses to ecolabels. *European Journal of Marketing*, 44(11/12), 1787-1810.

Thøgersen, J., & Noblet, C. (2012). Does green consumerism increase the acceptance of wind power? *Energy Policy*, 51(0), 854-862.

Thøgersen, J., & Ölander, F. (2003). Spillover of environment-friendly consumer behaviour. *Journal of Environmental Psychology,* 23(3), 225-236.

Truelove, H. B., Carrico, A. R., Weber, E. U., Raimi, K. T., & Vandenbergh, M. P. (2014). Positive and negative spillover of pro-environmental behavior: An integrative review and theoretical framework. *Global Environmental Change*, 29(0), 127-138. doi: http://dx.doi.org/10.1016/j.gloenvcha.2014.09.004

Turner, A., Fyfe, J., Retamal, M., White, S., & Coates, A. (2010). SEQ's one to one water savings program. *Water, 37*(1), 82-91.

Turner, A., White, S., Beatty, K., & Gregory, A. (2005). Results of the largest residential demand management program in Australia. *Water Science & Technology: Water Supply, 5*(1), 249-256.

United Nations (2018). Launch of the international decade of water for sustainable development. Retrieved from: www.un.org/pga/72/event-latest/launch-of-the-international-decade-of-water-for-sustainable-development-2018-2028/

Van den Honert, R. C. and J. McAneney (2011). The 2011 Brisbane floods: Causes, impacts and implications. *Water*, 3(4): 1149.

Van der Werff, E., Steg, L., & Keizer, K. (2014). Follow the signal: When past pro-environmental actions signal who you are. *Journal of Environmental Psychology*, 40(0), 273-282. doi: http://dx.doi.org/10.1016/j.jenvp.2014.07.004

Van der Werff, E., Steg, L., & Keizer, K. (2014 b). I am what I am, by looking past the present: The influence of biospheric values and past behavior on environmental self-identity. *Environment and Behavior*, 46(5), 626-657.

Verplanken, B., & Holland, R. W. (2002). Motivated decision making: effects of activation and self-centrality of values on choices and behavior. *Journal of Personality and Social Psychology*, 82(3), 434-447.

Verplanken, B., & Wood, W. (2006). Interventions to break and create consumer habits. *Journal of Public Policy & Marketing*, 25(1), 90-103.

Vörösmarty, C.J., Green, P., Salisbury, J. and Lammers, R.B. (2000). Global water resources: vulnerability from climate change and population growth. S*cience*, *289*(5477), pp.284-288.

Wagner, G. (2011). But will the planet notice? How smart economics can save the world. New York: Hill and Wang Inc.

Walton, D. (2010). *Appeal to expert opinion: Arguments from authority*. Penn State Press.

Walton, A., & Hume, M. (2011). Creating positive habits in water conservation: the case of the Queensland Water Commission and the Target 140 campaign. International Journal of Nonprofit and Voluntary Sector Marketing, 16(3), 215-224. doi: 10.1002/nvsm.421

Water Corporation. (2010). *Perth Residential Water Use Study 2008/2009*. Water Corporation Technical Report, Perth, Western Australia.

Water Services Association of Australia. (2013). *Dams Information Pack.* Retrieved from: www.wsaa.asn.au/publication/dams-information-pack

Weber, E. U. (1997). Perception and expectation of climate change. *Psychological perspectives to environmental and ethical issues in management*, 314-341.

Weber, E. U. (2006). Experience-based and description-based perceptions of long-term risk: Why global warming does not scare us (yet). *Climatic Change*, 77(1-2), 103-120.

Willis, E., Pearce, M., Mamerow, L., Jorgensen, B., & Martin, J. (2013). Perceptions of water pricing during a drought: A case study from South Australia. *Water*, 5(1), 197-223.

Willis, R. M., Stewart, R. A., Giurco, D. P., Talebpour, M. R., & Mousavinejad, A. (2013). End use water consumption in households: Impact of socio-demographic factors and efficient devices. *Journal of Cleaner Production* (0).

Willis, R. M., Stewart, R. A., Panuwatwanich, K., Jones, S., & Kyriakides, A. (2010). Alarming visual display monitors affecting shower end use water and energy conservation in Australian residential households. *Resources, Conservation and Recycling, 54*(12), 1117-1127.

Woods, J. (2008). What people do when they say they are conserving electricity? *Energy Policy*, 36(6): 1945-1956.

WHO/UNICEF. (2017). *Progress on drinking water, sanitation and hygiene: 2017 update and SDG baselines*. Joint Monitoring Program (JMP) for Water Supply, Sanitation and Hygiene. Geneva: World Health Organization (WHO) and the United Nations Children's Fund (UNICEF).

Chapter 2: Identifying water conservation behaviours

2.0 Introduction

The first research objective was to *identify water conservation behaviours for adoption at a household level*, to investigate as the basis of subsequent studies. This identification exercise was completed using a dual-method approach, via desktop analysis of literature (including grey literature) and workshops with water industry professionals. The outcomes of both approaches demonstrated the range of actions householders can participate in to reduce water consumption.

2.1 Construction of a 'long list' from the grey literature

Previous studies have touched on the number of water demand management behaviours that can be promoted to householders. One investigation into outdoor water conservation behaviours identified over 60 for consideration (Manning et al., 2013). The long lists of behaviours promoted through water saving resources, such as websites (e.g. Save Water Alliance) and books (e.g. Coulthard, 2006), have been criticised as confusing or disengaging, leaving the decision of which behaviours to engage with to the consumer (Gardner & Stern, 2008). From a pragmatic perspective, we needed to produce a list of behaviours that was long enough to incorporate the diversity of behaviour, whilst not being so exhaustive as to make subsequent data collection impractical.

First, a long-list of behaviours was developed, through review of grey and published literature. This focussed specifically on water conservation behaviours promoted in Australia during the Millennium Drought. Sources of water conservation behaviours included state-supported websites, such as *Water – Learn It! Live it!* (VIC), *Waterwise* (QLD), *Save Water* (Save Water Alliance, nationwide), *Water for Life* (NSW), *Watch Every Drop* (QLD), and printed material promoting water conservation (e.g. Coulthard, 2006). Behaviours originating from a number of different campaigns and water conservation programs were compiled and compared against each other. Those behaviours that appeared most frequently or were identified as creating the largest water savings, formed the basis of a 'long list' of 25 behaviours. A second round of literature review was carried out to ensure diversity of behaviours for investigation. This identified an additional ten behaviours for consideration by focusing on water conservation in the outside space. The process included comparison with behaviours identified within the '*Dry Tropics water smart residential outdoor water conservation program*' (Manning et al., 2013).

2.2 Behaviour verification by water industry professionals

The long-list of behaviours generated from the literature review underwent examination and verification through three workshop sessions with water industry professionals held in Brisbane, Perth and Melbourne (April, 2013). These cities were selected because they represented the main Australian hubs of the Centre for Research Cooperation Water Sensitive Cities (CRCWSC) and many of the industry partners involved with the research program. This permitted easier recruitment through existing networks and provided a range of water contexts from which participants would approach the issue of water consumption. The CRCWSC provided advice and ideas for potential organisations, and which individuals within organisations were particularly pertinent to be part of the workshops.

Workshop participants were invited from across the water sector and specifically for their experience working with communities and in public engagement. Most study participants were employees of industry partners of the CRC for Water Sensitive Cities program, representing water supply corporations, city councils, government departments, consultants and NGOs. Each invitee was emailed an invitation comprising the workshop program, the objective to identify and discuss water sensitive behaviours, and the significance of the project. To facilitate focussed discussion fifteen places were allocated per workshop. The summary of attendance is detailed in Table 1.

Table 1: List of organisations represented at the industry partner workshops.

Organisations represented at water professional workshops		
Brisbane	**Perth**	**Melbourne**
Brisbane City Council	Department of Water	Knox City Council
The Wilston Group	Metropolitan Redevelopment Authority	City of Kingston
Department of Energy and Water Supply	City of Gosnells	Yarra Riverkeepers
SEQ Water	Central West Catchment Management Authority (NSW)	Office of Living Victoria
Healthy Waterways	Eastern Metropolitan Regional Council	City of Boroondara
Brisbane City Council	Water Corporation	
Urban Land Development Authority	City of Vincent	
Gold Coast Water		
12 participants	*10 participants*	*5 participants*

Each workshop followed the same structure; an introduction to the project outlining the proposed outcomes of the study, a definition of behaviour and audience preferences, followed by participant discussion around potential target behaviours for householders to encourage water conservation. Participants were divided into groups of 3-5 people, with one scribe appointed to record behaviours on a prepared results sheet. The workshop adapted the nominal group technique (Delbecq & Van de Ven, 1971); in initial phases all suggestions, in this case behaviours, are considered valid and are recorded.

Participant groups were provided with the 'long lists' of behaviours generated from the grey literature review for comment and review. They were asked to refine the behaviours within the list, and were encouraged to add further behaviours they considered of significance for water conservation. The results of the discussions produced an additional 13 water conservation behaviours for inclusion in the investigations. The full list of behaviours was refined through categorisation, removal of redundancies and checked for indivisibility and an end-state target (McKenzie-Mohr, 2011; McKenzie-Mohr, Lee, Schultz & Kotler, 2011).

2.3 Categorisation of water conservation behaviours

The three stage process, i.e. two rounds of literature review and one round of discussion by water industry professional resulted in 46 behaviours for investigation. These were categorised into three behaviour types using open coding (Glaser & Strauss, 1967). Each behaviour was identified as curtailment, efficiency or maintenance type, based on typologies suggested by literature (e.g. Gardner & Stern 1996; Barr, Gilg & Ford, 2005). An iterative approach was taken, repeating the coding process with two researchers (to increase its validity and reliability) until all the behaviours had been allocated to the most appropriate category. The final list of behaviours, including the behaviour category is presented in Table 2. Further details about the behaviour categories are included in Chapter 3, section 1.3.

1) Efficiency behaviours

These are one-off behaviours involving the installation of (technological) systems or devices able to perform the same service with greater water efficiency, thereby saving water every time they are used (Barr, Gilg & Ford, 2005). Once the efficient device is installed the behaviour is complete, so the effort expended only happens once, however, there may be significant costs, whether financial, cognitive or physical associated with the initial purchase and installation (Gardner & Stern 1996; Barr, Gilg & Ford, 2005).

2) Curtailment behaviours

Curtailment behaviours involve reducing the amount of water expended on a regular, weekly, daily or several times-a-day basis, by reducing the amount of water consumed through the behaviour. This includes taking a shorter shower, selecting the short flush on a dual flush toilet, or turning the tap off sooner than usual. Curtailment type behaviours may include habitual behaviours, notable for their automaticity and stability within a given context and thus challenging to influence (Ouellette & Wood, 1998; Verplanken & Wood, 2006).

3) Maintenance behaviours

These are not carried out frequently enough to be considered habits, and do not involve changing systems to save water; rather, they involve periodic checks for leaks or behaviours that ensure that systems run efficiently (Ölander & Thøgersen, 1995; Kempton, Darley & Stern, 1992). If problems are identified, additional costs may be required to resolve them, including financial, cognitive or physical effort.

Table 2: Final list of behaviours created following expert review, allocated to the three categories of behaviour type described.

Efficiency	Curtailment	Maintenance
Install water efficient taps or aerators.	Take a shorter shower	Fix leaking taps (house-wide).
Replace a single flush toilet cistern with a dual flush system.	Collect shower warm-up water in a bucket to use in the garden.	Fix leaking hoses or irrigation systems.
Use a cistern weight if don't have a dual flush toilet.	Turn off tap when shaving or brushing teeth.	Fix leaking pipes (house-wide).
Install a low-flow showerhead.	Reduce the frequency of toilet flushing.	Fix leaking toilet cisterns.
Buy a water efficient (4 star or above) dishwasher.	Scrape plates clean of food instead of pre-rinsing.	Read the meter to monitor household water use.
Buy a water efficient (4 star or above) front-loader washing machine.	Do not use an in-sink garbage disposal unit.	Allow lawn to go 'golden' (i.e. brown-off).
Install a grey water system to reuse shower and laundry water in the garden (not for vegetables).	Wash-up dishes by hand.	Raise the thermostat on household evaporative air conditioners to 24oC
Install a rainwater tank to supply irrigation water.	If using a dishwasher, ensure it is full for every wash.	Wash the car(s) less often.
Install a rainwater tank to supply water for use inside the home.	Only wash full loads of clothes.	Use a 5 – 10cm layer of mulch on garden beds and potted plants.

Plumb the rainwater tank to the toilet for flushing.	Defrost food in the fridge overnight, rather than under a running tap.	
Install a water efficient targeted irrigation system.	Wash vegetables in a bowl of water, and then use it in the garden.	
Install a pool cover.	Compost kitchen scraps and add to garden, to improve the water retention of soil.	
Install a water efficient pool filter.	Water the garden with a watering can, rather than a hose.	
Group plants with similar water needs together.	Adjust watering schedules according to weather conditions and landscape requirements.	
Plant native or drought-tolerant plants.	Water the garden in the early morning or evening to reduce evaporation.	
Replace 'thirsty' species of turf with drought-resistant varieties of grasses.	Use a broom, instead of a hose, to clean outside spaces.	
Reduce the area of lawn within property.	Keep swimming pools covered when not in use to reduce evaporation.	
Use timer-controlled drip irrigation, rather than a sprinkler system.	Go meat-free one day a week.	
	Go dairy-free one day a week.	
18	**19**	**9**

As Table 2 shows, 18 behaviours were identified in the efficiency category, 19 in the curtailment category and nine in the maintenance category. Examples of efficiency behaviours include installing a low-flow showerhead or reducing the area of lawn within the property. Curtailment behaviours included washing vegetables in a bowl of water rather than under a running tap and using a broom instead of a hose to clean outside spaces Finally, maintenance behaviours related to fixing leaks in taps, hoses and so on and regular systems-checks such as reading the meter to monitor household water use and using a 5-10cm layer of mulch on garden beds.

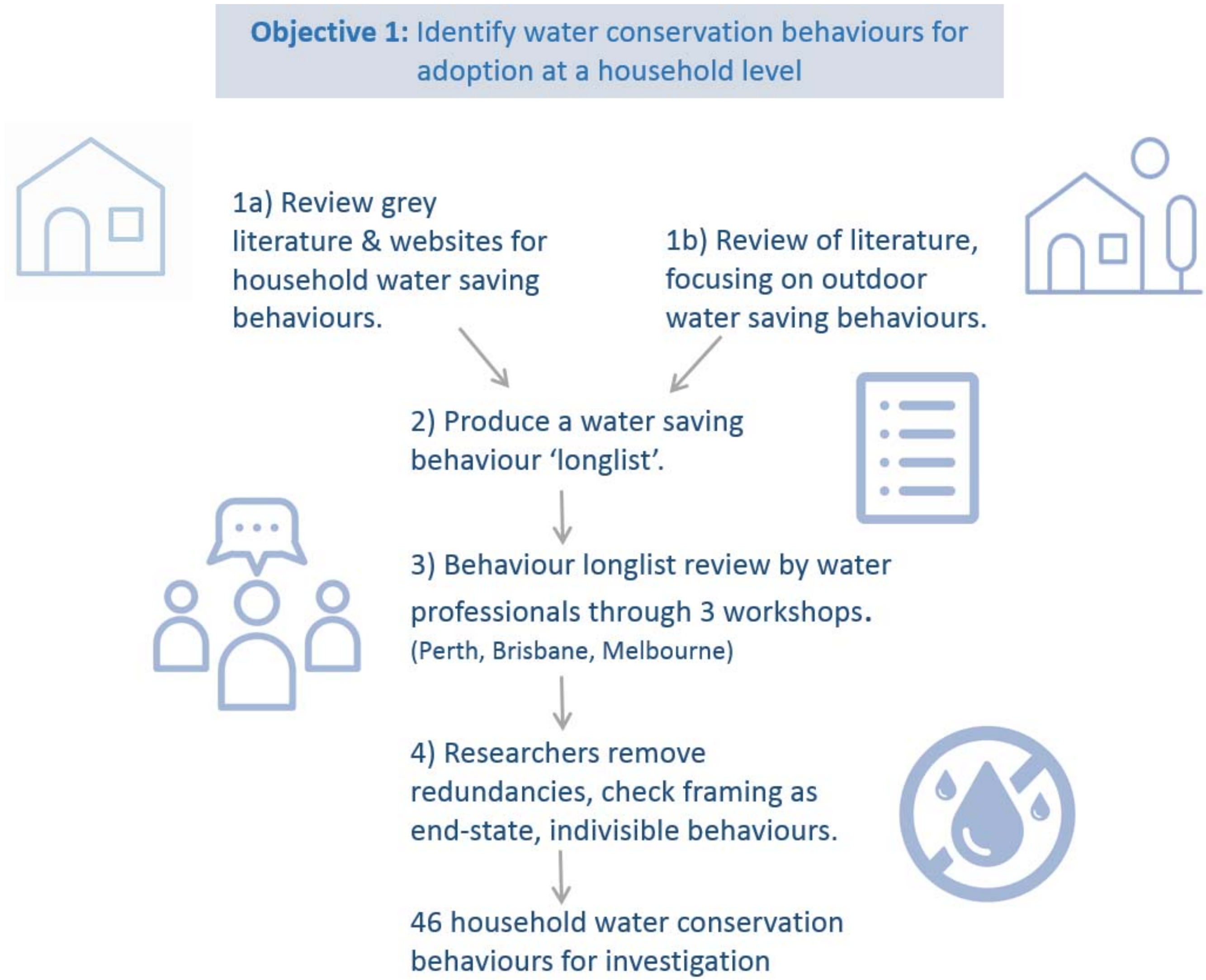

Figure A: Summary of the data collection process used to create a shortlist of household water conservation behaviours for investigation.

References

Barr, S., Gilg, A. W., & Ford, N. (2005). The household energy gap: Examining the divide between habitual and purchase-related conservation behaviours. *Energy Policy*, 33(11), 1425-1444. doi: 10.1016/j.enpol.2003.12.016

Coulthard, L. (2006). *365 Water saving tips*. USA: Hinkler Books.

Delbecq, A. L., & Van de Ven, A. H. (1971). A group process model for problem identification and program planning. *The Journal of Applied Behavioral Science*, 7(4), 466-492. doi: 10.1177/002188637100700404

Gardner, G. T., & Stern, P. C. (1996). *Environmental problems and human behavior*. Boston: Allyn & Bacon.

Gardner, G. T., & Stern, P. C. (2008). The short list: The most effective actions US households can take to curb climate change. *Environment: Science and Policy for Sustainable Development*, 50(5), 12-25.

Glaser, B., & Strauss, A. (1967). The discovery of grounded theory: Strategies for qualitative research. pp 101-116. Chicago: Aldine.

Kempton, W., Darley, J. M., & Stern, P. C. (1992). Psychological research for the new energy problems: Strategies and opportunities. *American Psychologist*, 47(10), 1213.

McKenzie-Mohr, D. (2011). Fostering sustainable behavior: An introduction to community-based social marketing. Canada: New Society Publishers.

McKenzie-Mohr, D., Lee, N. R., Schultz, P. W., & Kotler, P. (2011). Social marketing to protect the environment: What works. SAGE Publications, Incorporated.

Manning, C., Hargroves, K., Walker, M., Lange, J., Igloi, S., Bruce, G., & Desha, C. (2013). Dry Tropics water smart: A community based approach to residential outdoor water consumption. *Australian Water Association Conference*. Perth.

Ölander, F., & Thøgersen, J. (1995). Understanding of consumer behaviour as a prerequisite for environmental protection. *Journal of Consumer Policy*, 18(4), 345-385.

Ouellette, J. A., & Wood, W. (1998). Habit and intention in everyday life: The multiple processes by which past behavior predicts future behavior. *Psychological Bulletin*, 124(1), 54-74. doi: 10.1037/0033-2909.124.1.54

Save Water Alliance (2011) How to save water in the home. Accessed from http://www.savewater.com.au/, retrieved May 2013

Verplanken, B., & Wood, W. (2006). Interventions to break and create consumer habits. *Journal of Public Policy & Marketing*, 25(1), 90-103. doi: 10.2307/30000528

Chapter 3: Development and application of a tool for behaviour prioritisation

3.0 Introduction

This chapter addresses the second research objective, to d*evelop and test a prioritisation tool to facilitate behaviour selection for behaviour change program design.* Existing approaches to behaviour prioritisation provide a ranking or simplified selection process, based on an assessment of the impact of a behaviour on the issue at hand (e.g. Gardner & Stern, 2008) and / or the likelihood of adoption of the behaviour by the target audience (e.g. McKenzie-Mohr, 2011; McKenzie-Mohr & Schultz, 2014). Other researchers have suggested prioritising target behaviours through identification of the '*low-hanging fruit*'; those actions which are highly probable or have a high likelihood of participation (as they are seen to be easy) and have a high impact on addressing the problem (Inskeep & Attari, 2014). Governments have previously targeted high likelihood, easy to adopt behaviours as a means to start engaging consumers with, for example, pro-environmental behaviours (DEFRA, 2008). However, Thøgersen and Crompton (2009) caution against the promotion of '*simple and painless'* behaviours, i.e., behaviours that are easy to adopt, with a high likelihood of participation, but are '*environmentally insignificant*', with little meaningful impact on the issue at hand. Within the current context of a wide range of potential behaviours to focus demand management programming on, water managers therefore need a method of assessment accounting for both areas of concern.

The approach taken and described in this paper not only permits behaviours to be prioritised, but also provides insight for eventual intervention design, The data collected incorporated three separate measures of perceived likelihood; the financial cost, mental effort and physical effort involved in behaviour adoption. Other researchers interested in effort of adoption have scored behaviours combining these three measures (e.g. Attari, DeKay, Davidson & de Bruin, 2011; Manning et al., 2013). As participants in this study rated each type of effort or cost separately, the data allowed a more detailed understanding of which *type* of effort was scored highest and therefore might be perceived as a barrier to participation by respondents. The identification of the 'barrier effort' indicates how interventions could be developed that specifically address the largest or most recognised barrier to participation for each behaviour (Michie, van Stralen & West, 2011).

The paper included in this chapter has been subject to peer-review and published in the Journal of Environmental Science and Policy. It is presented in the publication layout as recommended by Monash University's guidelines for Thesis by Publication.

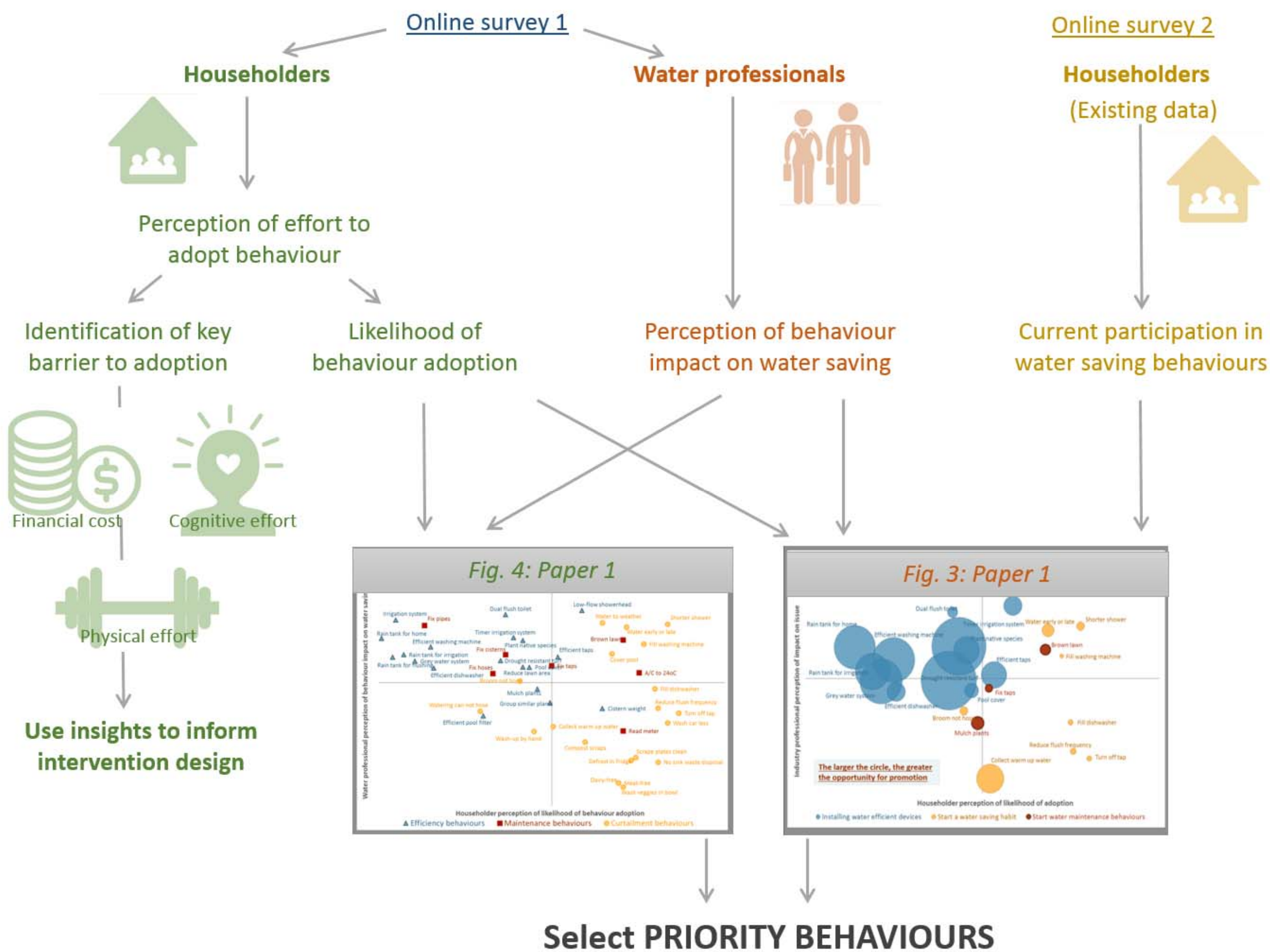

Figure A: Summary of the data collection process used to create an Impact-Likelihood matrix.

References

Attari, S. Z., DeKay, M. L., Davidson, C. I., & de Bruin, W. B. (2011). Changing household behaviors to curb climate change: How hard can it be? *Sustainability: The Journal of Record, 4*(1), 9-11.

Department for Environment, Food and Rural Affairs (DEFRA). (2008). *A framework for pro-environmental behaviours*. London: Department for Environment, Food and Rural Affairs.

Gardner, G. T., & Stern, P. C. (2008). The short list: The most effective actions US households can take to curb climate change. *Environment: Science and Policy for Sustainable Development, 50*(5), 12-25.

Inskeep, B. D., & Attari, S. Z. (2014). The water short list: The most effective actions US households can take to curb water use. *Environment: Science and Policy for Sustainable Development, 56*(4), 4-15.

McKenzie-Mohr, D. (2011). *Fostering sustainable behavior: An introduction to community-based social marketing*. Canada: New Society Publishers.

McKenzie-Mohr, D., & Schultz, P. W. (2014). Choosing effective behavior change tools. *Social Marketing Quarterly, 20*(1), 35-46.

Manning, C., Hargroves, K., Walker, M., Lange, J., Igloi, S., Bruce, G., & Desha, C. (2013). Dry Tropics water smart: A community based approach to residential outdoor water consumption. *Australian Water Association Conference*. Perth.

Michie, S., van Stralen, M. M., & West, R. (2011). The behaviour change wheel: A new method for characterising and designing behaviour change interventions. *Implementation Science, 6*(1), 42.

Thøgersen, J., & Crompton, T. (2009). Simple and painless? The limitations of spillover in environmental campaigning. *Journal of Consumer Policy, 32*(2), 141-163. doi: 10.1007/s10603-009-9101-1

3.1 Publication 1: *The Impact-Likelihood matrix: A policy tool for behaviour prioritisation*

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The Impact-Likelihood Matrix: A policy tool for behaviour prioritisation

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ABSTRACT

The proliferation of applied behaviour change science over the past decade has provided new ways of thinking about policy making. Policy makers now have a range of frameworks and methods to assist in formulating change for social and environmental benefits. However, the development of strategies for the identification and prioritisation of target behaviours has been less forthcoming. This paper outlines a tool to assist in behaviour selection. Behaviours are assessed for their potential impact on addressing a specific issue, the likelihood of adoption by the target audience and existing participation levels within the target audience. Each of these characteristics is scored, allowing behaviours to be mapped onto a meaningful, visual, matrix for prioritisation. Additional data on behaviour type and the key perceived barriers to participation in each behaviour are layered onto the matrix to provide direction for intervention design. An application of the prioritisation matrix is presented within an environmental context through a case study of water demand management behaviours for domestic consumers in Australia. The prioritisation matrix could provide a decision-making tool for policy makers to assist in the selection of target behaviours to address complex issues.

1. Introduction

Identifying and implementing solutions to complex environmental issues such as climate change, deforestation and natural resource management continues to challenge researchers and policy makers (Head, 2014). Human behaviour is a fundamental part of these environmental issues and therefore changing behaviour is a critical part of the solution (Corner and Owen, 2014; Schultz, 2011; Jackson, 2005; Ölander and Thøgersen, 1995). This has prompted governments to apply behaviour change science to address some of these concerns (e.g., Dilley, 2015; Kazdin, 2009). For example, 'nudge' interventions, designed to facilitate single-action beneficial outcomes, have been successfully trialled to support policy translation to behaviour change within the environmental, health and social fields (Jones et al., 2014, 2011).

While nudges may be useful when an individual outcome is defined, more complex policy problems are likely to have multiple behavioural solutions. For example within the environmental context, an array of actions, and target audiences, may contribute towards an environmental goal. The Global Action Plan Ecoteam program to reduce household environmental impacts targeted 93 behaviours across transportation, waste, shopping, water and energy consumption (Staats et al., 2004; Staats and Harland, 1995). Studies investigating household energy saving actions in the USA and Australia have identified between 100 and 261 behaviours for household energy consumption reduction (Woods, 2008; Hargroves et al., 2010; Boudet et al., 2016). A household water demand management program identified 64 behaviours just considering outdoor water use (Manning et al., 2013). Identifying clearly defined behaviours to achieve specific outcomes is vital for focused program design, ensuring successful intervention development and production of accurate program evaluation (McKenzie-Mohr and Smith, 1999; McKenzie-Mohr et al., 2011; Stern, 2011). For the environmental policy-maker with limited resources wanting to trial an intervention campaign, selecting target behaviours out of the myriad of options is a challenge. Tools to help decision-makers focus their behaviour change programs are therefore essential for goals to be met with the resources available.

1.1. Identifying and prioritising target behaviours

The behaviour change literature describes many methods to investigate audiences and develop effective intervention programs

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for behaviour adoption. For example, in the area of water conservation, audiences have been characterised by identity (Fielding and Hornsey, 2016), beliefs (Russell and Fielding, 2010), context (Gilbertson et al., 2011), habits (Russell and Fielding, 2010) and existing behaviours (Dean et al., 2016). The intervention methods used to modify water use behaviours have also undergone investigation, with evaluation of communication methods (e.g. Seyranian et al., 2015; Fielding et al., 2013; Syme et al., 2000), incentives (Gato-Trinidad and Gan, 2012), pricing structures (Olmstead and Stavins, 2009), and regulation (Oh and Svendsen, 2015). In contrast, it has been noted that there is a relative dearth of work on the behaviour identification and prioritisation elements of the behaviour change process (Inskeep and Attari, 2014; Department of Environment and Food Rural Affairs, 2008), with few methods trialled. The current research seeks to address this limitation by developing and testing a visual technique for prioritising target behaviours to change.

For some policy issues, such as getting cyclists to wear helmets (Quine et al., 2001), or encouraging citizens to pay taxes on time (Hallsworth et al., 2014), the behavioural outcome is evident. In the environmental field however, program goals, such as aiming to reduce carbon dioxide emissions, are complex (Ludwig, 2001) and identification of behaviours addressing such issues may require input from multiple stakeholders, including industry professionals, academics and target audience members (e.g. Hargroves et al., 2010; Boudet et al., 2016; Manning et al., 2013). As a result, behavioural solutions to issues of resource management may number in their hundreds (Boudet et al., 2016; Woods, 2008), resulting in the publication of lengthy '*How-to*' guides for personal environmental-impact reduction practices (such as Yarrow, 2008; Goodall, 2007; Berners-Lee, 2011). The identification and promotion of long lists of target behaviours for audience adoption has been criticised for being confusing, overwhelming target audiences, reinforcing existing misconceptions and reducing participation (Gardner and Stern, 2008; Karlin et al., 2014). Prioritisation of potential actions addresses such issues, and facilitates the development of focussed interventions (Gardner and Stern, 2002).

Various approaches to prioritisation have been proposed, including prioritising on the basis of how much resource can be saved through adopting a behaviour (i.e. amount of impact on the issue), the likelihood of behavioural adoption by the target audience, the level of current participation in a behaviour, and a combination of the three. In terms of using behavioural impact as a method for prioritisation, Gardner and Stern (2008) identified 17 actions that were estimated to save 58.2% of US household energy use and Inskeep and Attari (2014) identified 14 behaviours that could save up to 75.3% of indoor water use. The authors recommended that the 'shortlists' which emerged from their research be promoted to householders, although they also recognised that householders may face '*economic, psychological, sociocultural and informational*' barriers in behaviour participation (Inskeep and Attari, 2014, p.12).

The recognition that a range of barriers may hinder behavioural adoption and affect the ease of behavioural uptake (Gardner and Stern, 2008) despite audience motivation (Stern, 2000) speaks to the issue of likelihood of adoption, a second important dimension which can be used to prioritise behaviours in behaviour change campaigns. Financial, (Clarke and Brown, 2006), physical (Black et al., 1985), cognitive or temporal costs of participation (Bandura, 1997; Smith et al., 2010; Diekmann and Preisendorfer, 2003; Attari et al., 2010) may make a behaviour harder to engage in and thereby decrease the likelihood of adoption.

In contrast, behaviours with lower perceived costs or effort of participation are more likely to be adopted (Osbaldiston and Schott, 2011). Researchers have used perceptions of effort as a proxy for likelihood of behaviour adoption. Specifically, householder perceptions of physical effort, cognitive effort, temporal and financial costs were used to assess the likelihood of participation in energy-saving behaviours (Attari et al., 2011). However, prioritisation of behaviours based solely on the likelihood of adoption risks promotion of '*simple and painless*' behaviours (Thøgersen and Crompton, 2009). These behaviours may be low effort and relatively easy for audiences to perform, but have little impact on the issue at hand. This is of particular concern when considering the immediate, large-scale changes required to address many environmental issues (Thøgersen and Crompton, 2009; MacKay, 2008) and highlights the need to consider both impact on the issue and likelihood of adoption (Ölander and Thøgersen, 1995; Kollmuss and Agyemann, 2002) when considering behaviour prioritisation (Steg and Abrahamse, 2010).

One approach to prioritisation that incorporates the two concepts of impact on the issue and likelihood of adoption is the '*Community Based Social Marketing*' (CBSM) methodology. This combines behaviour identification with cost-benefit analysis to create and refine long-lists of behaviours, scoring them on their impact on the issue and probability of adoption by the target audience (McKenzie-Mohr and Smith, 1999; McKenzie-Mohr et al., 2011). Each behaviour identified is also scored on the existing level of engagement within the target community. If the target audience already engages with the desired behaviour, the potential for additional uptake is limited to the few people not already practising the behaviour. Behaviours with lower current participation therefore have greater potential, or opportunity, for adoption (McKenzie-Mohr et al., 2011). The CBSM method suggests combing the three scores for impact, likelihood of adoption and existing penetration to form a single numeric measure which can be used to rank and prioritise behaviours within a list (McKenzie-Mohr and Smith, 1999; McKenzie-Mohr et al., 2011).

1.2. Visualisation for behaviour prioritisation

Existing approaches, such as *Community Based Social Marketing,* provide a useful way to prioritise behaviours by reducing the assessment of impact, likelihood of adoption and existing penetration to a single number. However, this risks losing detail within the data which may be valuable to the behaviour prioritisation process. We therefore propose a novel method for prioritisation which uses a visual matrix, to represent behaviours on their impact and an effort-based measure of likelihood of adoption, overlaid with data on current participation by the target audience. A matrix provides decision makers with an easy-to-read summary of potential target activities and allows an understanding of how they relate to each other (Lazard and Atkinson, 2014; Trumbo, 1999). This paper demonstrates that mapping behaviours on to a matrix, using their impact on the issue and likelihood of adoption, allows identification of priority behaviours by their location within the grid, whilst retaining other valuable information such as clustering of particular behaviours (see Fig. 1).

Behaviours with a low impact on the issue and low likelihood of adoption (lower-left quadrant of Fig. 1), are low priority, as they are hard to adopt and achieve little to address the issue at hand; they are '*hard and ineffective*'. '*Easy but ineffective*' behaviours (lower-right quadrant) have a high likelihood of adoption, but lack impact on the issue. However, the '*Foot-in-the-Door*' effect suggests participation in an initial easy, small, behaviour can increase subsequent uptake of larger, more difficult behaviours (Freedman and Fraser, 1966). Therefore, low impact, easy behaviours could act as levers or catalysts which encourage adoption of additional, more impactful, behaviours in the future (Thøgersen and Ölander, 2003; Thøgersen and Noblet, 2012). Behaviours with a high likelihood of participation and large impact on the issue (top-right quadrant) are '*easy and effective*'. Described as '*low-hanging fruit*' (Attari et al.,

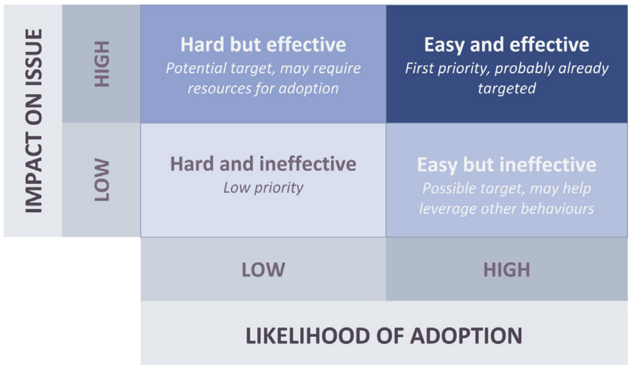

Fig. 1. The Impact – Likelihood Matrix for behaviour prioritisation.

2011), they should be the first priority for policy makers. However, they may already have a high level of existing audience engagement, reducing the utility of further promotion (Manning et al., 2013; McKenzie-Mohr and Schultz, 2014). Therefore, behaviours ranked as high impact, but low likelihood of adoption (top-left quadrant), '*hard but effective*', may provide the highest priority targets, as they should have low current participation rates but have a large impact on the issue.

The visualisation of behavioural characteristics using the matrix retains data richness that is lost with a single-score ranking system. It enables a more nuanced approach to prioritisation, allowing selection of behaviours by specific features, such as likelihood of engagement or scale of impact, or by their relative position within the matrix. Mapping potential behaviours in this way produces clusters of behaviours with similar scores. This is important as behavioural similarity has been proposed as a means to increase uptake of additional behaviours (Bratt, 1999), by leveraging off similar existing practices to create 'spillover' between behaviours and accelerate behaviour change (Thøgersen and Ölander, 2003; Thøgersen, 2004). Behaviours that cluster within the matrix may represent those seen as similar by stakeholders.

In addition, by incorporating perceptions of effort involved in behaviour participation as a proxy for likelihood of adoption, the matrix can visualise the key barriers associated with different groups of behaviours. Understanding key barriers to participation facilitates intervention design to specifically tackle these issues (Kollmuss and Agyeman, 2002). The Impact-Likelihood matrix visual tool could therefore assist decision-makers with behaviour prioritisation and intervention development for behaviour change policy.

1.3. Applying the Impact-Likelihood Matrix to a complex environmental issue: water demand management in Australian households

The current study applies the Impact-Likelihood Matrix to the critical environmental issue of water security. Securing clean water for people and the environment is essential for development, health and survival, and the need to conserve and protect water resources is key (Vorosmarty et al., 2010). Indeed, the World Economic Forum identifies water crises as the preeminent concern facing humanity over the next ten years (World Economic Forum, 2016). Therefore we use an investigation into water demand management behaviours for Australian households as a case study to illustrate application of the Impact-Likelihood Matrix. Australia's towns and cities are home to 90% of the country's growing population (Australian Bureau of Statistics, 2013c). Households use 70–80% of urban water supply (Gregory and Leo, 2003) and as the Australian population is expected to double from 23 to 46 million by 2075 (Australian Bureau of Statistics, 2013a), there is an urgent need to secure sustainable urban domestic water supplies (Brown et al., 2009).

Increasing the sustainability of water supplies by reducing household demand has been described as a '*no regrets*' strategy by the Intergovernmental Panel on Climate Change, as it facilitates future water security, regardless of the impacts of climate change on water supply (Bates et al., 2008). Australian householders already value water (Dolnicar and Hurlimann, 2010; Fielding et al., 2011) and participate in a range of water-saving behaviours (Khastagir and Jayasuriya, 2010; Carragher et al., 2012; Australian Bureau of Statistics, 2013b). Certainly, water-saving campaigns that were conducted during the 1997–2009 millennium drought produced significant results (e.g. Turner et al., 2005; Turner et al., 2010), with average water consumption in drought-affected areas decreasing by one third between 2000 and 2010 (Australian Bureau of Statistics, 2013b).

However, the latest figures show total domestic water consumption is on the rise with a 9% increase (from 1699GL in 2010–2011 to 1845 GL in 2014–2015) over the past four years (Australian Bureau of Statistics, 2015). In light of the importance of demand management strategies around the world, water managers need a tool to help prioritise the many potential household water conservation behaviours for demand management campaigns (Manning et al., 2013). Once this prioritisation process has taken place, policy makers are in a better position to develop effective interventions to promote the targeted behaviours (Campbell-Arvai and Arvai, 2015; Katz et al., 2016).

In the current study we also consider how water saving behaviours, like other resource conservation behaviours, may be categorised or grouped into types (Barr et al., 2005). Studies on energy conservation categorise energy saving behaviours into '*efficiency*', '*curtailment*' and '*maintenance*' behaviours based on their characteristics for performance (Karlin et al., 2014) and given the similarities between household energy and water conservation, we use the same categories to group water conservation behaviours. '*Efficiency behaviours*' apply new technology to produce a desired outcome using fewer resources, or produce a larger effect with the same resources (Barr et al., 2005). Efficiency behaviours have been described as one-off installation, purchase, or '*investment*' behaviours, such as fitting a dual-flush toilet (Barr et al., 2005; Gardner and Stern, 1996; Ölander and Thøgersen, 1995; Stern and Gardner, 1981). '*Curtailment behaviours*', such as reducing the frequency of toilet flushing, reduce resource consumption by modifying behaviours that are performed regularly and involve superficial decision making (Verplanken and Roy, 2015; Barr et al., 2005; Stern and Gardner, 1981). Some curtailment behaviours may also be habitual, i.e. repeated behaviours performed in a specific setting, such as taking a shorter shower (Ouellette and Wood, 1998; Verplanken and Wood, 2006). '*Maintenance*' or management behaviours ensure "*that household equipment is in good working order*" (Ölander & Thøgersen, 1995, p.349). These types of behaviour may be carried out regularly but not frequently and, unlike habits, require conscious thought and effort, such as fixing leaking taps (Ölander and Thøgersen, 1995; Kempton et al., 1992, 1985). By incorporating the behaviour type within the Impact-Likelihood Matrix, policymakers can see where certain groups of behaviours map onto the quadrants and therefore their level of priority. Understanding behaviour categories can assist policy makers with intervention design (Graymore et al., 2010; Dolnicar and Hurlimann, 2010) by signposting potential interventions for a particular type of behaviour (Boudet et al., 2016).

The aim of the current paper is therefore to develop, test and evaluate a method to help prioritise behaviours for the development of future water conservation behaviour change programs. We create a two-dimensional visual matrix, mapping behaviours by their characteristics into one of four quadrants to aid in prioritisation. We apply the tool to the context of household water conservation and in doing this we are able to address the following research questions:

RQ1: *In terms of their impact on water saving, and the likelihood of target audience adoption, which behaviours should be prioritised as the foci for future water saving campaigns?*

RQ2: *Where do different types of water saving behaviours, curtailment, efficiency and maintenance, fall within the matrix?*

RQ3: *Which behaviours already have high rates of audience participation and are therefore lower priority?*

RQ4: *What are the main barriers to engagement with the water saving behaviours and how can these be addressed through intervention design?*

To address these questions, we investigate the perceived impact of water saving behaviours on Australian household water consumption and the relative physical, mental or financial effort involved as a proxy for likelihood of behaviour adoption.

2. Method

2.1. Identification of water-saving behaviours

A multi-stage method was used to identify potential water-saving behaviours and investigate the impact and likelihood of adoption of each. A review of grey literature, mainly produced in Australia during the millennium drought, was undertaken to produce a comprehensive long-list of possible household water saving behaviours. Sources included water-saving campaigns from federal (e.g. '*Save Water Alliance*') and state government (e.g. '*Waterwise*' in Queensland and '*Water: Learn it, Live it*' in Victoria), NGO programs (e.g. '*Every Drop Counts*', Royal Botanic Gardens, Victoria) and media information drives (e.g. ABC News '*Water Saving Tips*'). As many sources recommended the same behaviours, redundancies were removed. Behaviours were also checked for indivisibility i.e. they could not be divided into further behaviours (instead of including '*fix leaks*', we used '*fix leaking taps*' and '*fix leaking pipes*') and end-state conditions, i.e. promoting a final behaviour, rather than a precursor (instead of '*create a water efficient garden*', we used '*group plants with similar water needs together*' and '*plant native, drought-tolerant plants*') (McKenzie-Mohr et al., 2011).

The resultant shortlist of 31 behaviours was presented to 27 water industry professionals through workshops held in three major metropolitan cities in Australia (Brisbane, Perth and Melbourne). Workshop participants were asked to assess the behaviours for relevance and utility and to identify additional behaviours to incorporate in the list. Based on the input from the water professionals, 46 behaviours were finally identified for investigation. These were divided into 19 '*curtailment*' behaviours, 18 '*efficiency*' behaviours, and nine '*maintenance*' behaviours using the definitions described above (Section 1.3). See Supplementary materials for the full list of behaviours investigated.

2.2. Impact of water-saving behaviours: water industry professionals sample

The impact of a water-saving behaviour may be assessed objectively, by analysing the actual volume of water saved (Inskeep and Attari, 2014) using digital 'smart' water meters which record consumption events for comparison with self-reported household curtailment behaviours (Cardell-Oliver et al., 2016; Beal et al., 2016; Mead and Aravinthan, 2009). However, low-volume curtailment behaviours are hard to identify in this way (Inskeep and Attari, 2014). Research on householder subjective perceptions of water consumption has produced contradictory results over consumer awareness, or lack of awareness, of water consumption (Pearce et al., 2014; Fielding et al., 2013; Beal et al., 2013; Syme et al., 2000) and identified misconceptions on water saving volumes (Attari, 2014). Investigators have therefore turned to resource industry professionals for potentially more accurate subjective estimates of impact, for example within the Townsville Residential Energy Demand program (TRED) (Hargroves et al., 2010).

In the current study, water industry professionals self-selecting with expertise in water conservation, were invited by email to participate in an online survey to identify perceptions of impact on water saving. All those invited were involved with the Cooperative Research Centre (CRC) for Water Sensitive Cities program, a large water-focused research collaboration between government, the private sector and university researchers. This was deemed to be an appropriate group to recruit from in light of the expertise of participants in the CRC, their membership in a broad range of water-related organisations and their interest in the research conducted within the CRC. The survey elicited 19 full and four partial responses from individuals self-selecting as experts in the field of water conservation and based in Western Australia (five), Queensland (six) and Victoria (12). Four of the online survey respondents had taken part in the previous behaviour identification workshops. Most of the respondents worked in local government (12), with five in state government, four in a water utility, one for a charity and one for a private company. All respondents selected at least one area of expertise (multiple response), with 15 selecting sustainability, 11 water management, eight community engagement, seven water consumption, seven planning, five conservation and two pollution control.

To assess the impact on water saving of each of the 46 behaviours under investigation, the water professionals recruited for the survey were asked '*What in your opinion would the effect of taking up the behaviour have on the amount of water saved by a household?*' The water professionals scored each behaviour using a Likert-type five-point scale (1 = 'very low', 5 = 'very high'). Scores were collated from respondents for each behaviour and the mean calculated to produce a single score per behaviour. This score represented each behaviour's perceived level of impact on water saving.

2.3. Likelihood of behaviour adoption: community sample

The literature suggests a range of factors relating to the likelihood of behavioural adoption (see Section 4), however, a critical first step in encouraging behaviour is making it easy, or reducing the amount of effort (Thaler and Sunstein, 2008). The more effortful the behaviour, the less likely it is to be adopted (Graymore et al., 2010; Dolnicar and Hurlimann, 2010). Steps to reduce effort, and thus increase likelihood of adoption, include reducing the costs associated with performing the behaviours (Behavioural Insights Team, 2014), such as the physical or mental effort involved with the behaviour (Smith et al., 2010) or introducing defaults (Thaler et al., 2013). On this basis, the current study assessed the likelihood of behaviour adoption by asking Australian householders to consider the level of physical, financial and cognitive effort associated with practicing water conservation behaviours.

Adult Australian householders living in urban areas (N = 151) were recruited by a commercial internet-based research company to answer an online survey. The survey included sociodemographic questions concerning state, age, gender, dwelling type (7 response options), home ownership (5 possible responses), education (12 response options) and income (7 options, from <$20,000 per annum to >$150,000 per annum). Respondents were 52% female, 48% male, and based in every state in Australia, (36% NSW, 22% VIC, 19% QLD, 11% SA, 13%WA, 3% TAS, 1% ACT, 1%NT), in approximately the same proportions as the Australian population. Most respondents had post-high school qualification, 11% with a diploma, 27% with a bachelor degree and 13% with a postgraduate qualification; this is slightly higher than the Australian average (9.1% with a diploma, 17% bachelor degree, 6.7% hold a postgraduate qualification (Australian Bureau of Statistics, 2012).

Survey respondents were asked to score each of the 46 water saving behaviours (19 curtailment behaviours, 18 efficiency behaviours, nine maintenance behaviours) on three measures of participation cost using a Likert-type five-point scale (1 = 'very low', 5 = 'very high'). These measures were physical effort '*What in your opinion will be the level of physical effort involved in taking part in the behaviour?*', cognitive effort '*What is the amount of thinking and planning involved in taking part in the behaviour?*' and financial cost '*How much you think it would cost to take part in the behaviour?*'. By obtaining scores on these three main types of effort involved in behaviour participation, we were able to assess which of these was considered the most important for each behaviour. The highest scoring effort type (physical, cognitive or financial) was identified as the '*key barrier*' to participation. As likelihood of participation increases with decreased effort (Osbaldiston and Schott, 2011), the '*key barrier*' scores were reverse-coded to produce the '*likelihood of adoption*' score used to construct the prioritisation matrix.

2.4. Existing participation and opportunity for behaviour adoption: National Survey

In addition to understanding the impact and likelihood of behaviour adoption, decision-makers also need to know the existing levels of behaviour engagement within the target audience and thus the potential, or opportunity, for behaviour change policy to create an impact (McKenzie-Mohr et al., 2011). This study used data on current participation drawn from an existing dataset of the water behaviour practices of Australian adult residents. Participants were recruited by a commercial internet-based research company (N = 5194) to answer an online survey (see Dean et al., 2016 for details of the sample). A representative sampling frame was used, based on gender, age, location and education. This survey only investigated 21 of the 46 behaviours investigated in the matrix study, therefore participation data is not comprehensive for the Impact-Likelihood Matrix.

Survey participants were asked whether they had participated in nine (out of 18) water efficiency behaviours, such as installing a water-efficient dishwasher, dual-flush toilet or targeted irrigation system, by selecting a response from '*Yes*', '*No, already in the house when I moved in*', '*No, renting*', '*No, not interested*', '*No, can't afford it*', '*No, not applicable*', and '*No, other*'. The responses *Yes*' or '*No, already in the house when I moved in*' indicate that the behaviour had already been carried out, therefore there is no opportunity for further behaviour adoption by these participants. The responses '*No, renting*' and '*No, not applicable*', indicate that the behaviour is not relevant to the participant, therefore also has no opportunity for future adoption. However, the responses '*No, not interested*', '*No, can't afford it*' and '*No, other*' suggest that survey participants could change their behaviour in the future, for example through exposure to appropriate behaviour change interventions. Therefore the combined percentage of these three responses were used to calculate the proportion of the population with the opportunity for future behaviour change. This opportunity score was used to define the width of behaviour opportunity 'bubbles' within the Impact-Likelihood Matrix (see Fig. 3, Section 3.5). The larger the behaviour opportunity bubble, the greater the opportunity for promotion by policy-makers, as the fewer people currently practice the behaviour.

Respondents were also asked about their adoption and frequency of participation in twelve (out of 19) curtailment behaviours, such as taking a shorter shower or filling the dishwasher for every use. Responses offered were '*Always*', '*Often*', '*Sometimes*', '*Rarely*' or '*Never*'. The percentage of '*Never*' responses was used to calculate the score for opportunity of behaviour adoption, which again was used to define the width of the behaviour opportunity 'bubbles'. The results are illustrated in Fig. 3, Section 3.5.

2.5. Mapping water-saving behaviours onto the Impact-Likelihood Matrix

To map water-saving behaviours onto a matrix we used the scores calculated, as described above, from the three survey samples (see Table 1 for a summary of data sources). To summarise, water industry professional perceptions of behaviour impact were collated and a mean score calculated for each behaviour. Household perceptions of effort (physical, financial and cognitive) involved in behaviour participation were averaged, ordered by size and the highest score across the three types of effort was identified as the '*key barrier*'. This score was reversed to use as a proxy for likelihood of adoption. The impact scores and likelihood scores were normalised and a prioritisation matrix was plotted using the z-score calculated for impact and likelihood of each behaviour (Breakwell et al., 2014), see Fig. 2, Section 3.1. Note that the matrix also labels the behaviours as efficiency, curtailment or maintenance.

3. Results and discussion

3.1. Prioritising water-saving behaviours using the Impact-Likelihood Matrix

Inspection of the Impact-Likelihood matrix shown in Fig. 2 allows us to address the first two research questions, by identifying which behaviours should be prioritised as the focus for water-saving programs and where different types of behaviours fall within the matrix. Behaviours in the top-right quadrant of Fig. 2, '*Easy and effective*', were scored high likelihood of adoption and high impact, so are '*low hanging fruit*' (Attari et al., 2011) and represent the first priority for policy makers. These behaviours are perceived to have the highest impact by water industry professionals and are most likely to be adopted as they are

Table 1
Source of data used to map behaviours onto the Impact-Likelihood Matrix.

Measure Data	Impact Score	Likelihood Score	Opportunity Score
Source	Water industry professional online survey (N = 19 + 4)	Inverse of key barrier score from householders (n = 151).	Household online survey (N = 5194) on existing practice and current participation for nine installation behaviours and twelve curtailment behaviours
Calculation	Mean Z-score	Inverse of key barrier score Z-score	% opportunity (inverse of those not currently practicing the behaviour) % opportunity to increase frequency (inverse of those currently performing the behaviour infrequently)

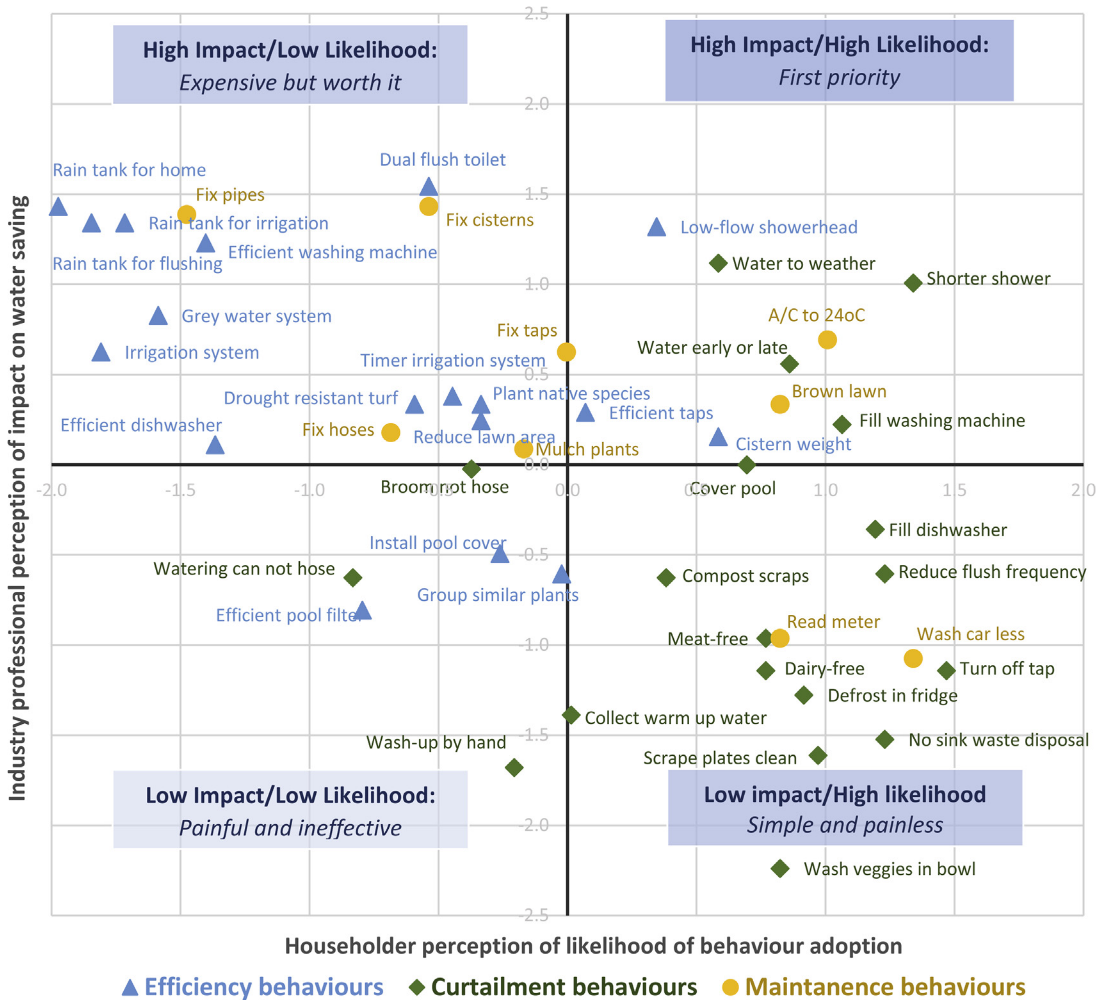

Fig. 2. Prioritisation matrix produced from industry perception of behavioural impact and household perception of likelihood of adoption, illustrating types of behaviour.

considered to involve the least effort (as perceived by householders). From Fig. 2, it can be seen that this includes efficiency behaviours such as installation of a low-flow showerhead, or water efficient taps, curtailment behaviours such as '*Take a shorter shower*', '*Water the garden according to weather conditions*', and '*Fill the washing machine for every cycle*' and maintenance behaviours '*Set the evaporative air conditioner to 24°*' and '*Leave the lawn to go brown*'. Addressing research question 3, Fig. 3 illustrates the opportunity for promotion of (some of) the behaviours. As might be expected, these low-effort behaviours have relatively high existing penetration, meaning there may be limited scope for additional future adoption by the target audience. It should be noted that further data needs to be collected on all 46 behaviours considered in the current study if we are to obtain a full picture of existing penetration rates of behaviours in this quadrant.

Behaviours in the top-left quadrant of the matrix (Fig. 2) were scored as high impact to reduce water consumption but with low likelihood of adoption, making them '*Hard but effective*' and potential second choices for policy-makers to target and communities to adopt. Fig. 2 shows these are primarily efficiency behaviours (11 of 17), such as '*Install a dual flush toilet*' or '*Install a rainwater tank to provide water to use in the home*' with some maintenance behaviours (6 of 11) such as '*Fix leaking pipes*'. This finding suggests they might become targets for future water saving campaigns, as effective actions which will save a lot of water, but that few people are currently doing. Householder perception that these behaviours have a low likelihood of adoption is supported by the empirical data on existing penetration illustrated in Fig. 3, which shows that there is currently low levels of participation for many of these behaviours. The exception to this is the installation of dual flush toilets, as they were made mandatory in new-build homes in Australia in 1993.

Behaviours mapped into the lower-right quadrant are those assessed to have a low impact on water savings but a high likelihood of adoption by householders, or '*Easy and effective*'. These are predominantly curtailment behaviours, with high rates of current performance, and thus low opportunity for future engagement (see Figs. 2 and 3). Of the 14 behaviours in this quadrant, two are maintenance behaviours ('*Read the meter*' and '*Wash the car less*') and the remaining 12 are curtailment behaviours (e.g. '*Cover the swimming pool*', '*Scrape plates clean of food*', '*Wash vegetables in a bowl of water*'); no efficiency behaviours appear here. Superficially, these behaviours could be seen as low priority, however it has been suggested that easy behaviours could be leveraged to facilitate adoption of additional water saving behaviours through affecting participant knowledge, skills or self-efficacy (Aitken et al., 1994; Lauren et al., 2016; Thøgersen and Ölander, 2003). Leveraging behaviour in this way is known as catalytic behaviour change (Austin et al., 2011), or 'spillover' (Thøgersen and Ölander 2003; Thøgersen, 2013). The concept of 'spillover', a model for accelerated behaviour change, could potentially be of interest within this context to increase the rate of behavioural uptake when needed, for example, in a future drought situation. However, policy makers should be wary of

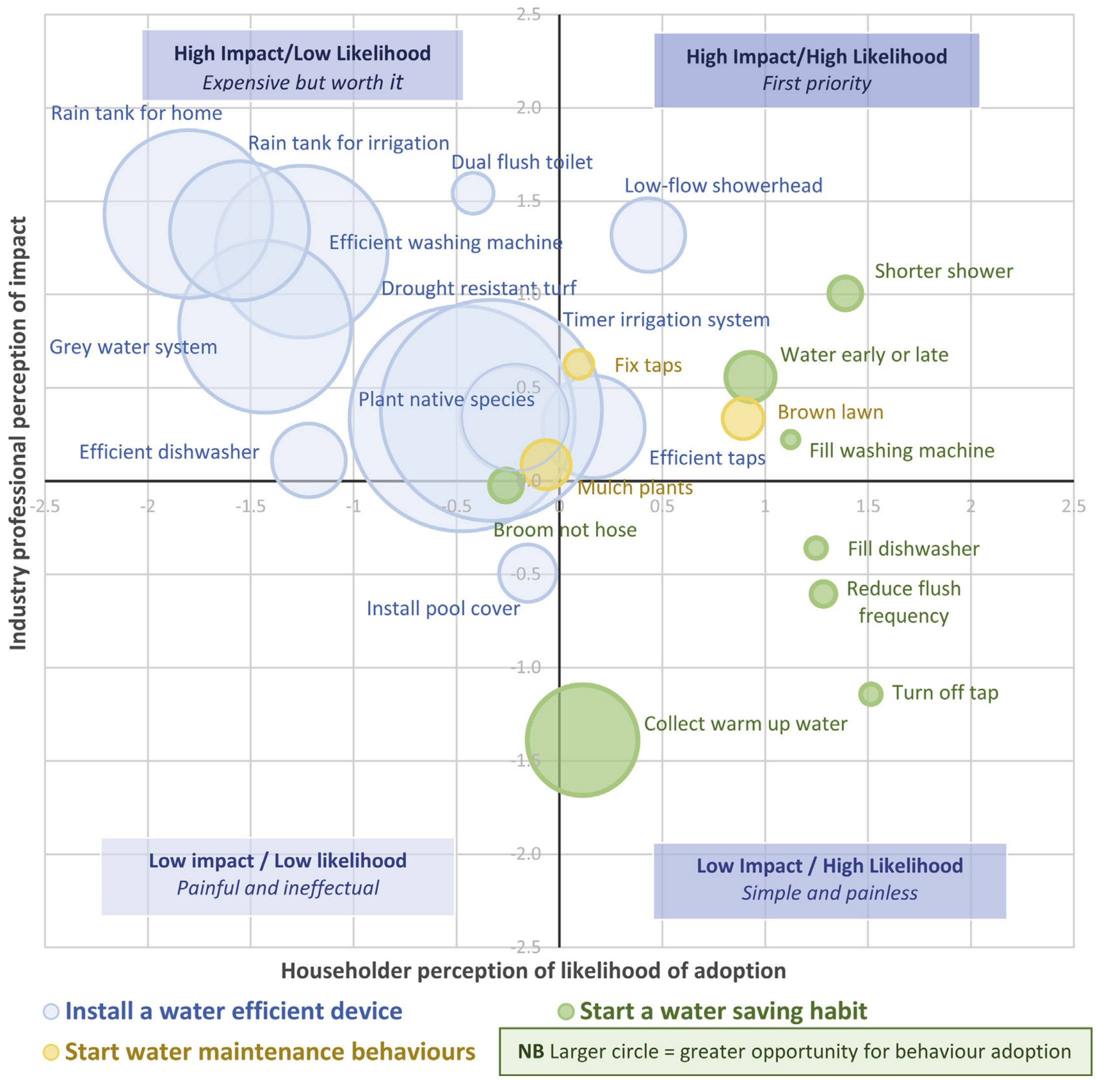

Fig. 3. Prioritisation matrix produced from industry perception of behavioural impact and household perception of likelihood of adoption, illustrating the opportunity for future behaviour adoption.

promoting 'low impact-high likelihood of adoption' behaviours unless a 'spillover' effect is demonstrated, as their low impact would provide little meaningful water savings unless additional behaviours were also adopted (Thøgersen and Crompton, 2009).

Behaviours located in the lower-left quadrant of the matrix (i.e. '*Hard and ineffective*' behaviours) were identified as low likelihood of adoption and low impact on water saving, so are low priority for targeting by policy makers. Only six out of the 46 behaviours investigated fell into this section; three efficiency behaviours (e.g. '*Install a pool cover*', '*Group similar water using plants together in the garden*'), and three curtailment behaviours (e.g. '*Use a broom rather than a hose to clean outside spaces*', '*Use a watering can rather than a hose to water the garden*'). The low number of behaviours in this quadrant is probably due to the initial behaviour identification process. Behaviours that do not save water would not be promoted within lists of water-saving behaviours, therefore all behaviours investigated have already been tacitly prioritised as water-savers. The opportunity data of four of the behaviours is illustrated in Fig. 3 and suggests that they are not uncommon in practice, although their perceived difficulty (in terms of the amount of effort required to adopt) suggests this should not be the case. Both the high effort, low impact on water saving and low opportunity for additional uptake data suggest that these behaviours should be lowest priority for future campaigns.

As might be expected, Fig. 3 demonstrates that behaviours with the lowest current participation (and most opportunity) are those in the '*low likelihood of adoption*' region of the graph, i.e. the efficiency behaviours in the upper-left quadrant. The match between the likelihood and participation data, which came from two different sources, lends support to our conclusions. The low likelihood behaviours include '*Install a grey water system for the home*', '*Install a water efficient washing machine*' and '*Install a rainwater tank to provide water for use inside the home*'. Efficiency behaviours with only a small opportunity, such as installing a water efficient dishwasher or a pool cover, should not be targeted as priority behaviours compared to installing a rainwater tank or replacing a lawn with drought resistant grass species, which have a much larger opportunity. In addition, fewer people have installed a water-efficient washing machine than a low-flow showerhead, so there is a greater opportunity for promotion of washing machine installation in future water conservation campaigns. These data provide an answer to research question three about which types of behaviours already have high rates of participation and are therefore of low priority. Overall, the data suggest that opportunity for many of the curtailment behaviours is fairly small compared with efficiency behaviours, suggesting that efficiency behaviours should be prioritised in future campaigns, in preference to the curtailment behaviours illustrated.

The information displayed on the matrices allows for selection of priority behaviours based on their perceived impact, likelihood of adoption and opportunity for uptake. However, the efficacy of behaviours will vary with context, for example, the volume of water saved in the outdoor space may depend on evaporation rates and will therefore be affected by location, temperature and weather patterns (Mini et al., 2014; Troy et al., 2005). Policy makers should also consider other characteristics, including cost or location to facilitate behaviour selection.

3.2. Implications for intervention development

In addition to prioritising behaviours in terms of their impact, likelihood of adoption and opportunity for promotion, the Impact-Likelihood Matrix allows us to better understand the nature of barriers facing audiences in changing their behaviours. The matrix provides data to address research question four; an assessment of the main barriers to engaging in water saving behaviours and how interventions may be developed to overcome these barriers. Householders scored behaviours on three kinds of effort (physical, cognitive, financial). The highest scoring effort type was identified as the key barrier to behaviour uptake, as shown in Fig. 4. Thaler and Sunstein (2008) emphasise that the first step to any behaviour change is to make the behaviour easy, so barriers to behaviour adoption would have to be addressed to enable adoption. This assumes that the householder is already motivated to change behaviour and is prevented from doing so due to the presence of the barrier (Steg and Abrahamse, 2010). The identification of key barriers provides important guidance to tailor intervention design to specifically address and overcome hurdles, in this case of financial, physical and cognitive effort each behaviour entails. The result of incorporating key barrier types onto the Impact-Likelihood Matrix is illustrated in Fig. 4. On the whole, curtailment behaviours score highest on physical effort, whereas efficiency and maintenance behaviours score highest on financial cost. This could provide guidance for policy-makers to tailor interventions for priority behaviours according to the reason householders provide for low rates of compliance.

Most behaviours in the top left quadrant of Fig. 4, with high impact but low likelihood of adoption, are (perceived to be) financially difficult. This holds for both efficiency (for example, installation of a water tank or water efficient dishwasher) and maintenance (fixing pipes around the house or fixing hoses) behaviours. This suggests that, given householder motivation (Stern, 2000), low adoption of these water saving behaviours is due to the high cost of performance. Therefore, incentives or rebate schemes may be appropriate when designing intervention programs for these behaviours (Hill and Symmonds, 2011). Conversely, behaviours in the lower right quadrant of Fig. 4, which are low impact but have high likelihood of adoption, such as

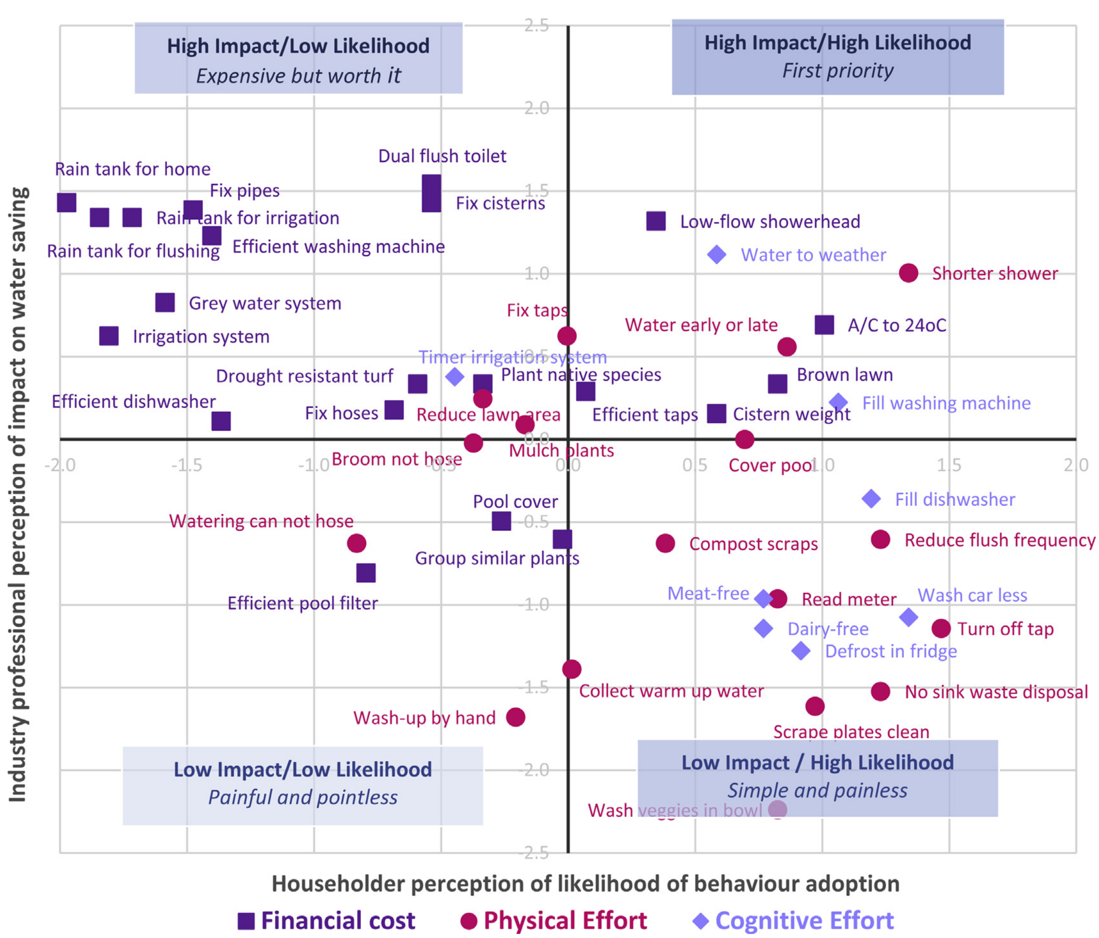

Fig. 4. Prioritisation matrix produced from industry perception of behavioural impact and household perception of likelihood of adoption, illustrating key barrier to participation for each behaviour.

turning off taps, reducing flush frequency or composting scraps, are considered to be physically, rather than cognitively or financially, costly. Indeed, across the matrix as a whole, there are twice as many physical effort behaviours in the right hand side (high likelihood of adoption) compared to the left hand side (low likelihood of adoption). This suggests that householders find physical barriers less of an impediment to participation than financial barriers.

Cognitive effort was the least frequently cited, with it emerging as the key barrier for only eight of the 46 behaviours (17%). The only behaviour located within the low likelihood of participation quadrants due to cognitive cost was installing a timed irrigation system. The other seven behaviours, such as filling the washing machine or dishwasher or washing the car less, map into the high likelihood of adoption quadrants, showing the allocated score for cognitive effort was low.

As has been discussed, specific behaviour types tend to have similar barriers. In this case study, efficiency behaviours are perceived to have high financial costs reducing likelihood of adoption, whereas curtailment behaviour barriers concern physical or cognitive effort. Maintenance behaviours seem to have a combination of the three (see Supplementary data for a full breakdown of the key barrier for each behaviour). The barriers, or limiting conditions for behaviour change, (Stern, 1992) may be addressed within intervention design. For example, grants, rebates and subsidies could be used to address the financial barrier to increase rates of participation in top-left (efficiency) behaviours with low likelihood of adoption but high impact. Generalising about intervention types for behaviours within the top-right quadrant of Fig. 4, with high likelihood of adoption and high impact, is more difficult as they are represented by a range of behaviour types and all three key barriers investigated. The high likelihood of adoption scores might suggest that the most important intervention may be raising awareness through education or communication programs. For behaviours with high current rates of participation (as shown in Fig. 3, Section 3.1), the development of intervention programs for behaviours in the top-right quadrant is not recommended as they are already well-established within the target audience.

Behaviours in the lower-right quadrant of Fig. 4, with low impact but high likelihood of adoptionthat could potentially have utility as leverage or 'catalytic' behaviours, were scored as physically difficult. For curtailment behaviours an alternate, physically easier method for participation may be required. For efficiency or maintenance behaviours an intervention may consist of additional assistance being provided for fitting or maintaining of equipment which the target household is unable to do. Table 2 outlines a range of intervention ideas addressing different behaviour types and key barriers. It should be noted that identification of a key barrier only allows for the consideration and mitigation of the highest scoring effort type. Therefore, designing interventions to address the key barrier may not enable behaviour adoption if it was awarded a high score on multiple effort types. This should be taken into account when applying the matrix tool.

4. Limitations

The case study used to test the Impact-Likelihood Matrix relies on water industry professional perceptions of impact on water savings. The subjective data produced therefore makes the location of behaviours within the matrix vulnerable to error. Ideally these data would be replaced with objective data on actual volumes of water saved through behaviour adoption. As more work is carried out on end-use water consumption by households (Beal et al., 2016) and as smart meter analyses become more sophisticated (e.g. Cardell-Oliver et al., 2016), a more precise measure of water saved by each water conservation behaviour will be gained and the behaviours can be located on the matrix more accurately. This demonstrates the need for high quality data to create a high quality matrix for use in policy decision making.

Further investigation into how the perceptions of stakeholders vary in terms of the impact and effort involved with behaviour participation would also provide an understanding of accuracy of perception and whether behaviours are perceived differently by water professionals compared to householders. Previous research has found that, for example, accuracy of consumer perceptions of water consumption and energy consumption behaviours varied considerably (Attari, 2014; Attari et al., 2010). Comparison of expert versus perceptions are particularly utilised within the risk literature to ensure audience engagement with risk-related issues (e.g. Morris and Smart, 2012; Krewski et al., 2012; Siegrist and Gutscher, 2006). If perceptions of water conservation behaviours are significantly different between householders and water professionals, this would highlight the need to engage directly with target audiences to ensure appropriate behaviour selection and intervention design.

This case study considers only three types of barriers. The advantage of this was that these are known to be important barriers and are easy to assess. However, other applications of the

Table 2
Intervention planning frame applying barrier effort and behaviour type to direct intervention design.

Barrier Effort Behaviour Type	Cognitive	Financial	Physical
Curtailment	Strategically placed stickers as reminders for participation Promote for recent home-movers – as this is a habit continuity it provides an opportunity for new habits to be adopted (Verplanken and Roy, 2016)	None of the curtailment behaviours were identified as financially onerous	Suggest physically easier methods or highlight the ease of participation when particular methods are used
Efficiency	Provide information on the best appliance to purchase depending on household preferences – like a tailored 'which' guide, with price comparison and details of local stores Step-by-step guides for installation of appliances, e.g. plans for rainwater tanks or how to fit a new dishwasher	Rebates or subsidies for water efficient appliances, from irrigation systems to washing machines	Encourage use of subsided fitting services (e.g. as used by Manning et al., 2013)
Maintenance	DIY 'how-to' guides, workshops in partnership with local hardware stores	Subsidies to support regular checks of major appliances (water tanks, irrigation systems, grey water systems)	Volunteer or professional programs to help those least physically able to carry out maintenance on their water systems, inside and outside the home

matrix may incorporate other drivers and barriers to change, such as individual motivation (Verplanken and Holland, 2002), values (Poortinga et al., 2004), or attitudes (Gatersleben et al., 2002; Levine and Strube, 2012). Within the household water conservation literature, social norms and identity in particular are seen as key motivators or barriers affecting likelihood of participation in specific behaviours (Fielding et al., 2011, 2012; Whitmarsh and O'Neill, 2010; Van der Werff et al., 2013; Abrahamse and Steg, 2013). Future research is needed to further investigate factors affecting the likelihood of adoption of water conservation behaviours.

Finally, this paper used national data on perceptions of impact and effort, however, the impact and effort involved in adopting some behaviours may be affected by context, including location, environmental conditions, house size and home ownership. For example, installation and use of pool covers is more relevant, has a greater impact in preventing water loss through evaporation, and may have a higher rate of existing participation in warmer or dryer areas of Australia. When applying the matrix, policy-makers should use local data to ensure the measures of impact, likelihood and penetration are accurate for their situation.

5. Conclusions

The Impact-Likelihood Matrix is a way of visualising the outcomes of investigation into potential behaviours to target through behaviour change programs and intervention design. It can capture information on key areas of complexity withindifferences between behaviours, provides a platform to present nuanced data simply to decision makers and may facilitate focused policy implementation. By selecting and scoring specific behavioural characteristics, differences and similarities between actions can be clearly illustrated and options selected accordingly. The Impact-Likelihood Matrix provides an additional, easy-to-use tool to assist in policy decision making and to clarify prioritisation of potential behaviours for efficient and effective behaviour change campaigns. The visual representation of behaviour characteristics allows for immediate discrimination between similar behaviours and an understanding of how behaviours with similar characteristics cluster together. By identifying the barriers to behaviour adoption the matrix also provides information to facilitate intervention design appropriate to each behaviour.

The types of data used to build the visualisation may differ from one program to another, depending on the issue under consideration and the availability of subjective or objective data. The combination of perspectives of effort or likelihood of adoption from householders and impact on water saving from water industry professionals allows both perspectives to be considered. Once behaviours are understood, in terms of their impact, the effort involved and participation rates, interventions can be developed to address audience perceptions, whether in effort or in terms of the impact of the behaviour. The large numbers of potential behaviours in social and environmental policy making renders the Impact-Likelihood Matrix of particular use, whether investigating reduction of carbon emissions or practices to improve population health.

This study provides an initial case study using the Impact-Likelihood Matrix only, so further investigation is required. However, its basic tenets make the matrix applicable to many areas of policy margin across a variety of difference behaviours types and subject matter. Additional use will provide a deeper understanding of target behaviours for policy makers and the development of more focussed and effective behaviour change campaigns into the future.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.envsci.2016.11.013.

References

Abrahamse, W., Steg, L., 2013. Social influence approaches to encourage resource conservation: a meta-analysis. Global Environ. Change 23 (6), 1773–1785.
Aitken, C.K., McMahon, T.A., Wearing, A.J., Finlayson, B.L., 1994. Residential water use: predicting and reducing consumption. J. Appl. Soc. Psychol. 24 (2), 136–158.
Attari, S.Z., DeKay, M.L., Davidson, C.I., De Bruin, W.B., 2010. Public perceptions of energy consumption and savings. Proc. Natl. Acad. Sci. 107 (37), 16054–16059.
Attari, S.Z., DeKay, M.L., Davidson, C.I., de Bruin, W.B., 2011. Changing household behaviors to curb climate change: how hard can it be? Sustain.: J. Rec. 4 (1), 9–11.
Attari, S.Z., 2014. Perceptions of water use. Proc. Natl. Acad. Sci. 111 (14), 5129–5134.
Austin, A., Cox, J., Barnett, J., Thomas, C., 2011. Exploring Catalyst Behaviours: Summary Report to the Department for Environment, Food and Rural Affairs. Brook Lyndhurst for Defra, London.
Australian Bureau of Statistics, 2012. Year Book Australia, 2012 (cat.No. 1301.0). . Retrieved from www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/1301.0~2012~Main%20Features~Educational%20attainment~110.
Australian Bureau of Statistics, 2013a. Population projectionsAustralia, 2012 (base) to 2101 (cat. No. 3222.0), . . Retrieved from: www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3222.02012%20(base)%20to%202101?OpenDocument.
Australian Bureau of Statistics, 2013b. Regional Population Growth: Australia, 2011–2012 (cat. No. 3218.0). . Retrieved from: www.abs.gov.au/ausstats/abs@.nsf/mf/3218.0.
Australian Bureau of Statistics, 2013c. Environmental Issues: Water Use and Conservation, March 2013 (cat.no. 4602.0.55.003). . Retrieved from: www.abs.gov.au/AUSSTATS%5Cabs@.nsf/0/A568D8D31EA91CCBCA2577DF00155222?Opendocument.
Australian Bureau of Statistics, 2015. 4610.0 – Water Account, Australia, 2013–14. . Retrieved from: www.abs.gov.au/ausstats/abs@.nsf/mf/4610.0.
Bandura, A., 1997. Self-efficacy: The Exercise of Self-control Gordonsville. WH Freeman & Co, VA.
Barr, S., Gilg, A.W., Ford, N., 2005. The household energy gap: examining the divide between habitual-and purchase-related conservation behaviours. Energy Policy 33 (11), 1425–1444.
Bates, B., Kundzewicz, Z.W., Wu, S., Palutikof, J., 2008. Climate change and water. Intergovernmental Panel on Climate Change (IPCC), .
Beal, C.D., Stewart, R.A., Fielding, K., 2013. A novel mixed method smart metering approach to reconciling differences between perceived and actual residential end use water consumption. J. Clean. Prod. 60, 116–128.
Beal, C.D., Gurung, T.R., Stewart, R.A., 2016. Demand-side management for supply-side efficiency: modelling tailored strategies for reducing peak residential water demand. Sustain. Prod. Consum. 6, 1–11.
Behavioural Insights Team, 2014. EAST: Four Simple Ways to Apply Behavioural Insights. . Retrieved from: http://www.behaviouralinsights.co.uk/wp-content/uploads/2015/07/BIT-Publication-EAST_FA_WEB.pdf.
Berners-Lee, M., 2011. How Bad Are Bananas? The Carbon Footprint of Everything. Greystone Books.
Black, J.S., Stern, P.C., Elworth, J.T., 1985. Personal and contextual influences on household energy adaptations. J. Appl. Psychol. 70 (1), 3.
Boudet, H.S., Flora, J.A., Armel, K.C., 2016. Clustering household energy-saving behaviours by behavioural attribute. Energy Policy 92, 444–454.
Bratt, C., 1999. Consumers' environmental behavior generalized, sector-based, or compensatory? Environ. Behav. 31 (1), 28–44.
Breakwell, G.M., Smith, J.A., Wright, D.B., 2014. Research Methods in Psychology, 4th ed. Sage, Los Angeles.
Brown, R.R., Keath, N., Wong, T.H.F., 2009. Urban water management in cities: historical, current and future regimes. Water Sci. Technol. 59 (5) .
Campbell-Arvai, V., Arvai, J., 2015. The promise of asymmetric interventions for addressing risks to environmental systems. Environ. Syst. Decis. 35 (4), 472–482.
Cardell-Oliver, R., Wang, J., Gigney, H., 2016. Smart meter analytics to pinpoint opportunities for reducing household water use. J. Water Resour. Plann. Manag. 04016007.
Carragher, B.J., Stewart, R.A., Beal, C.D., 2012. Quantifying the influence of residential water appliance efficiency on average day diurnal demand patterns at an end use level: a precursor to optimised water service infrastructure planning. Resour. Conserv. Recycl. 62, 81–90.

Clarke, J.M., Brown, R.R., 2006. Understanding the factors that influence domestic water consumption within Melbourne. Aust. J. Water Resour. 10 (3), 261.
Corner, A.K.G., Owen, P., 2014. Behaviour Change for Sustainability. Oxford, UK.
Dean, A.J., Lindsay, J., Fielding, K.S., Smith, L.D., 2016. Fostering water sensitive citizenship–community profiles of engagement in water-related issues. Environ. Sci. Policy 55, 238–247.
Department of Environment, Food Rural Affairs, 2008. Framework for Pro-environmental Behaviours. Department for Environment, Food and Rural Affairs, London.
Diekmann, A., Preisendörfer, P., 2003. Green and greenback: the behavioral effects of environmental attitudes in low-cost and high-cost situations. Ration. Soc. 15 (4), 441–472.
Dilley, L.T., 2015. Governing our choices: 'pro-environmental behaviour' as a practice of government. Environ. Plan. C: Gov. Policy 33 (2), 272–288.
Dolnicar, S., Hurlimann, A., 2010. Australians' water conservation behaviours and attitudes. Aust. J. Water Resour. 14 (1), 43–53.
Fielding, K.S., Hornsey, M.J., 2016. A social identity analysis of climate change and environmental attitudes and behaviors: insights and opportunities. Front. Psychol. 7.
Fielding, K.S., Louis, W.R., Warren, C., Thompson, A., 2011. Understanding Household Attitudes and Behaviours Towards Waste, Water and Energy Conservation. CSIRO Publishing, Melbourne, Australia, pp. 199–214.
Fielding, K.S., Russell, S., Spinks, A., Mankad, A., 2012. Determinants of household water conservation: the role of demographic, infrastructure, behavior, and psychosocial variables. Water Resour. Res. 48 (10) .
Fielding, K.S., Spinks, A., Russell, S., McCrea, R., Stewart, R., Gardner, J., 2013. An experimental test of voluntary strategies to promote urban water demand management. J. Environ. Manag. 114 (0), 343–351.
Freedman, J.L., Fraser, S.C., 1966. Compliance without pressure: the foot-in-the-door technique. J. Pers. Soc. Psychol. 4 (2), 195.
Gardner, G.T., Stern, P.C., 1996. Environmental Problems and Human Behavior. Allyn & Bacon, Needham Heights, MA, USA.
Gardner, G.T., Stern, P.C., 2002. Environmental Problems and Human Behavior, 2nd ed. Pearson Custom Publishing, Boston.
Gardner, G.T., Stern, P.C., 2008. The short list: the most effective actions US households can take to curb climate change. Environ.: Sci. Policy Sustain. Dev. 50 (5), 12–25.
Gatersleben, B., Steg, L., Vlek, C., 2002. Measurement and determinants of environmentally significant consumer behavior. Environ. Behav. 34 (3), 335–362.
Gato-Trinidad, S., Gan, K., 2012. Preliminary analysis of the cost effectiveness of rainwater tanks rebate scheme in Greater Melbourne, Australia. Water Soc. 153, 127.
Gilbertson, M., Hurlimann, A., Dolnicar, S., 2011. Does water context influence behaviour and attitudes to water conservation? Aust. J. Environ. Manag. 18 (1), 47–60.
Goodall, C., 2007. How to Live a Low-carbon Life. Earthscan, London.
Graymore, M., Wallis, A., O'Toole, K., 2010. Understanding drivers and barriers: the key to water use behaviour change. Water Sci. Technol.: Water Supply 10 (5), 679–688.
Gregory, G.D., Leo, M.D., 2003. Repeated behavior and environmental psychology: the role of personal involvement and habit formation in explaining water consumption. J. Appl. Soc. Psychol. 33 (6), 1261–1296.
Hallsworth, M., List, J., Metcalfe, R., Vlaev, I., 2014. The Behavioralist as Tax Collector: Using Natural Field Experiments to Enhance Tax Compliance (No w20007). National Bureau of Economic Research.
Hargroves, K., Desha, C., Reeve, A., 2010. Report to the Townsville CitySolar Community Capacity Building Program Identification and Assessment of Homeowner Behaviours Related to Reducing Residential Energy Demand. .
Head, B.W., 2014. Evidence, uncertainty, and wicked problems in climate change decision making in Australia. Environ. Plan. C: Gov. Policy 32 (4), 663–679.
Hill, T., Symmonds, G., 2011. Sustained water conservation by combining incentives: data and rates to effect consumer behavioural change. Water Soc. 153, 409–420.
Inskeep, B.D., Attari, S.Z., 2014. The water short list: the most effective actions US households can take to curb water use. Environ.: Sci. Policy Sustain. Dev. 56 (4), 4–15.
Jackson, T., 2005. Motivating sustainable consumption: a review of evidence on consumer behaviour and behavioural change. Guildford Surrey, Sustainable Development Research Network, .
Jones, R., Pykett, J., Whitehead, M., 2011. Governing temptation: changing behaviour in an age of libertarian paternalism. Prog. Hum. Geogr. 35 (4), 483–501.
Jones, R., Pykett, J., Whitehead, M., 2014. The geographies of policy translation: how nudge became the default policy option. Environ. Plan. C: Gov. Policy 32 (1), 54–69.
Karlin, B., Davis, N., Sanguinetti, A., Gamble, K., Kirkby, D., Stokols, D., 2014. Dimensions of conservation exploring differences among energy behaviors. Environ. Behav. 46 (4), 423–452.
Katz, D., Grinstein, A., Kronrod, A., Nisan, U., 2016. Evaluating the effectiveness of a water conservation campaign: combining experimental and field methods. J. Environ. Manag. 180, 335–343.
Kazdin, A.E., 2009. Psychological science's contributions to a sustainable environment: extending our reach to a grand challenge of society. Am. Psychol. 64 (5), 339.
Kempton, W., Harris, C.K., Keith, J.G., Weihl, J.S., 1985. Do consumers know "What works" in energy conservation? Marriage Fam. Rev. 9 (1–2), 115–133.
Kempton, W., Darley, J.M., Stern, P.C., 1992. Psychological research for the new energy problems: strategies and opportunities. Am. Psychol. 47 (10), 1213.
Khastagir, A., Jayasuriya, N., 2010. Optimal sizing of rain water tanks for domestic water conservation. J. Hydrol. 381 (3), 181–188.
Kollmuss, A., Agyeman, J., 2002. Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior? Environ. Educa. Res. 8 (3), 239–260.
Krewski, D., Turner, M.C., Lemyre, L., Lee, J.E., 2012. Expert vs. public perception of population health risks in Canada. J. Risk Res. 15 (6), 601–625.
Lauren, N., Fielding, K.S., Smith, L., Louis, W.R., 2016. You did: so you can and you will: self-efficacy as a mediator of spillover from easy to more difficult pro-environmental behaviour. J. Environ. Psychol. 48, 191–199.
Lazard, A., Atkinson, L., 2014. Putting Environmental Infographics Center Stage The Role of Visuals at the Elaboration Likelihood Model's Critical Point of Persuasion. Science Communication 1075547014555997.
Levine, D.S., Strube, M.J., 2012. Environmental attitudes, knowledge, intentions and behaviors among college students. J. Soc. Psychol. 152 (3), 308–326.
Ludwig, D., 2001. The era of management is over. Ecosystems 4 (8), 758–764.
MacKay, D., 2008. Sustainable Energy-without the Hot Air. UIT Cambridge.
Manning, C., Walker, M., Lange, J., Igloi, S., Bruce, G., Desha, C., 2013. Dry Tropics water smart: a community based approach to residential outdoor water consumption. Paper Presented at the 2013 Australian Water Association Conference, Perth.
McKenzie-Mohr, D., Schultz, P.W., 2014. Choosing effective behavior change tools. Soc. Market. Q. 20 (1), 35–46.
McKenzie-Mohr, D., Smith, W., 1999. Fostering Sustainable Behaviour: An Introduction to Community-based Social Marketing. New Society Publishers.
McKenzie-Mohr, D., Lee, N.R., Schultz, P.W., Kotler, P., 2011. Social Marketing to Protect the Environment: What Works. SAGE Publications, Incorporated.
Mead, N., Aravinthan, V., 2009. Investigation of household water consumption using smart metering system. Desalin. Water Treat. 11 (1–3), 115–123.
Mini, C., Hogue, T.S., Pincetl, S., 2014. Estimation of residential outdoor water use in Los Angeles, California. Landscape Urban Plann. 127, 124–135.
Morris, E.A., Smart, M.J., 2012. Expert versus lay perception of the risks of motor vehicle-generated air pollution. Transport. Res. Part D: Transp. Environ. 17 (1), 78–85.
Oh, C., Svendsen, G.T., 2015. Command-and-control or taxation? The cases of water regulation in California and Denmark. Environ. Manag. Sustain. Dev. 4 (2), 141–151.
Ölander, F., Thøgersen, J., 1995. Understanding of consumer behaviour as a prerequisite for environmental protection. J. Consum. Policy 18 (4), 345–385.
Olmstead, S.M., Stavins, R.N., 2009. Comparing price and nonprice approaches to urban water conservation. Water Resour. Res. 45 (4) .
Osbaldiston, R., Schott, J.P., 2011. Environmental sustainability and behavioral science: meta-analysis of proenvironmental behavior experiments. Environ. Behav. 0013916511402673.
Ouellette, J.A., Wood, W., 1998. Habit and intention in everyday life: the multiple processes by which past behavior predicts future behavior. Psychol. Bull. 124 (1), 54.
Pearce, M., Willis, E., Mamerow, L., Jorgensen, B., Martin, J., 2014. The prestige of sustainable living: implications for water use in Australia. Geogr. J. 180 (2), 161–174.
Poortinga, W., Steg, L., Vlek, C., 2004. Values, environmental concern, and environmental behavior a study into household energy use. Environ. Behav. 36 (1), 70–93.
Quine, L., Rutter, D.R., Arnold, L., 2001. Persuading school-age cyclists to use safety helmets: effectiveness of an intervention based on the theory of planned behaviour. Br. J. Health Psychol. 6 (4), 327–345.
Russell, S., Fielding, K., 2010. Water demand management research: a psychological perspective. Water Resour. Res. 46 (5) .
Schultz, P., 2011. Conservation means behavior. Conserv. Biol. 25 (6), 1080–1083.
Seyranian, V., Sinatra, G.M., Polikoff, M.S., 2015. Comparing communication strategies for reducing residential water consumption. J. Environ. Psychol. 41, 81–90.
Siegrist, M., Gutscher, H., 2006. Flooding risks: a comparison of lay people's perceptions and expert's assessments in Switzerland. Risk Anal. 26 (4), 971–979.
Smith, L., Curtis, J., Van Dijk, P., 2010. What the zoo should ask: the visitor perspective on pro-wildlife behavior attributes. Curator: Mus. J. 53 (3), 339–357.
Staats, H.J., Harland, P., 1995. The ecoteam program in The Netherlands. Study 4: A Longitudinal Study on the Effects of the EcoTeam Program on Environmental Behaviour and Its Psychological Backgrounds Summary Report. Summary Report, E&M, .
Staats, H., Harland, P., Wilke, H.A., 2004. Effecting durable change a team approach to improve environmental behavior in the household. Environ. Behav. 36 (3), 341–367.
Steg, L., Abrahamse, W., 2010. How to promote energy savings among households: theoretical and practical approaches. Psychological Approaches to Sustainability: Worldwide Current Trends in Research, , pp. 10–32.
Stern, P.C., Gardner, G.T., 1981. Psychological research and energy policy. Am. Psychol. 36 (4), 329.
Stern, P.C., 1992. Psychological dimensions of global environmental change. Annu. Rev. Psychol. 43 (1), 269–302.
Stern, P.C., 2000. New environmental theories: toward a coherent theory of environmentally significant behavior. J. Soc. Issues 56 (3), 407–424.

Stern, P.C., 2011. Contributions of psychology to limiting climate change. Am. Psychol. 66 (4), 303–314.
Syme, G.J., Nancarrow, B.E., Seligman, C., 2000. The evaluation of information campaigns to promote voluntary household water conservation. Eval. Rev. 24 (6), 539–578.
Thøgersen, J., Crompton, T., 2009. Simple and painless? The limitations of spillover in environmental campaigning. J. Consum. Policy 32 (2), 141–163.
Thøgersen, J., Noblet, C., 2012. Does green consumerism increase the acceptance of wind power? Energy Policy 51 (0), 854–862. doi:http://dx.doi.org/10.1016/j.enpol.2012.09.044.
Thøgersen, J., Ölander, F., 2003. Spillover of environment-friendly consumer behaviour. J. Environ. Psychol. 23 (3), 225–236.
Thøgersen, J., 2004. A cognitive dissonance interpretation of consistencies and inconsistencies in environmentally responsible behavior. J. Environ. Psychol. 24 (1), 93–103.
Thøgersen, J., 2013. Psychology: inducing green behaviour. Nat. Clim. Change 3 (2), 100–101.
Thaler, R.H., Sunstein, C.R., 2008. Easy does it: how to make lazy people do the right thing. N. Repub. 238 (6), 20–22.
Thaler, R.H., Sunstein, C.R., Balz, J.P., 2013. Choice architecture. In: Shafir, E. (Ed.), The Behavioral Foundations of Public Policy. Princeton University Press, Princeton, NJ, pp. 428–439.
Troy, P.N., Holloway, D., Randolph, B., 2005. Water Use and the Built Environment: Patterns of Water Consumption in Sydney. City Futures Research Centre Research Paper No.1.
Trumbo, J., 1999. Visual literacy and science communication. Sci. Commun. 20 (4), 409–425.
Turner, A., White, S., Beatty, K., Gregory, A., 2005. Results of the largest residential demand management program in Australia. Water Sci. Technol.: Water Supply 5 (1), 249–256.
Turner, A., Fyfe, J., Retamal, M., White, S., Coates, A., 2010. SEQ's one to one water savings program. Water 37 (1), 82–91.
Van der Werff, E., Steg, L., Keizer, K., 2013. The value of environmental self-identity: the relationship between biospheric values, environmental self-identity and environmental preferences, intentions and behaviour. J. Environ. Psychol. 34, 55–63.
Verplanken, B., Holland, R.W., 2002. Motivated decision making: effects of activation and self-centrality of values on choices and behavior. J. Pers. Soc. Psychol. 82 (3), 434.
Verplanken, B., Roy, D., 2015. Empowering interventions to promote sustainable lifestyles: testing the habit discontinuity hypothesis in a field experiment. J. Environ. Psychol. 45, 127–134.
Verplanken, B., Roy, D., 2016. Empowering interventions to promote sustainable lifestyles: testing the habit discontinuity hypothesis in a field experiment. J. Environ. Psychol. 45, 127–134.
Verplanken, B., Wood, W., 2006. Interventions to break and create consumer habits. J. Public Policy Market. 25 (1), 90–103.
Vörösmarty, C.J., McIntyre, P.B., Gessner, M.O., Dudgeon, D., Prusevich, A., Green, P., Glidden, S., Bunn, S.E., Sullivan, C.A., Liermann, C.R., Davies, P.M., 2010. Global threats to human water security and river biodiversity. Nature 467 (7315), 555–561.
Whitmarsh, L., O'Neill, S., 2010. Green identity, green living? The role of pro-environmental self-identity in determining consistency across diverse pro-environmental behaviours. J. Environ. Psychol. 30 (3), 305–314.
Woods, J., 2008. What people do when they say they are conserving electricity? Energy Policy 36 (6), 1945–1956.
World Economic Forum, 2016. Global Risks 2016, 11th ed. World Economic Forum, Geneva. . Retrieved from: www3. weforum.org/docs/Media/TheGlobalRisksReport2016. pdf.
Yarrow, J., 2008. How to Reduce Your Carbon Footprint: 500 Simple Ways to Save Energy, Resources, and Money. Chronicle Books.

Chapter 4: Identification of appropriate data sources for behaviour prioritisation

4.0 Introduction

The publication in Chapter 4 described the development and application of a tool to assist in behaviour prioritisation and selection. The paper highlighted the potential of using a visual framework to help select focal behaviours to develop future campaigns, based on perceptions of impact on the issue, likelihood of adoption, and existing participation rates. It also discussed the potential utility of the insights stemming from identifying key barriers for future intervention design. Construction of the matrix required input from two distinct sources of data; water professionals and householders. Both stakeholders were approached for input via online surveys to collect data on their perceptions of various behaviour characteristics; current participation rates, impact on the issue and the financial, cognitive and physical effort required for participation. In building the matrix, the water professionals were presumed to have greater insight into the impact of behaviours in terms of volume of water saved, due to their personal experience and professional capacity. On the other hand, householders, as important stakeholders for adoption of behaviours, perceptions were utilised to calculate the likelihood of adoption of each behaviour.

While the paper was in peer-review, one reviewer commented that, "*there appears some disparity between the reality of impacts and perceived likelihood of impacts*", i.e., that some of the behaviours scored as high impact by the water professionals may not actually be impactful in reality, such as installing an efficient dishwasher. Indeed, some of the behaviours scored as high likelihood of adoption by householders may be lower likelihood, such as collecting warm up water. The potential inconsistency between scoring and reality was acknowledged in the paper revision as a limitation of using the available subjective data to construct the matrix. However, the feedback from reviewers raised an important question about the reliability and appropriateness of data to inform the matrix from expert and lay sources. This chapter forms a second part of Objective 2, to *develop and test a prioritisation tool to facilitate behaviour selection for behaviour change program design*, by investigating research question 2.2, *Do householders and water professionals differ in their perceptions of the household water saving behaviours?*

Given the potential variability in perceptions between stakeholder groups, ideally objective data would be used to construct the decision making framework. However, gathering data to gain an objective understanding of the impact and likelihood of adoption of each of the 46 water saving behaviours under investigation would be a highly complex task. The fine-grained nature of some of the behaviours under consideration means impact, in terms of volume of water consumed, is not possible to measure at the moment, even using the latest smart-meter data (Cardell-Oliver, Wang & Gigney, 2016; Makki, Stewart & Beal, 2015). Collecting data on the likelihood of adoption of behaviours is also difficult; the financial cost of installation of efficient behaviours could be assessed but the cognitive and physical load of participation are themselves subject to a range of variables, including the demographics of the target audience. This issue (described in more detail in the paper) means we must currently be content with subjective data rather than objective data inputs.

With objective data unavailable to construct prioritisation charts like the impact-likelihood matrix, the validity and reliability of data sources therefore becomes a topic of interest. There is an extensive literature, particularly in the area of risk assessment, comparing opinions of 'expert' and 'lay' stakeholders to identify differences in perception. The evidence seems mixed; some researchers advocate for expertise-determined validity of perception or opinion (e.g. Hansen et al., 2003), others suggest there is insufficient empirical evidence to ascertain differences in perspectives (e.g. Rowe & Wright, 2001) and indeed other studies suggest there is little difference in perceptions or accuracy of opinion between the two groups (e.g. Siegrist & Gutscher, 2006). It was therefore considered important to investigate whether there are divergent perceptions across the key stakeholder: water professionals and householders. .

Paper 2 describes investigations into the 'lay' household and 'expert' water professional data, to understand whether these stakeholders differ in their perceptions of the characteristics of water conservation behaviours. Specifically, the study aimed to ascertain if the scores provided from these two main stakeholders were aligned or different. If perceptions were different, this has implications for data collection; if water professionals perceive behaviours as significantly different to householders, estimates or information sourced purely from professional assumptions may be erroneous. On the other hand, if water professional perceptions aligned with householders, this could simplify the requirements to gain data for creation of prioritisation matrices.

The paper included in this chapter is a replication of a journal submission and therefore the referencing follows the journal style guide. At the time of writing the paper is under review with Urban Water Journal.

References

Cardell-Oliver, R., Wang, J., & Gigney, H. (2016). Smart meter analytics to pinpoint opportunities for reducing household water use. *Journal of Water Resources Planning and Management*, 142(6), 04016007.

Hansen, J., Holm, L., Frewer, L., Robinson, P., & Sandøe, P. (2003). Beyond the knowledge deficit: Recent research into lay and expert attitudes to food risks. *Appetite*, 41(2), 111-121.

Makki, A. A., Stewart, R. A., Beal, C. D., & Panuwatwanich, K. (2015). Novel bottom-up urban water demand forecasting model: Revealing the determinants, drivers and predictors of residential indoor end-use consumption. *Resources, Conservation and Recycling*, 95, 15-37.

Rowe, G., & Wright, G. (2001). Differences in expert and lay judgments of risk: myth or reality? *Risk Analysis*, 21(2), 341-356.

Siegrist, M., & Gutscher, H. (2006). Flooding risks: A comparison of lay people's perceptions and expert's assessments in Switzerland. *Risk Analysis*, 26(4), 971-979.

4.0.1 Publication 2: *Whose view do we use? Comparing expert water professional and lay householder perspectives on water saving behaviours*

Whose view do we use? Comparing expert water professional and lay householder perspectives on water saving behaviours

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Abstract

Using behavioural science to help address complex issues, such as water conservation, requires prioritisation of behaviours for focused program design. This can present a challenge to water managers. Prioritisation tools can help, but require data to base decisions on. Some sectors, such as health or ecological science, obtain expert-derived data to fill any gaps for statistical modelling. However, there is an ongoing debate over the utility of expert, rather than lay, stakeholder perspectives. We extend previous research by examining perceptions held by expert water professionals (n = 44), and lay householder (n= 151) stakeholders, regarding household water-saving behaviours and barriers to participation. We also consider whether the behaviour type affects perceptions of these two groups. We find consistency between expert and lay perceptions on current behaviour participation rates and the impact of each behaviour on water saving. There was less agreement on perceptions of the effort required for water-saving behaviour adoption. These differences in opinion over the effort involved in behaviour participation could have implications for behaviour selection and intervention design. Our findings suggest that, on the whole, expert-derived data can be used for behaviour prioritisation, but lay input is valuable when everyday (curtailment) or maintenance type water-saving behaviours are under consideration.

Highlights

- Comparison of lay and expert perceptions of household water saving behaviours to check data source validity for behaviour prioritisation.
- ‘Lay’ householders and ‘expert’ water professionals hold comparable views on efficiency behaviour participation and impact.
- Differences exist across perceptions of cognitive, physical and financial effort for curtailment and maintenance behaviours.

4.1 Introduction

Water security is a critical issue globally and is likely to become more important in the future (Vörösmarty et al., 2010). Although there is a range of strategies that will be important to address water security (Wong & Brown, 2009), household water conservation is an important strategy in the suite of approaches to manage urban water demand (Russell & Fielding, 2010, Beal, Gurung & Stewart, 2016). Multiple methods have been investigated to modify household water consumption through influencing householder water use behaviours (Inman & Jeffrey, 2006). The range of potential actions that could contribute to household water demand management is considerable; one study identified 64 behaviours just within the outdoor space (Manning et al., 2013). Targeting specific behaviour is considered to produce greater success than using a general message, such as “save water” (Schultz, 2011). However, one of the challenges facing policy makers tasked with rolling out water demand management programs is selecting which behaviours to prioritise and promote (Inskeep & Attari, 2014; Manning et al., 2013).

4.1.1 Behaviour prioritisation

Research investigating methods to assist the decision-making process has identified a number of approaches to prioritise behaviours. Behaviours may be prioritised in terms of the impact on the issue, such as how much water could be saved through adoption of various household behaviours (Gardner & Stern, 2008; Inskeep & Attari, 2014). The likelihood of behaviour adoption has also been considered in behavioural selection, to take into account the various barriers that stakeholders may face in participating in a target behaviour (Gardner & Stern, 2008; Steg & Vlek, 2009; Kneebone, Smith & Fielding, 2017). Audiences are more likely to engage in behaviours with fewer or smaller barriers to adoption (Osbaldiston & Schott, 2012). The Community-Based Social Marketing (CBSM) approach considers behavioural impact on the issue and likelihood of adoption alongisde existing participation rates to inform decisions over prioritisation. Behaviours with low current participation levels have a greater opportunity for further adoption into the future, so are identified as higher priority to target (McKenzie-Mohr & Smith, 1999; McKensie Mohr et al., 2011). In CBSM, behaviours are scored on each of these characterstics (i.e., impact, likelihood and current particiation) to generate a total which can be used to rank behaviours of interest (McKenzie-Mohr & Smith, 1999; McKensie Mohr et al., 2011).

Recent research has extended the CBSM approach with a prioritisation tool that maps water-saving behaviours onto a 2x2 visual Impact-Likelihood matrix, drawing on the same three metrics: likelihood of behaviour adoption, impact of the behaviour on the issue and existing participation (Kneebone, Smith & Fielding, 2017). The scores allocated allow behaviours to be mapped into one of four quadrants to aid decision making for behaviour selection. Behaviours assessed as low impact and low likelihood of adoption are low priority, those with high impact and high likelihood of adoption represent low-hanging fruit, whilst high impact, low likelihood of adoption behaviours might be useful if appropriate intervention design is implemented to increase the chance of participation and low impact, high likelihood of adoption may help leverage additional behaviour uptake (Kneebone et al., 2017).

Prioritising behaviours to target in future water saving campaigns therefore requires data on the assessment criteria. Water managers and policy makers would benefit from reliable, robust data on the impact and likelihood of adoption of each behaviour, to base their decisions upon when designing demand management programs. Decision-makers may gain insight from existing literature, or generate data from stakeholder groups, such as experts in the field (Manning et al., 2013) or the householders whose engagement is sought (Attari, 2014). Understanding the level of agreement in perceptions of behaviours between stakeholder groups could be extremely important. Such understanding could provide direction on whom to engage as a reliable source of data when applying a decision-making framework such as the CBSM approach or the Impact-Likelihood matrix. The current paper addresses this important question by comparing the responses of water industry experts with lay householders in evaluating key characteristics of water-saving behaviours.

4.1.2 Gathering data for behaviour prioritisation

Ideally, the data gathered for a prioritisation exercise would be derived from objective measures, such as the volumetric quantities of water saved per behaviour over a given time period. Although research into end-point water use behaviours is greatly increasing our understanding of impact of some household practices (e.g., Cardell-Oliver, Wang & Gigney, 2016; Makki et al., 2015), these data have not yet been obtained for many of the lower-impact, water saving behaviours, such as washing vegetables in a bowl, or defrosting food in the fridge rather than under a tap. Moreover, objective data does not exist for the likelihood of behaviour adoption. Therefore, prioritisation attempts using these criteria have drawn on subjective measures of the perceived impact of water conservation behaviours and the likelihood of their adoption (Kneebone et al., 2017; Attari, 2014; Manning et al., 2013).

As discussed, sourcing subjective data then becomes an important consideration for researchers, namely, whose perceptions should be used for behaviour prioritisation? The urban water management sector involves many different stakeholders, from government to private enterprise, politicians to community leaders and water utilities to private householders (Brown et al., 2009; Marks & Zadoroznyj, 2005). The appeal to authority, using expert opinion to provide guidance or direction, might seem an appropriate approach (Walton, 2010). Indeed, many sectors, such as the environmental or health fields, expert opinion provides an important source of information. For example, in ecological science, data gaps may be filled through consultation with appropriate experts; personal field experience lends sufficient legitimacy to provide input for statistical modelling (e.g., Lele & Allen, 2006; Martin et al., 2005; Donlan et al., 2010). Health researchers also incorporate expert opinion generated from clinical experiences to complement evidence-based medicine (Tonelli, 1999; Morice et al., 2014). Similarly, the risk analysis sector has historically approached experts and noted authorities to provide insight into unknown or poorly understood categories of risk (Ouchi, 2004; Cox, Revie & Sanchez, 2012).

However, expert-derived data, while certainly of great utility in particular situations, may not reflect perspectives held by non-expert, or lay groups (Rinaudo & Garin, 2005). Lay stakeholders, such as householders, may comprise the target audience for engagement and involvement in behaviour change programs, including within the water conservation field (e.g. Fielding et al., 2013; Jorgensen, Graymore & O'Toole, 2009). If expert, that is, water professional, perceptions of the impact and likelihood of water saving behaviours differs markedly from those of lay householders, this may affect the approach taken to behaviour prioritisation. Specifically, if differences in perceptions of expert and lay stakeholders are present and pronounced, the same behaviour may be prioritised differently depending on whose perceptions are used. Differences in prioritisation could affect target behaviour selection, and potentially result in less effective program design.

4.1.3 Stakeholder perceptions of water saving behaviours

Existing work comparing expert and lay perceptions of water-related issues suggests that these two groups may indeed hold different perspectives on water, specifically around resource use and management. Researchers have identified perceptual differences between lay and expert groups through assessment of water management decisions, (Burnham, Ma, Endter-Wada, & Bardsley, 2016), and monitoring opinions on water scarcity or availability (Cockerill, Badurek, & Hale, 2014). One example from Arizona found that the lay public were more concerned about levels of water consumption than expert policy makers (Larson, White, Gober, Harlan & Wutich, 2009).

Other research has acknowledged the presence of different perceptions between lay and expert practitioners in the water sector, calling for water policy makers to be sensitive to the needs and perceptions of the household consumers they are affecting (Jones, Evangelinos, Gaganis & Polyzou, 2011). Policy maker sensitivity is of particular importance, as differing perspectives may lead householders to distrust the water authority and subsequently not adopt the water saving practices promoted (Jorgensen, Graymore & O'Toole, 2009). It has been suggested that the role and responsibilities of water sector professionals, that is, to ensure efficient and positive outcomes for the water sector, creates inevitable differences in perspective compared with a general public who are more concerned about the fairness and the impact of water policy decisions (Syme & Hatfield-Dodds, 2007).

Although past research has compared lay and expert perceptions of water management options, to our knowledge researchers have not investigated if there are differences in lay and expert perceptions of water conservation behaviours. However, research relating to water conservation behaviour suggests a number of dimensions of interest for comparison of expert and lay perceptions. We previously noted three behaviour characteristics used in prioritisation tools; impact on the issue, likelihood of adoption by the target audience and current participation rates. Understanding perceptions of impact of a behaviour on the issue is of particular interest, not only allows a behaviour to be mapped using prioritisation criteria, but also because audiences are more motivated to adopt a behaviour if it is seen to be impactful (Smith, Curtis & Van Dijk, 2010).

Even if an audience is motivated to enact a behaviour, the effort required for adoption may limit participation (Gardner & Stern, 2008). The less effortful behaviours are, the more likely the target audience is to participate in them (Hurlimann, Dolnicar & Meyer, 2009; Osbaldiston & Schott, 2012). Hence, if experts underestimate lay perceptions of the effort required to adopt a behaviour, the effectiveness of the intervention may be reduced. Previous studies suggest the financial cost of participation, and the physical and cognitive (thinking and planning) effort involved in water conservation behaviour adoption are important considerations (Clarke & Brown, 2006; Dolnicar & Hurlimann, 2010; Kneebone, Fielding & Smith, 2018). Accurate identification of potential barriers to adoption provides useful insight to aid intervention design (Kok, Lo, Peters & Ruiter, 2011).

Finally, if a behaviour is perceived to be widely enacted within a community then it may motivate additional adoption through creation of a social norm (Allcott, 2011). Social norms have been successfully used to promote household water conservation (Bernedo, Ferraro & Price, 214; Schultz et al., 2016). If lay and expert stakeholders perceive current participation levels of specific behaviours to be different, this may also affect behaviour selection and program efficacy.

4.1.4 Behaviour categorisation and audience perceptions

Investigating and comparing expert and lay stakeholder perceptions of behavioural impact on the issue, effort of adoption and current participation levels helps assess whether data derived from expert opinion is a legitimate or reliable basis for behaviour prioritisation. However, these are not the only behavioural characteristics that may affect how water-saving behaviours are perceived. Categorisation work carried out on energy consumption behaviours, and pro-environmental behaviours more broadly, have identified three main types, or classes, of behaviour: Curtailment, efficiency and maintenance. Curtailment (or habitual) behaviours are enacted regularly, take place within a stable setting, potentially as part of a routine, and require little skill or financial resources for adoption (Gregory & Leo, 2003; Gilg & Barr, 2006; Karlin et al., 2014). They include behaviours such as turning off taps, or reducing frequency of toilet flushing. Efficiency (or installation) behaviours involve the adoption of new technologies and systems around the home, including water efficient taps, dishwashers, washing machines or irrigation systems (Syme, Nancarrow & Seligman, 2000; Gilg & Barr, 2006; Karlin et al., 2014,). Maintenance behaviours ensure that systems work properly to prevent leaks and water wastage. They include actions such as mending hoses, or changing the thermostat on evaporative air conditioning units (Karlin et al., 2014).

In recent work on householder perceptions of water conservation behaviours, behaviour type was a key construct for behaviour similarity; householders used the category of behaviour type when assessing behaviours as different or similar (Kneebone, Fielding & Smith, 2018). Given that behaviour type therefore seems to affect householder perceptions of behaviours, we also examined whether expert water professional and lay householder perceptions of impact, effort of adoption and current participation rates varied across the three different types of water saving behaviours.

4.1.5 Current study

As we have noted, identifying whether, and where, water experts and householders differ in perception has implications for behaviour prioritisation, intervention design and water demand management program development. Although this is an important issue to address, to our knowledge past research has not been conducted in this area.

Therefore, we aimed to investigate lay householders' and expert water professionals' perceptions of household water saving behaviours in terms of perceived levels of current participation, the impact of the behaviour on water conservation, and the cognitive, physical and financial effort involved in adopting water conservation behaviours. We also sought to examine whether perceptions differed between these two groups across the three behaviour types; curtailment, efficiency and maintenance. The study is designed to answer the following questions:

RQ 1: Do householders and water professionals differ in their perceptions of the levels of current participation in household water saving behaviours?

RQ 2: Do householders and water professionals differ in their perceptions of the impact of behaviours on water saving?

RQ 3: Do householders and water professionals differ in their perceptions of the effort (physical, financial and cognitive) involved in adoption of water saving behaviours?

RQ4: Do householders' and water professionals' perceptions differ across behaviour types?

4.2 Method

This study used data from a survey investigating perceptions of household water conservation behaviours. The survey was designed to elicit perceptions of the behavioural characteristics (described in section 1.4 above) of 46 pre-identified water conservation behaviours. The survey used a Likert-type, 1-5 scale (very low, low, medium, high, very high, and don't know) to record respondent perceptions of five behaviour criteria: current participation rates in Australia, the impact of behaviours on water saving, and the physical, mental and financial effort involved in behaviour adoption (see Table 1).

Table 1: Characteristics of water saving behaviours used to assess perceptions of participation, impact and effort involved in behaviour adoption.

Characteristic	Definition provided within the survey
Current participation	The proportion of households who have performed, or are performing the behaviour at present
Individual impact	The effect of adopting the behaviour on reducing water consumption of the household
Physical effort	The physical effort involved in performing the behaviour
Mental effort	The cognitive cost, or amount of thinking and planning required to perform the behaviour
Financial cost	The monetary cost of performing the behaviour

The household water saving behaviours investigated in the study were identified through review of grey and published literature, focussing specifically on water behaviours promoted in Australia during the country's 1996-2010 drought (Bureau of Meteorology, 2015). A 'longlist' of potential behaviours was discussed and refined through three workshops with water professionals experienced in working with communities in Australia. Workshop participants were asked to assess the behaviours for relevance and utility and to identify any additional behaviours for inclusion. This process resulted in the selection of 46 potential behaviours for investigation through the study; 19 were curtailment behaviours, 18 were efficiency behaviours and nine related to maintenance (see Table 2 below).

Table 2: List of behaviours investigated, arranged by behaviour type.

Curtailment behaviours	Efficiency behaviours	Maintenance behaviours
Use a broom, instead of a hose, to clean outside spaces	Use a cistern weight if don't have a dual flush toilet	Raise the thermostat on household evaporative air conditioners to 24ºC
Collect shower warm-up water in a bucket to use in the garden	Replace 'thirsty' species of turf with drought-resistant varieties of grasses	Allow lawn to brown off
Compost kitchen scraps and add to garden	Replace a single flush toilet cistern with a dual flush system	Fix leaking toilet cistern
Keep swimming pools covered when not in use, to reduce evaporation.	Buy a water efficient (4 star or above) dishwasher	Fix leaking hoses or irrigation systems
Go dairy-free one day a week	Install a water efficient pool filter	Fix leaking pipes (house-wide)
Go meat-free one day a week	Install water efficient taps or aerators	Fix leaking taps (house-wide)
If using a dishwasher, ensure it is full for every wash	Buy a water efficient (4-star or above) front-loader washing machine	Use a 5 – 10cm layer of mulch on garden beds and potted plants
Defrost food in the fridge overnight, rather than under a running tap	Install a grey water system to reuse shower and laundry water in the garden	Read the meter to monitor household water use
Scrape plates clean of food instead of pre-rinsing	Group plants with similar water needs together.	Wash the car(s) less often
Do not use an in-sink garbage disposal unit	Install a water efficient targeted irrigation system	
Reduce the frequency of toilet flushing	Install a low-flow shower head	
Only wash full loads of clothes	Plant native or drought-tolerant plants	
Take a shorter shower	Install a pool cover	
Turn off tap when shaving or brushing teeth	Plumb the rainwater tank into the toilet for flushing	
Wash vegetables in a bowl of water, and then use it in the garden.	Install a rainwater tank to supply water for use inside the home	
Water the garden in the early morning or evening to reduce evaporation	Install a rainwater tank to supply irrigation water	
Wash-up dishes by hand	Reduce the area of lawn within property	
Adjust watering schedules according to weather conditions and landscape requirements	Use timer-controlled drip irrigation, rather than a sprinkler system	
Water the garden with a watering can, rather than a hose		

4.2.1. Participants and procedure

Australian householders (HH) were recruited to answer the water conservation behaviour survey through a market research company. Participants were offered a small reward as an incentive for their contribution and answered sociodemographic questions in addition to the questions about behaviour characteristics. Within the sample of 151 respondents, 47.7% were female, the majority lived in urban or suburban areas (87%) and 40% held a bachelor or postgraduate degree. Most lived in the Australian states of New South Wales (36%), Victoria (22%) and Queensland (19%). Respondents aged 18-24 accounted for 11% of the sample, 21% were 25-34, 23% were 35 – 44 and 45% were aged over 44. Full demographic data are listed in Appendix 1.

Water industry professionals (WP) (n=44) were recruited through communication channels used by the Cooperative Research Centre for Water Sensitive Cities (a large water research program in Australia) to answer the same behaviour survey. Water utilities, water services organisations and water networks in Australia were also contacted directly. Respondents self-selected as having expertise in water-saving, with most survey participants indicating experience in fields related to water conservation (water supply, sustainability, water cycle management, water consumption, community engagement, conservation). Two thirds (64%) report they have contact with the community (‘sometimes’, ‘often’ or ‘very often’). The most common employment sector was government and water or utility provider (33% each), followed by local government (11%) and private company (9%). On average, each respondent had nearly a decade of work experience within the water industry and over 6.5 years in their current organisation. The survey also included basic demographic questions for comparison with the householder demographics. The sample was 43% female and nearly all water professionals held a bachelor or postgraduate degree; 7% were aged 18-24, 36% aged 25-34, 29% aged 35 – 44 and 28% aged 44-70.

4.2.2 Data analysis approach

Independent sample t-tests were conducted comparing the perceptions of water professionals (WP n=44) and householders (HH n=151). We used Levene’s test of Equality of Variances on each t-test result (SPSS 20), ran the Welch-Satterthwaite method to correct for any error and reported the most appropriate result (Pallant, 2016). We adopted a conservative alpha level (p<.01) because of the number of analyses being conducted with the same samples and the associated increased risk of Type 1 error (i.e., false positives).

4.3 Results

The t-test results indicated where the scores allocated by water professionals (experts) and householders (lay audience) to the various behaviour characteristics were significantly different ($p < 0.01$). All 46 behaviours were assessed for current participation, impact, physical and cognitive effort, but only 23 for financial effort because all curtailment behaviours and some maintenance behaviours do not involve a monetary cost for participation. Differences in the scores are recorded in Table 3 below, including which audience scored behaviours higher. The behaviours scored significantly differently are listed in Table 4. Appendix 2 lists the full data, including the mean scores, mean difference and significance value for the scores allocated to the characteristics of each behaviour.

Table 3: Summary of significant differences in scores allocated to types of water saving behaviours by water professionals and householders.

Criteria scored	No. behaviours assessed	No. behaviours scored significantly differently (p<0.01)	% of behaviours	Water professional scores higher	Householder scores higher
Current participation	46	**6**	13.04	4	2
Impact on water saving	46	**3**	6.52	1	2
Physical effort	46	**6**	13.04	6	0
Cognitive effort	46	**10**	21.74	10	0
Financial cost	23	**6**	26.09	1	5

Table 4: Behaviours scored significantly differently (p<0.01) by water professionals and householders.

Current participation	Impact on water saving	Physical effort	Cognitive effort	Financial cost
Use a broom, instead of a hose, to clean outside spaces	**Defrost food in the fridge overnight, rather than under a running tap**	Use a broom, instead of a hose, to clean outside spaces	Collect shower warm-up water in a bucket to use in the garden	**Use a cistern weight if don’t have a dual flush toilet**

Turn off tap when shaving or brushing teeth	**Wash vegetables in a bowl of water, and then use it in the garden.**	Collect shower warm-up water in a bucket to use in the garden	Go dairy-free one day a week	Buy a water efficient (4-star or above) front-loader washing machine
Wash vegetables in a bowl of water, and then use it in the garden.	Raise the thermostat on household evaporative air conditioners to 24oC	Compost kitchen scraps and add to garden	Reduce the frequency of toilet flushing	**Group plants with similar water needs together.**
Water the garden in the early morning or evening to reduce evaporation		Water the garden with a watering can, rather than a hose	Take a shorter shower	**Allow lawn to brown off**
Install a grey water system to reuse shower and laundry water in the garden		Plant native or drought-tolerant plants	Wash vegetables in a bowl of water, and then use it in the garden.	**Fix leaking hoses or irrigation systems**
Use a 5 – 10cm layer of mulch on garden beds and potted plants		Use a 5 – 10cm layer of mulch on garden beds and potted plants	Adjust watering schedules according to weather conditions and landscape requirements	**Fix leaking taps (house-wide)**
			Water the garden with a watering can, rather than a hose	
			Group plants with similar water needs together.	
			Raise the thermostat on household evaporative air conditioners to 24^{o}C	
			Read the meter to monitor household water use	

KEY: Curtailment behaviours, Efficiency behaviours, Maintenance behaviours

Behaviours in bold were scored higher by householders than water professionals.

4.3.1 Perceptions of current participation level for household water saving behaviours

As Table 3 illustrates, expert water professionals and lay householders displayed considerable similarity in their perceptions of current participation in the 46 behaviours investigated. Only six behaviours were scored differently, four were seen as higher participation by water professionals and two by householders.

4.3.2 Perceptions of behaviour impact on water saving

The two stakeholder groups also seem to have similar views of the impact of each behaviour on water saving, with only three behaviours (6.5%) scored significantly differently. Two behaviours were scored as having a greater impact on water saving by householders and one by water professionals.

4.3.3 Perceptions of the physical, cognitive and financial effort involved in behaviour adoption

For assessment of the physical effort involved in behavioural participation, six (13%) out of the 46 behaviours investigated were scored significantly differently, with water professionals scoring behaviours higher than householders. This means, for these behaviours at least, water professionals viewed behaviours as more physically effortful than householders.

For cognitive effort of participation, ten behaviours (21.7%) were scored significantly differently by water professionals and householders, with all behaviours scored higher by water professionals. This suggests that water professionals viewed behaviours as involving a greater amount of cognitive effort, requiring more thinking and planning, than householders.

Perceptions of financial cost of behaviour participation were only measured for the 18 efficiency and six maintenance behaviours, as curtailment behaviours and three of the maintenance behaviours save money (by reducing the amount of water used), rather than cost money to implement. Six behaviours (25%) were scored significantly differently and five of these were scored higher by householders than water professionals. This suggests that, on the whole, householders viewed these behaviours to involve a greater financial cost than water professionals.

4.3.4 Differences in perceptions across the three types of water saving behaviour

Figure 2 illustrates how differences in perception between householders and water professionals relates to behaviour type; curtailment behaviours, efficiency behaviours and maintenance behaviours. Table 5 summarises whether the significantly different scores were higher for water professionals or householders.

Considering perceptions of current participation, householders and water professionals produced largely consistent scores for maintenance and efficiency behaviours, with only 11.1% and 5.6% of scores significantly different for the two behaviour types. Four (21%) of the curtailment behaviours were scored significantly differently. Two curtailment behaviours were scored higher by water professionals and one by householders, suggesting that neither audience consistently sees these types of behaviours as having higher rates of participation.

As noted above, water professional and householder perceptions were closely aligned on the perceived impact of behaviours on water saving; only 10% differed for curtailment behaviours and 11% for maintenance behaviours, and there were no significantly different scores for the efficiency behaviours.

Water professional and householder consideration of physical effort involved in behaviour participation also had a high level of consistency for efficiency behaviours (only 5% significantly different) and maintenance behaviours (11% significantly different). Four curtailment behaviours (21%) were scored differently by householders and water professionals. All the significantly different scores across the three behaviour types were higher for water professionals than householders. This suggests that when the physical effort involved in adopting curtailment behaviours is perceived differently, water professionals see the behaviours as more physically effortful to adopt.

The cognitive effort of behaviour participation varied across behaviour types; 36.8% of curtailment behaviours and 22.2% of maintenance behaviours were scored significantly differently by water professionals than householders. The two groups were similar in their judgements of the cognitive effort of efficiency behaviours, with only 5.6% significantly different. As with physical effort, all the significant differences were scored higher by water professionals than householders.

In terms of the financial cost of behaviour adoption, there was agreement over the cost of efficiency behaviours, with three out of 18 behaviours (16.7%) scored significantly differently, two scored higher by householders and one by water professionals. Half of the maintenance behaviours assessed (three out of six) were scored significantly higher by householders than water professionals. This provides some suggestion that the financial cost of installing and fixing water systems around the home may sometimes be viewed as more financially effortful (costly) by householders than water professionals.

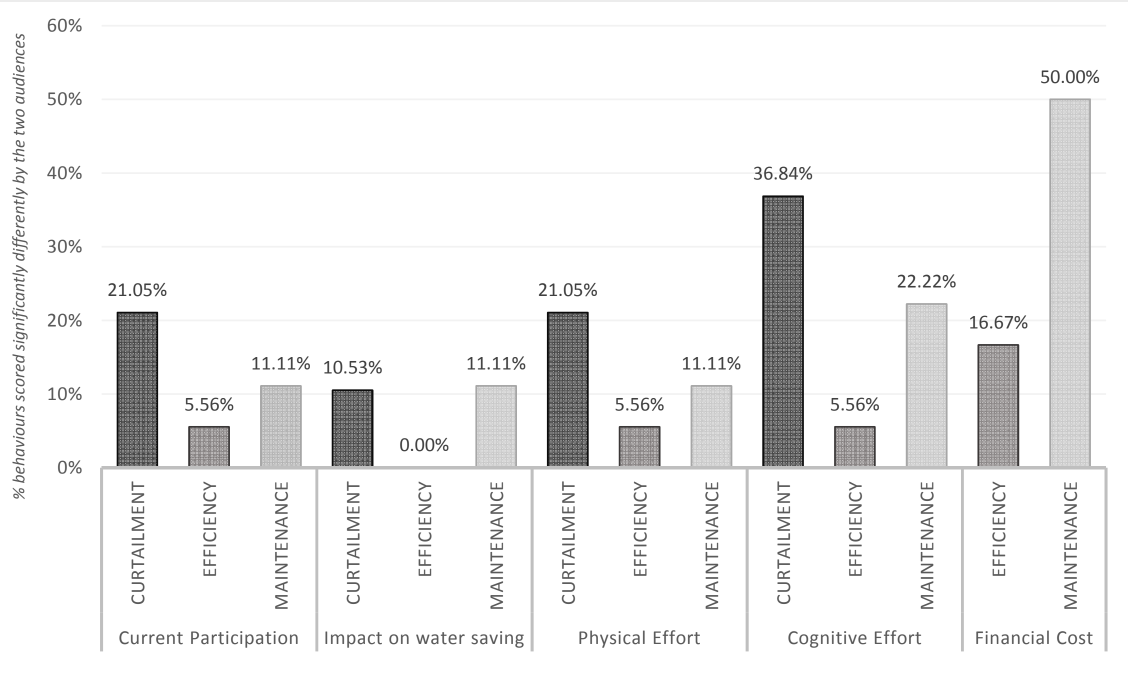

Figure 1: The proportion (%) of scores allocated to behaviour characteristics that were significantly different (p<0.01) between householders and water professionals, across the three types of behaviour.

Table 5: Summary of the number and proportion of behaviours scored significantly differently (p<0.01) by water professionals (WP) and householders (HH), by behaviour type.

Criterion being scored	Behaviour type	Number of behaviours scored by the two audiences	Number behaviours scored significantly differently	% of behaviours scored significantly differently	WP scores higher	HH scores higher
Current participation	Curtailment	19	4	21.05	3	1
	Efficiency	18	1	5.56	0	1
	Maintenance	9	1	11.11	1	0
Impact on water saving	Curtailment	19	2	10.53	0	2
	Efficiency	18	0	0.00	0	0

	Maintenance	9	1	11.11	1	0
Physical effort	Curtailment	19	4	21.05	4	0
	Efficiency	18	1	5.56	1	0
	Maintenance	9	1	11.11	1	0
Cognitive effort	Curtailment	19	7	36.84	7	0
	Efficiency	18	1	5.56	1	0
	Maintenance	9	2	22.22	2	0
Financial cost	Curtailment	0	N/A	N/A	N/A	N/A
	Efficiency	18	3	16.67	1	2
	Maintenance	6	3	50.00	0	3

4.4 Discussion

Our study provides an indication of areas of similarity and difference in perspectives of ‘expert’ water professionals and ‘lay’ householders across key characteristics of water-saving behaviours. We found that, on the whole, perspectives on water-saving behaviours were closely aligned. This means that expert water professional opinions largely complement the opinions of householders (illustrated with green in Table 6). The finding, that expert water professionals have similar perceptions to lay householders, is helpful for policymakers, as it strengthens the commonly-used appeal to expert opinion (Walton, 2010).

The high level of agreement between these two stakeholders could potentially be explained by the context of household water consumption in Australia. During Australia’s 1996 – mid-2010 ‘Millennium Drought’ (Bureau of Meteorology, 2015), highly successful water saving campaigns were run which facilitated reductions in household water consumption by up to 50% (Grant et al., 2013). For example, an eight month ‘Target 140’ campaign in Queensland targeting behaviours such as installing water efficient showerheads, decreased water consumption from 180 litres to 129 litres per person per day (Walton & Hume, 2011). Research has found that people who have experienced drought conditions are more supportive of water saving behaviours, regardless of other demographic variables (Gilbertson, Hurlimann & Dolnicar, 2011; Fielding, Russell, Spinks & Mankad, 2012). Therefore, if they had lived in Australia during the drought, all of our study participants, whether householders or water professionals, could hold pro-water conservation attitudes and similar perceptions of water saving behaviours due to their lived experience and post-drought context of life in Australia.

Our findings also lend support to previous work investigating Australian knowledge and attitudes towards water-saving behaviour. Recent work on water literacy reported that 73% of Australians know that "*Water conservation actions by householders can significantly reduce the amount of water used in urban areas*" and found that such water related knowledge was significantly associate with the adoption of 'everyday' (curtailment) water saving behaviours and the adoption of water saving devices (efficiency-type behaviours) (Dean, Fielding & Newton, 2016).

Despite the alignment between water professional and householder perceptions, there were a few points of difference that may be worth bearing in mind for decision-makers, for example, concerning the cognitive effort and financial cost of behaviour adoption. These points of difference are illustrated in Table 6; if 20-30% of the behaviours were scored significantly differently this is indicated in orange and in red where over 30% of the behaviours were scored significantly differently. In these instances, it may be useful to seek additional data directly from householders to validate an expert opinion. These findings strengthen previous calls for increased use of collaboration between (lay) users and (expert) decision makers in water management (Butler & Memon, 2005; Rinaudo & Garin, 2005) and explain why the investigation of differences in perceptions between expert and lay stakeholders is salient to ongoing issues of water resource management.

Table 6: Summary of the implications of differences in perception between stakeholders when sourcing data to inform behaviour prioritisation.

	Behaviour Type		
Behaviour characteristic being investigated	**Curtailment**	**Efficiency**	**Maintenance**
Current participation	Can use water professional perspective, householder input useful addition.	Use water professional perspective	Use water professional perspective
Behaviour impact on the issue	Use water professional perspective	Use water professional perspective	Use water professional perspective
Physical effort of behaviour adoption	Can use water professional perspective, householder input useful addition.	Use water professional perspective	Use water professional perspective

Cognitive effort of behaviour adoption	Need to get input from householders	Use water professional perspective	Can use water professional perspective, householder input useful addition.
Financial cost of behaviour adoption	N/A	Use water professional perspective	Need to get input from householders

The differences in perception over the financial cost of participation in efficiency and maintenance behaviours may reflect findings that, despite positive attitudes towards water conservation, the financial cost of installing (and maintaining) water-saving appliances acts as a barrier to participation (Dolnicar & Hurlimann, 2010). The nature of such behaviours may also make a difference; an American study found householders identified more visible, salient, curtailment behaviours for personal water conservation, despite recommending efficiency-type behaviours for others to adopt (Attari, 2014). In addition, water professionals could be expected to know more about efficiency devices, where they can be purchased and at what price, whereas householder may lack this knowledge. Furthermore, professionals working within the water sector may not perceive the financial costs of installing and maintaining water-efficient devices as a barrier to adoption in the same way as householders with on average lower education and income levels.

4.4.1 Limitations

As mentioned previously, context is known to influence current and past experience with water conservation (Dolnicar & Hurlimann, 2010; Fielding et al., 2012). Both sets of data were collected from across Australia, so we were unable to use location as a potential moderator. It would have been interesting to compare perceptions of householders and water professionals across specific Australian locations, such as Perth, Brisbane, and Melbourne, each of which face different water-related issues. This could have provided additional insight into perceptual comparisons such as whether expert and lay perceptions from some locations align more closely than those from other locations, depending on experiences of water consumption and conservation.

Our study investigated behaviours based on their typology, that is, curtailment, efficiency and maintenance. Recent research in this area suggests that location of the behaviour, that is, where it is enacted within the home, may also be an important criterion to householders than behaviour type (Kneebone, Fielding & Smith, 2018). This may provide another, potentially more salient, perspective on grouping or investigating behaviours.

4.4.2 Future research

The current findings highlight some potential areas for consideration both when interventions are being developed and in identifying priority behaviours for promotion in behaviour change campaigns. Further investigation could verify these findings through application; to test whether behaviours identified through household perception prioritisation would have a greater rate of adoption than behaviours identified using water professional perceptions. The identified difference in perceptions of the cognitive and physical effort of behaviour adoption may indicate that householders have greater efficacy, or rate themselves as more capable of carrying out the behaviours from a physical or mental perspective. Alternately, water professionals may have better insight regarding the practical aspects of behaviour adoption, meaning householders are overly optimistic. Further research to measure the effort involved in behaviour participation from an empirical perspective would be required to determine which of these hypotheses is correct.

Furthermore the subjective perceptions of both expert and lay groups about the behaviours could be tested against objective data, that is, comparing perceptions of current participation rates with actual participation rates and comparing perceptions of impact with the actual water savings achieved through behaviour adoption. Due to the limitations of end-use water consumption studies (Beal, Stewart & Fielding, 2013), these direct comparisons would only be possible for some of the behaviours under investigation. Objective measures for the effort of adoption could also be investigated. The financial cost of behaviour participation could be determined by investigating average market prices of efficiency devices and of undertaking maintenance behaviours. Doing so would reveal whether water professionals or householders held a more accurate perception of financial cost.

4.5 Conclusions

In general, householders and water professionals hold similar perceptions about water saving behaviours around the home. The small number of differences that did emerge appear to be more pronounced for curtailment type behaviours. When considering barriers to behaviour adoption, water professionals tend to score behaviours as higher in cognitive and physical effort, whereas householders perceived financial effort as more important. The overall alignment of expert and lay perceptions of behaviour means that the appeal to expert opinion would be supported in investigating water conservation behaviours, with opportunities for confirmatory additional data collection from householders as required.

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4.6 References

Allcott, H. (2011). Social norms and energy conservation. *Journal of Public Economics*, 95(9-10), 1082-1095.

Attari, S. Z. (2014). Perceptions of water use. *Proceedings of the National Academy of Sciences, 111*(14): 5129-5134.

Beal, C. D., Gurung, T. R., & Stewart, R. A. (2016). Demand-side management for supply-side efficiency: Modelling tailored strategies for reducing peak residential water demand. *Sustainable Production and Consumption*, 6, 1-11.

Beal, C. D., Stewart, R. A., & Fielding, K. (2013). A novel mixed method smart metering approach to reconciling differences between perceived and actual residential end use water consumption. *Journal of Cleaner Production*, 60, 116-128.

Bernedo, M., Ferraro, P. J., & Price, M. (2014). The persistent impacts of norm-based messaging and their implications for water conservation. *Journal of Consumer Policy*, 37(3), 437-452.

Brown, R., Farrelly, M., & Keath, N. (2009). Practitioner perceptions of social and institutional barriers to advancing a diverse water source approach in Australia. *International Journal of Water Resources Development*, 25(1), 15-28.

Bureau of Meteorology. (2015). *Recent rainfall, drought and southern Australia's long-term rainfall decline.* Accessed January 2018 from www.bom.gov.au/climate/updates/articles/a010-southern-rainfall-decline.shtml

Burnham, M., Ma, Z., Endter-Wada, J., & Bardsley, T. (2016). Water management decision making in the face of multiple forms of uncertainty and risk. *Journal of the American Water Resources Association*, *52*(6), 1366-1384.

Butler, D., & Memon, F. A. (Eds.). (2005). *Water demand management*. London, UK: International Water Association Publishing. ISBN 1843390787

Cardell-Oliver, R., Wang, J., & Gigney, H. (2016). Smart meter analytics to pinpoint opportunities for reducing household water use. *Journal of Water Resources Planning and Management*, 142(6), 04016007.

Clarke, J. M. and R. R. Brown (2006). Understanding the factors that influence domestic water consumption within Melbourne. *Australian Journal of Water Resources*, 10(3): 261.

Cockerill, K., Badurek, C., & Hale, R. (2014). Managing water in western North Carolina: Decision-maker perceptions and policy implementation. *Environmental Practice*, 16(2), 94-101. doi:10.1017/S1466046614000015

Cox, R., Revie, C.W., Sanchez, J. (2012). The use of expert opinion to assess the risk of emergence or re-emergence of infectious diseases in Canada associated with climate change. *PLoS One* 7(7): e41590. https://doi.org/10.1371/journal.pone.0041590

Dean, A. J., Fielding, K. S., & Newton, F. J. (2016). Community knowledge about water: Who has better knowledge and is this associated with water-related behaviors and support for water-related policies? *PLoS One* 11(7): e0159063.

Dolnicar, S., & Hurlimann, A. (2010). Australians’ water conservation behaviours and attitudes. *Australasian Journal of Water Resources*, 14(1), 43-53.

Donlan, C. J., Wingfield, D. K., Crowder, L. B. and Wilcox, C. (2010). Using expert opinion surveys to rank threats to endangered species: A case study with sea turtles. *Conservation Biology*, 24: 1586–1595. doi:10.1111/j.1523-1739.2010.01541.x

Fielding, K. S., Russell, S., Spinks, A., & Mankad, A. (2012). Determinants of household water conservation: The role of demographic, infrastructure, behavior, and psychosocial variables. *Water Resources Research*, 48(10).

Fielding, K. S., Spinks, A., Russell, S., McCrea, R., Stewart, R., & Gardner, J. (2013). An experimental test of voluntary strategies to promote urban water demand management. *Journal of Environmental Management*, 114, 343-351.

Gardner, G. T. and P. C. Stern (2008). The short list: The most effective actions US households can take to curb climate change. *Environment: Science and Policy for Sustainable Development* 50(5): 12-25.

Gilbertson, M., Hurlimann, A., & Dolnicar, S. (2011). Does water context influence behaviour and attitudes to water conservation? *Australasian Journal of Environmental Management*, 18(1), 47-60.

Gilg, A. and S. Barr (2006). Behavioural attitudes towards water saving? Evidence from a study of environmental actions. *Ecological Economics*, 57(3): 400-414.

Grant, S.B., Fletcher, T.D., Feldman, D., Saphores, J.D., Cook, P.L., Stewardson, M., Low, K., Burry, K. and Hamilton, A.J. (2013). Adapting urban water systems to a changing climate: Lessons from the Millennium Drought in Southeast Australia. *Environmental Science and Technology* 47(19): 10727-10734.

Gregory, G. D., & Leo, M. D. (2003). Repeated behavior and environmental psychology: The role of personal involvement and habit formation in explaining water consumption*. Journal of Applied Social Psychology*, 33(6), 1261-1296.

Hurlimann, A., Dolnicar, S., & Meyer, P. (2009). Understanding behaviour to inform water supply management in developed nations – A review of literature, conceptual model and research agenda. *Journal of Environmental Management*, 91(1), 47-56.

Inman, D. and Jeffrey, P. (2006). A review of residential water conservation tool performance and influences on implementation effectiveness. *Urban Water Journal*, 3(3): 127-143.

Inskeep, B. D. and Attari, S. Z. (2014). The water short list: The most effective actions US households can take to curb water use. *Environment: Science and Policy for Sustainable Development*, 56(4): 4-15.

Jones, N., Evangelinos, K., Gaganis, P., & Polyzou, E. (2011). Citizens' perceptions on water conservation policies and the role of social capital. *Water Resources Management*, 25(2), 509-522.

Jorgensen, B., Graymore, M., & O'Toole, K. (2009). Household water use behavior: An integrated model. *Journal of Environmental Management*, 91(1), 227-236.

Karlin, B., Davis, N., Sanguinetti, A., Gamble, K., Kirkby, D., & Stokols, D. (2014). Dimensions of conservation: Exploring differences among energy behaviors. *Environment and Behavior*, 46(4), 423-452.

Kneebone, S., Fielding, K., & Smith, L. (2018). It's what you do and where you do it: Perceived similarity in household water saving behaviours. *Journal of Environmental Psychology*, 55, 1-10.

Kneebone, S., Smith, L., & Fielding, K. (2017). The Impact-Likelihood Matrix: A policy tool for behaviour prioritisation. *Environmental Science & Policy*, 70, 9-20.

Kok, G., Lo, S. H., Peters, G. J. Y., & Ruiter, R. A. (2011). Changing energy-related behavior: An intervention mapping approach. *Energy Policy*, 39(9), 5280-5286.

Larson, K. L., White, D. D., Gober, P., Harlan, S., & Wutich, A. (2009). Divergent perspectives on water resource sustainability in a public–policy–science context. *Environmental Science & Policy*, 12(7), 1012-1023.

Lele, S. R. and Allen, K. L. (2006). On using expert opinion in ecological analyses: A frequentist approach. *Environmetric*s, 17: 683–704. doi:10.1002/env.786

McKenzie-Mohr, D., Lee, N. R., Kotler, P., & Schultz, P. W. (2011). *Social marketing to protect the environment: What works?* London: Sage Publications.

McKenzie-Mohr, D., & Smith, W. (1999). *Fostering sustainable development. An introduction to community-based social marketing*. Canada: New Society Publishers.

Makki, A. A., Stewart, R. A., Beal, C. D., & Panuwatwanich, K. (2015). Novel bottom-up urban water demand forecasting model: Revealing the determinants, drivers and predictors of residential indoor end-use consumption. *Resources, Conservation and Recycling*, *95*, 15-37.

Manning, C., Hargroves, K., Walker, M., Lange, J., Igloi, S., Bruce, G., & Desha, C. (2013). Dry Tropics Water Smart: A community based approach to residential outdoor water consumption. In 2013 Australian Water Association Conference (OzWater 2013), Perth Convention Centre, WA.

Marks, J. S. & Zadoroznyj, M. (2005). Managing sustainable urban water reuse: structural context and cultures of trust. *Society & Natural Resources* 18(6): 557-572.

Martin, T. G., Kuhnert, P. M., Mengersen, K. & Possingham, H. P. (2005). The power of expert opinion in ecological models using Bayesian methods: Impact of grazing on birds. *Ecological Applications*, 15: 266–280. doi:10.1890/03-5400

Morice, A.H., Millqvist, E., Belvisi, M.G., Bieksiene, K., Birring, S.S., Chung, K.F., Dal Negro, R.W., Dicpinigaitis, P., Kantar, A., McGarvey, L.P. & Pacheco, A. (2014). Expert opinion on the cough hypersensitivity syndrome in respiratory medicine. *European Respiratory Journal*, 44 (5) 1132-1148; DOI: 10.1183/09031936.00218613

Osbaldiston, R., & Schott, J. P. (2012). Environmental sustainability and behavioral science: Meta-analysis of proenvironmental behavior experiments. *Environment and Behavior*, 44(2), 257-299.

Ouchi, F. (2004). *A literature review on the use of expert opinion in probabilistic risk analysis*. Policy Research Working Paper; No. 3201. World Bank, Washington, DC.

Pallant, J. (2016). *SPSS survival manual: A step by step guide to data analysis using IBM SPSS*. 6th Edition. Australia: Allen & Unwin publishing.

Rinaudo, J. D., & Garin, P. (2005). The benefits of combining lay and expert input for water-management planning at the watershed level. *Water Policy*, 7(3), 279-293.

Russell, S., & Fielding, K. (2010). Water demand management research: A psychological perspective. *Water Resources Research*, 46(5). doi:10.1029/2009WR008408.

Schultz, P. W. (2011). Conservation means behavior. *Conservation Biology* 25(6): 1080-1083.

Schultz, P. W., Messina, A., Tronu, G., Limas, E. F., Gupta, R., & Estrada, M. (2016). Personalized normative feedback and the moderating role of personal norms: A field experiment to reduce residential water consumption. *Environment and Behavior*, 48(5), 686-710.

Smith, L., Curtis, J., & Van Dijk, P. (2010). What the zoo should ask: the visitor perspective on pro-wildlife behavior attributes. *Curator: The Museum Journal*, 53(3), 339-357.

Syme, G. J. & Hatfield-Dodds, S. (2007). The role of communication and attitudes research in the evolution of effective resource management and arrangements. In K. Hussey & S. Dovers (Eds.) *Managing water for Australia: The social and institutional challenges*. (Chapter 2, pp 11-22). Collingwood: Australia. CSIRO Publishing.

Syme, G. J., Nancarrow, B. E., & Seligman, C. (2000). The evaluation of information campaigns to promote voluntary household water conservation. *Evaluation Review*, 24(6), 539-578.

Tonelli, M. R. (1999). In defense of expert opinion. *Academic medicine: Journal of the Association of American Medical Colleges* 74(11): 1187-1192.

Vörösmarty, C.J., McIntyre, P.B., Gessner, M.O., Dudgeon, D., Prusevich, A., Green, P., Glidden, S., Bunn, S.E., Sullivan, C.A., Liermann, C.R. and Davies, P.M., (2010). Global threats to human water security and river biodiversity. *Nature*, 467(7315), p.555.

Walton, D. (2010). *Appeal to expert opinion: Arguments from authority*. Pennsylvania: USA. The Pennsylvania State University Press.

Walton, A. & Hume, J. (2011). Creating positive habits in water conservation: The case of the Queensland Water Commission and the Target 140 campaign. *International Journal of Non-profit and Voluntary Sector Marketing* 16(3): 215-224.

Wong, T. H. F., & Brown, R. R. (2009). The Water Sensitive City: Principles for practice. *Water Science and Technology*, *60*(3), 673-682.

APPENDIX 1: Comparison of householder and water professional demographic data.

	Householder	Water professional		Householder	Water professional
Female	47.68%	43.18%	Urban	50.99%	84.44%
Male	52.32%	56.82%	Sub-urban	36.42%	15.56%
18-24/18-25	10.60%	6.67%	Rural	15.23%	0.00%
25-34/26-35	20.53%	35.56%			
35-44/36-45	23.18%	28.89%	ACT	0.66%	0.00%
45-54/46-55	18.54%	17.78%	NSW	36.42%	8.89%
55-64/56-65	15.23%	11.11%	NT	0.66%	0.00%
65 years +	11.92%	0.00%	QLD	18.54%	8.89%
School	21.85%	0.00%	SA	11.26%	6.67%
Vocational	27.15%	2.22%	TAS	1.99%	0.00%
Diploma	11.26%	N/A	VIC	21.85%	40.00%
Bachelor Degree	27.15%	48.89%	WA	8.61%	35.56%
Post-Graduate Degree	12.58%	48.89%	**No. respondents**	**151**	**45**

APPENDIX 2: Full data set for t-test results, including the mean scores, mean difference and significance value for the scores allocated to the characteristics of each behaviour by the two stakeholders.

	CURRENT PARTICIPATION				IMPACT ON WATER SAVING				PHYSICAL EFFORT				COGNITIVE EFFORT			
Water saving behaviour	WP mean	HH mean	Sig. (2-tailed)	Mean Difference	WP mean	HH mean	Sig. (2-tailed)	Mean Difference	WP mean	HH mean	Sig. (2-tailed)	Mean Difference	WP mean	HH mean	Sig. (2-tailed)	Mean Difference
CURTAILMENT																
Use a broom, instead of a hose, to clean outside spaces	3.48	2.94	0.00	0.55	3.23	3.52	0.12	-0.30	3.55	3.01	0.01	0.54	2.49	2.26	0.23	0.23
Collect shower warm-up water in a bucket to use in the garden	1.59	1.87	0.09	-0.28	2.81	3.03	0.25	-0.22	3.30	2.80	0.01	0.50	3.02	2.33	0.00	0.69
Compost kitchen scraps and add to garden	2.55	2.61	0.70	-0.06	2.67	2.97	0.14	-0.30	3.17	2.60	0.00	0.57	2.88	2.45	0.03	0.43
Keep swimming pools covered when not in use, to reduce evaporation.	2.83	2.84	0.99	0.00	3.47	3.25	0.26	0.22	2.89	2.43	0.02	0.46	2.49	2.22	0.15	0.27
Go dairy-free one day a week	1.71	1.94	0.27	-0.23	2.29	2.12	0.38	0.17	2.29	2.21	0.67	0.08	2.95	2.39	0.00	0.56
Defrost food in the fridge overnight, rather than under a running tap	3.62	3.39	0.26	0.23	2.50	3.17	0.00	-0.67	1.95	2.01	0.71	-0.07	2.56	2.31	0.21	0.26
If using a dishwasher, ensure it is full for every wash	3.51	3.19	0.07	0.32	3.15	3.49	0.07	-0.34	2.12	2.13	0.95	-0.01	2.34	2.16	0.40	0.18
Only wash full loads of clothes	3.60	3.22	0.03	0.38	3.56	3.52	0.83	0.04	2.02	2.17	0.44	-0.14	2.43	2.23	0.31	0.19
Go meat-free one day a week	2.31	2.05	0.20	0.26	2.29	2.11	0.35	0.19	2.18	2.20	0.94	-0.01	2.87	2.39	0.02	0.49
Do not use an in-sink garbage disposal unit	3.32	3.16	0.56	0.16	2.48	3.03	0.01	-0.55	2.10	2.14	0.83	-0.04	2.42	2.10	0.16	0.32
Reduce the frequency of toilet flushing	2.26	2.47	0.23	-0.21	2.98	3.30	0.07	-0.32	1.93	2.14	0.27	-0.21	2.84	2.12	0.00	0.72
Scrape plates clean of food instead of pre-rinsing	2.88	2.70	0.33	0.18	2.53	2.99	0.02	-0.46	2.48	2.28	0.28	0.19	2.60	2.15	0.02	0.45
Take a shorter shower	2.89	2.82	0.68	0.07	3.74	3.50	0.16	0.25	2.35	2.08	0.13	0.26	3.14	1.92	0.00	1.21
Turn off tap when shaving or brushing teeth	3.62	2.96	0.00	0.65	2.93	3.19	0.15	-0.26	1.77	2.01	0.18	-0.24	2.45	1.95	0.02	0.50
Wash vegetables in a bowl of water, and then use it in the garden.	1.69	2.29	0.00	-0.61	2.26	2.91	0.00	-0.65	2.65	2.36	0.11	0.29	2.80	2.29	0.01	0.51
Wash-up dishes by hand	2.73	2.94	0.23	-0.21	2.76	3.04	0.17	-0.27	3.33	2.92	0.03	0.41	2.68	2.26	0.03	0.43
Water the garden in the early morning or evening to reduce evaporation	3.86	3.07	0.00	0.79	3.72	3.42	0.10	0.30	2.64	2.34	0.10	0.30	2.76	2.31	0.01	0.46
Adjust watering schedules according to weather conditions and landscape requirements	2.95	2.91	0.84	0.04	3.76	3.42	0.05	0.34	2.54	2.33	0.26	0.20	3.49	2.49	0.00	1.00
Water the garden with a watering can, rather than a hose	2.06	2.30	0.17	-0.24	2.95	3.36	0.03	-0.42	3.92	3.26	0.00	0.67	3.02	2.49	0.01	0.54
KEY	Significant at p<0.01			Water professional mean score > Householder mean score				Householder mean score > Water professional mean score								

	CURRENT PARTICIPATION				IMPACT ON WATER SAVING				PHYSICAL EFFORT				COGNITIVE EFFORT				FINANCIAL COST			
Water saving behaviour **EFFICIENCY**	WP mean	HH mean	Sig. (2-tailed)	Mean Difference	WP mean	HH mean	Sig. (2-tailed)	Mean Difference	WP mean	HH mean	Sig. (2-tailed)	Mean Difference	WP mean	HH mean	Sig. (2-tailed)	Mean Difference	WP mean	HH mean	Sig. (2-tailed)	Mean Difference
Use a cistern weight if don't have a dual flush toilet	2.14	2.54	0.03	-0.40	2.97	3.21	0.20	-0.24	2.44	2.48	0.82	-0.05	2.51	2.47	0.82	0.04	1.62	2.49	0.00	-0.87
Replace 'thirsty' species of turf with drought-resistant varieties of grasses	2.52	2.49	0.89	0.03	3.41	3.21	0.22	0.20	3.40	3.10	0.11	0.30	3.18	2.99	0.31	0.18	3.41	3.13	0.13	0.28
Replace a single flush toilet cistern with a dual flush system	3.94	3.55	0.03	0.38	3.83	3.49	0.02	0.34	3.32	3.04	0.13	0.28	2.89	2.82	0.67	0.07	3.33	3.10	0.12	0.23
Buy a water efficient (4 star or above) dishwasher	3.08	3.30	0.12	-0.22	3.34	3.40	0.75	-0.06	2.85	2.62	0.18	0.23	2.85	2.78	0.70	0.07	3.88	3.55	0.02	0.32
Install a water efficient pool filter	2.75	2.68	0.79	0.07	2.90	3.05	0.55	-0.15	2.88	2.85	0.92	0.02	2.96	2.62	0.09	0.34	3.39	3.24	0.43	0.15
Install water efficient taps or aerators	3.33	2.97	0.02	0.37	3.44	3.22	0.17	0.23	2.83	2.66	0.30	0.17	2.59	2.59	0.99	0.00	2.64	2.77	0.36	-0.13
Buy a water efficient (4-star or above) front-loader washing machine	3.11	3.21	0.44	-0.10	3.54	3.49	0.79	0.04	2.88	2.64	0.19	0.23	2.85	2.79	0.72	0.07	4.00	3.57	0.00	0.43
Install a grey water system to reuse shower and laundry water in the garden	1.61	2.26	0.00	-0.65	3.40	3.46	0.77	-0.05	3.71	3.48	0.21	0.23	3.62	3.40	0.23	0.22	3.67	3.67	0.98	0.00
Group plants with similar water needs together.	2.27	2.32	0.80	-0.05	3.03	2.94	0.60	0.09	3.05	2.64	0.02	0.41	3.47	2.82	0.00	0.65	1.89	2.52	0.00	-0.62
Install a water efficient targeted irrigation system	2.62	2.41	0.28	0.21	3.78	3.44	0.05	0.34	3.61	3.61	0.99	0.00	3.51	3.50	0.93	0.02	3.63	3.79	0.32	-0.16
Install a low-flow shower head	3.69	3.32	0.01	0.37	3.87	3.57	0.06	0.30	2.83	2.52	0.04	0.31	2.70	2.46	0.14	0.23	2.26	2.62	0.02	-0.36
Plant native or drought-tolerant plants	2.92	2.77	0.36	0.15	3.60	3.21	0.02	0.38	3.29	2.77	0.00	0.52	3.24	2.89	0.04	0.34	2.76	2.99	0.20	-0.22
Install a pool cover	2.94	2.79	0.47	0.16	3.35	3.01	0.08	0.34	3.08	2.59	0.01	0.48	2.63	2.30	0.07	0.33	3.08	2.95	0.46	0.13
Plumb the rainwater tank into the toilet for flushing	2.00	2.24	0.21	-0.24	3.44	3.60	0.38	-0.16	3.56	3.66	0.55	-0.11	3.42	3.54	0.50	-0.12	3.93	3.81	0.50	0.12
Install a rainwater tank to supply water for use inside the home	2.02	2.42	0.03	-0.40	3.61	3.63	0.93	-0.02	3.57	3.68	0.52	-0.11	3.42	3.57	0.40	-0.15	4.14	3.88	0.11	0.25
Install a rainwater tank to supply irrigation water	2.73	2.77	0.85	-0.04	3.47	3.50	0.82	-0.04	3.42	3.54	0.47	-0.12	3.09	3.45	0.02	-0.36	4.05	3.74	0.04	0.31
Reduce the area of lawn within property	2.82	2.63	0.21	0.19	3.35	3.29	0.70	0.07	3.30	2.99	0.10	0.30	3.08	2.98	0.60	0.10	2.74	2.96	0.23	-0.23
Use timer-controlled drip irrigation, rather than a sprinkler system	2.70	2.47	0.25	0.23	3.62	3.25	0.03	0.37	3.11	2.78	0.05	0.33	3.11	2.91	0.31	0.19	3.11	3.05	0.74	0.06

	CURRENT PARTICIPATION				IMPACT ON WATER SAVING				PHYSICAL EFFORT				COGNITIVE EFFORT				FINANCIAL COST			
Water saving behaviour **MAINTANENCE**	WP mean	HH mean	Sig. (2-tailed)	Mean Difference	WP mean	HH mean	Sig. (2-tailed)	Mean Difference	WP mean	HH mean	Sig. (2-tailed)	Mean Difference	WP mean	HH mean	Sig. (2-tailed)	Mean Difference	WP mean	HH mean	Sig. (2-tailed)	Mean Difference
Raise the thermostat on household evaporative air conditioners to 24oC	2.69	2.50	0.34	0.19	3.30	2.79	0.01	0.51	2.26	2.05	0.25	0.21	2.91	2.06	0.00	0.85	1.70	2.26	0.01	-0.56
Allow lawn to brown off	2.92	2.72	0.33	0.20	3.60	3.29	0.06	0.31	1.90	2.11	0.20	-0.20	2.63	2.14	0.03	0.49	1.56	2.36	0.00	-0.79
Fix leaking toilet cistern	3.28	3.28	0.99	0.00	3.47	3.58	0.48	-0.11	3.09	2.99	0.50	0.10	3.05	2.88	0.30	0.16	2.93	3.10	0.28	-0.17
Fix leaking hoses or irrigation systems	3.03	3.10	0.68	-0.07	3.29	3.45	0.37	-0.15	3.12	3.13	0.97	-0.01	2.88	2.95	0.66	-0.07	2.51	3.18	0.00	-0.67
Fix leaking pipes (house-wide)	3.21	3.26	0.74	-0.06	3.73	3.64	0.59	0.09	3.66	3.48	0.30	0.18	3.68	3.32	0.04	0.36	3.68	3.61	0.65	0.07
Fix leaking taps (house-wide)	3.64	3.30	0.02	0.34	3.36	3.40	0.84	-0.03	2.93	2.81	0.42	0.12	2.75	2.67	0.60	0.08	2.25	2.80	0.00	-0.55
Use a 5 – 10cm layer of mulch on garden beds and potted plants	3.20	2.61	0.00	0.59	3.15	3.11	0.82	0.04	3.63	2.90	0.00	0.73	2.80	2.68	0.47	0.12	2.54	2.85	0.06	-0.31
Read the meter to monitor household water use	1.60	1.86	0.14	-0.26	2.77	2.48	0.10	0.29	2.45	2.36	0.63	0.09	3.20	2.31	0.00	0.89	1.28	1.88	0.00	-0.60
Wash the car(s) less often	3.28	3.16	0.48	0.12	2.84	3.23	0.03	-0.39	2.10	2.07	0.87	0.03	2.26	2.08	0.31					
KEY	Significant at p<0.01				Water professional mean score > Householder mean score					Householder mean score > Water professional mean score										

Chapter 5: Investigating perceptions of similarity

5.0 Introduction

The third publication in this thesis forms the first part of an investigation relating to the third research objective: '*Identify potentially catalytic behaviours, to facilitate operationalisation of spillover theory*'. It does so by answering question 3.1, '*Which of the water saving behaviours under investigation are perceived as similar by householders?*' Within the water saving context, the spillover effect suggests an opportunity to encourage faster, more effective behaviour adoption (Thøgersen, 1999; Thøgersen 2004). However, identification of the catalytic behaviours that may facilitate spillover, has not yet been operationalised (Chapter 1, section 1.1 – 1.2). The focus on perceived similarity is based on the idea that similarity of behaviours may help facilitate spillover, through mechanisms such as self-perception, cognitive dissonance and the preference for consistency (Cialdini, Trost & Newsom, 1995; Priolo et al., 2016).

In investigating individual perceptions of behaviours, it was important to understand how individuals categorise and organise concepts. Canter, Brown & Groat (1985) suggest "an understanding of the categories people use and how they assign concepts to those categories is one of the central clues to the understanding of human behaviour". They emphasise the value of exploring the categorical organisation of concepts, and the need to use individuals' own terminology to understand the 'subjective meaning' of terms (Szalay & Deese, 1978). Previous investigations examining similarity through use of Q-sorts, or paired comparisons, have faced criticism for producing simplistic results. Investigators have commented that the variety of characteristics that perception of similarity are based upon is too complex to understand through such methods (Canter, Brown & Groat, 1985).

Sort procedure has been suggested as an alternative method as it places fewer restrictions on participant responses (Canter, Brown & Groat, 1985; Barnett, 2004). This method allows study participants to create any number of groups, freely divide items into the groups, using personally-derived categories (Brewer & Lui, 1996; Garling 1976; Barnett, 2004). As a data elicitation technique, sort procedure provides a qualitative approach to categorisation to investigate perceptual frameworks and categorisation of concepts (Barnett, 2004**.** The outcomes can be investigated using qualitative and quantitative methods to understand both the constructs themselves and the differences (or similarities) between them (Dobbie & Green, 2013). Statistical analysis can be graphed to visualise the relationships between constructs and categories created by participants (Barnett, 2004).

This chapter contains Paper 3 which has been published in the peer-reviewed Journal of Environmental Psychology. It is presented in the published form, as recommended in the Monash University guidelines for a Thesis by Publication.

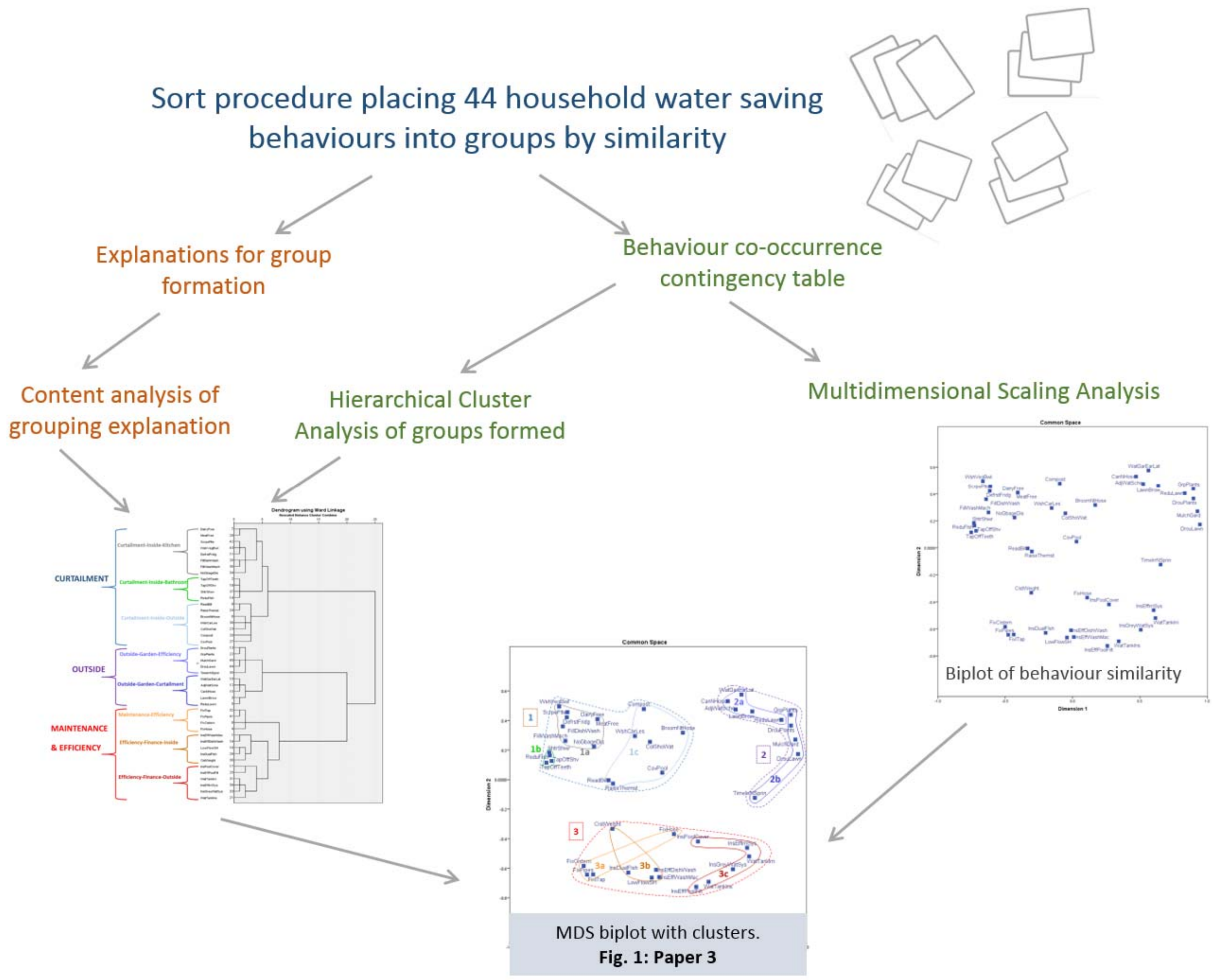

Figure A: Summary of the data collection and analysis approach used to produce a behaviour similarity biplot.

References

Barnett, J. (2004). The multiple sorting procedure (MSP). In Breakwell, G. (Ed.), *Doing social psychology research*. Ch 12, pp. 289-304. Bodmin: Blackwell Publishing.

Brewer, M. B., & Lui, L. N. (1996). Use of sorting tasks to assess cognitive structure. In Schwarz, N. & Sudman, S. (Eds.). *Answering Questions: Methodology for Determining Cognitive and Communicative Processes in Survey Research*. Pp. 373-385. San Francisco: Jossey-Bass.

Canter, D., Brown, J., & Groat, L. (1985). A multiple sorting procedure for studying conceptual systems. In Brenner, M., Brown, J. & Canter, D. (Eds.). *The research interview: Uses and approaches* (pp. 79–114). London: Academic Press.

Cialdini, R. B., Trost, M. R., & Newsom, J. T. (1995). Preference for consistency: The development of a valid measure and the discovery of surprising behavioral implications. *Journal of Personality and Social Psychology*, 69(2), 318.

Dobbie, M. F. (2013). Public aesthetic preferences to inform sustainable wetland management in Victoria, Australia. *Landscape and Urban Planning*, 120(0), 178-189. doi: http://dx.doi.org/10.1016/j.landurbplan.2013.08.018

Gärling, T. (1976). A multidimensional scaling and semantic differential technique study of the perception of environmental settings. *Scandinavian Journal of Psychology*, 17(1), 323-332.

Priolo, D., Milhabet, I., Codou, O., Fointiat, V., Lebarbenchon, E., & Gabarrot, F. (2016). Encouraging ecological behaviour through induced hypocrisy and inconsistency. *Journal of Environmental Psychology*, 47(Supplement C), 166-180. doi: https://doi.org/10.1016/j.jenvp.2016.06.001

Szalay, L. B., & Deese, J. (1978). Subjective meaning and culture: An assessment through word associations. Lawrence Erlbaum Associates.

Thøgersen, J. (1999). Spillover processes in the development of a sustainable consumption pattern. *Journal of Economic Psychology*, 20(1), 53-81. doi: http://dx.doi.org/10.1016/S0167-4870(98)00043-9

Thøgersen, J. (2004). A cognitive dissonance interpretation of consistencies and inconsistencies in environmentally responsible behavior. *Journal of Environmental Psychology*, 24(1), 93-103. doi: http://dx.doi.org/10.1016/S0272-4944(03)00039-2

5.1 Publication 3: '*It's what you do and where you do it; Perceived similarity in household water saving behaviours*'

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It's *what* you do and *where* you do it: Perceived similarity in household water saving behaviours

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A B S T R A C T

In the face of continued environmental degradation, policy makers need to accelerate public uptake of pro-environmental behaviours. Promoting behaviours which catalyse the adoption of other similar behaviours through the spillover effect has been proposed as a potential solution. This requires understanding which behaviours are seen as similar and what criteria are used to identify behavioural similarity. We used a sorting procedure with 32 householders in Melbourne, Australia, to investigate the perceived similarity of household water conservation behaviours and identify the underlying constructs used to distinguish between similar and dissimilar behaviours. Location was the primary attribute used to define behavioural similarity, specifically whether behaviours took place indoors or outdoors. Participants also distinguished between curtailment, efficiency and maintenance-type behaviours. Our findings provide empirical support for existing theoretical behaviour taxonomies. The results could inform design of future water-saving campaigns to promote catalytic behaviours, by leveraging off similar, existing behaviours for effective behaviour change results.

1. Introduction

The adverse impact of human behaviour on global ecosystems has been well-documented (Gardner & Stern, 2002, pp. 253–276; Vlek & Steg, 2007), with human resource consumption causing direct and indirect negative effects (Goudie, 2013). Increasing participation in more sustainable choices has become an important area for policy makers, community leaders, governments and non-governmental organisations (Stern, 2011). Due to this, policy makers have turned to psychology to understand how we can accelerate uptake of multiple sustainable, pro-environmental, policies and actions (Gifford, 2014; Kazdin, 2009; Oskamp, 2000). One idea that encapsulates the focus on creating change through participation in multiple sustainable behaviours is the ‘spillover’ approach to behaviour change (Department of Environment, Food & Rural Affairs, 2008; Thøgersen & Crompton, 2009). The concept of spillover suggests that practicing one environmental behaviour may speed-up, or catalyse, the adoption of additional environmental behaviours (Thøgersen & Ölander, 2003; Thøgersen, 1999). The existence of spillover and its underlying theoretical processes are yet to be fully investigated (Truelove, Carrico, Weber, Raimi, & Vandenbergh, 2014). However, preliminary findings indicate that catalytic behaviour change may be more likely when target and trigger behaviours are perceived as similar in some way, for example within a specific pro-environmental theme (Thøgersen & Ölander, 2003; Thøgersen, 2004), or requiring similar resources for adoption (Margetts & Kashima, 2017).

Two related mechanisms have been proposed to explain the spillover phenomenon; cognitive dissonance and self-perception theory. Cognitive dissonance describes the unpleasant, motivational arousal behind the need for consistency in personal beliefs, attitudes and/or behaviours (Festinger, 1957). People generally prefer consistency within (or between) their cognitions and their actual behaviour to inconsistency in their thoughts and behaviours (Cooper, 2007). Self-perception theory, proposed as an alternative to cognitive dissonance theory, suggests an individual learns about their attitudes and values from observations of their own behaviour (Bem, 1967). Both mechanisms are demonstrated through the ‘foot-

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in-the-door' (FITD) effect; householders asked to sign a petition or display a small notice were more than twice as likely (48%) to cooperate with a subsequent request to display a large sign in their garden compared with the control group (17%) (Freedman & Fraser, 1966). Compliance levels were highest (76%, $p < 0.01$) when the two requests were similar (to display small and large signs promoting safe driving). A review of 28 FITD studies found the effect was only present when the behaviours requested of participants were prosocial, and therefore similar in theme (Dillard, Hunter, & Burgoon, 1984).

These findings suggest that the promotion of behaviours similar to an individual's existing practices could motivate behaviour change either as an avoidance of cognitive dissonance (Swim & Bloodhart, 2013; Thøgersen & Crompton, 2009; Thøgersen, 2004) or by leveraging an individual's self-perception as someone who already does 'this kind of thing' (Thøgersen & Crompton, 2009; Thøgersen & Ölander, 2003). Both approaches support the potential utility of perceived behavioural similarity in triggering catalytic behaviour change (Thøgersen & Noblet, 2012; Thøgersen, 2004).

However, there has been little investigation of behavioural compliance and similarity; one review of FITD found only two studies investigating this connection (Burger, 1999). The reviewer suggested the limited numbers could be due to the subjectivity of assessing similarity and a lack of understanding about whether, or how, behaviours are similar to each other (Burger, 1999). There seems to be a paucity of knowledge on judgement of similarity, and the criteria used to assess similarity, despite its potential importance for spillover (Austin, Cox, Barnett, & Thomas, 2011; Burger, 1999; Thøgersen & Crompton, 2009).

1.1. Behaviour categorisation

The objective similarity of behaviours can be assessed through analysis of the presence or absence of specific characteristics, producing a taxonomic framework (Thøgersen & Ölander, 2003). Proposed methods for categorising pro-environmental behaviours (PEB) for example utilise behaviour location, actions performed or resources required, to define similarity (Thøgersen & Crompton, 2009). Stern's research identifies four types of PEBs: environmental activism, non-activist public sphere, private sphere environmentalism and other pro-environmental behaviours, underpinned by contextual factors, attitudes, capabilities and habits (Stern, 2000). The *private sphere environmentalism* behaviours are further delineated into purchase-related ('efficiency') behaviours, frequency of use-related ('curtailment') behaviours, waste disposal, and 'green consumerism' (Stern & Gardner, 1981; Stern, 2000). This division is supported by a study of UK householder participation in 40 PEBs, where adoption fell into three categories; purchase decisions, such as buying organic food; frequent, habitual, behaviours, such as turning lights off; and behaviours relating to waste separation and treatment (Barr, Gilg, & Ford, 2005).

Further research on resource consumption PEBs (primarily energy-saving behaviours) has supported a distinction between efficiency and curtailment practices (e.g. Gardner & Stern, 2008; Oikonomou, Becchis, Steg, & Russolillo, 2009). One review confirms the use of 'curtailment' or 'efficiency' to define energy conservation behaviours, with a third category defined for regular management or 'maintenance' behaviours (Karlin et al., 2014). These three categories were identified through a two factor approach, using frequency of participation and financial cost of adoption to classify behaviours. Each energy behaviour categorised as low-frequency/high-cost (efficiency), high-frequency/low-cost (curtailment) or low-frequency, low-cost (maintenance) (Karlin et al., 2014). This approach incorporates habitual behaviours, normally defined as automatically performed, repeated behaviours cued within stable contexts (Verplanken & Aarts, 1999), within the 'curtailment' (high-frequency/low-cost) category (Karlin et al., 2014).

Additional dimensions have been proposed for objective categorisation of energy-saving behaviours (Boudet, Flora, & Armel, 2016). An analysis of 261 energy-saving behaviours on nine attributes, including impact, cost, frequency, skill required and location (Boudet et al., 2016) produced four behavioural categories, including 'family style' (frequent, low-cost, low-skill behaviours) and 'call an expert' (infrequent, financially costly, high-skill behaviours) (Boudet et al., 2016). In contrast, an international study of self-reported participation in ten energy-saving behaviours ($n > 10{,}000$) produced a one-dimensional class through Rasch modelling (Urban & Ščasný, 2016). The authors propose that behaviour adoption is a function of the motivation and effort involved; thus the efficiency-curtailment dichotomy is an artefact of the difficulty of behaviour participation (Urban & Ščasný, 2016).

1.2. The role of participation effort

Thøgersen has also highlighted the role of effort required to engage in pro-environmental behaviours as a potentially important dimension of similarity (Thøgersen, 2004). Effort is related to the perceived (Kollmuss & Agyeman, 2002) or actual barriers (Santos, 2008; Vining & Ebreo, 1992) of behavioural participation, including the financial, (Clarke & Brown, 2006), physical, cognitive or temporal effort involved in participation (Bandura, 1997; Smith, Curtis, & Van Dijk, 2010). Behaviours that require more effort are less likely to be adopted (Dolnicar & Hurlimann, 2010; Graymore, Wallis, & O'Toole, 2010; Urban & Ščasný, 2016). It is not known whether, or how, perceptions of effort influence perceptions of behavioural similarity.

1.3. Current study: investigating perceptions of household water-saving behaviours

Investigation of behaviour categorisation through researcher-derived attributes, patterns of participation or effort of adoption, provides us with objective measures of similarity of potential use in selecting 'catalytic' behaviours. However, as Thøgersen states "*Obviously, what matters is how the actors themselves, not some outside observer, perceive the two behaviours*" (2004, p94). It is currently unknown which of the characteristics used to objectively categorise behaviours are significant to consumer perceptions of similarity (Thøgersen, 2004). Improving knowledge on perceptions of similarity through understanding individuals' subjective categorisation of behaviours could assist in application of the spillover model for catalytic behaviour adoption (Truelove et al., 2014).

We therefore aim to investigate perceived similarity of pro-environmental behaviours by target audiences, using the context of water conservation behaviours. The supply and use of water is one of the key environmental challenges facing the planet (Levy & Sidel, 2011). Like many countries, Australia has a complex relationship with water and water supply (World Watch Institute, 2016), experiencing cycles of drought and flood. Climate change is predicted to further impact rainfall quantity and frequency (CSIRO & BoM, 2016), making it difficult for water managers to meet the demands of a growing urban population (Gregory & Hall, 2011). Increased understanding of water saving behaviours could inform future water saving campaigns in Australia and internationally, accelerate the adoption of water conservation activities and facilitate effective application of demand management programs (Fielding, Russell, Spinks, & Mankad, 2012).

Households are the largest urban water consumer in Australia

(Gregory & Hall, 2011) and household adoption of water conservation practices has produced dramatic reductions of water consumption (Walton & Hume, 2011). The focus of this study is therefore to investigate which dimensions or attributes of water saving behaviours are key to perceived similarity by urban householders. As we used a qualitative inductive process we do not make any firm hypotheses. However, past research suggests that attributes such as behaviour type (curtailment, efficiency, maintenance) and participation effort may influence assessment of similarity. By investigating householder perceptions directly we aim to illuminate behaviour categorisation by the target audience. This study therefore addresses two main research questions:

RQ 1: Which of the water saving behaviours under investigation are perceived as similar by householders?
RQ 2: Why are they seen as similar; specifically, what criteria do householders use to determine perceptions of similarity?

2. Method

To investigate our research questions we used Multiple Sort Procedure (MSP). This allows participants to organise objects and explain their categorisation. MSP has been used to explore perceptions of images of wetlands (Dobbie & Green, 2013; Dobbie, 2013), architectural styles (Groat, 1982), landscapes (Scott & Canter, 1997) and consumer preferences or perceptions of similarity of food products (e.g. Chollet, Lelièvre, Abdi, & Valentin, 2011). Subjects formulate their own rationale for creating and allocating objects to groups (Barnett, 2004; Brewer & Lui, 1996). Multiple Sort Procedure outcomes enable qualitative and quantitative investigation of object categorisation, participant-defined constructs and perceived differences (or similarities) between objects (Dobbie, 2009).

2.1. Participants

Study participants, recruited through university networks, were provided with an explanatory statement describing the research as investigating water use behaviours. Recruitment continued until saturation was reached. All 32 participants were resident in urban Australia, but varied in terms of age, cultural, and educational background, ensuring response diversity (Austin et al., 2011). Study participants were 59% female, 21% were aged 18–25, 56% aged 26–45 and 22% aged 46–65. Most (70%) had been living in Australia for over 3 years, with 41% living in Australia for over 25 years. Only 34% had Australian parents, 9% had one Australian parent, 54% neither parent was Australian. Participants were well-educated; 80% had a bachelor or postgraduate degree; 47% were home owners and 53% were renters. Over 80% had previously experienced water restrictions of some kind and 96% reported this had impacted their water consumption.

2.2. Procedure

Individual participants were presented with 44 water saving behaviours on cards; the behaviours came from a review of grey literature on household water conservation (Kneebone, Smith, & Fielding, 2017). Once the study procedure was explained, participants conducted a 'free' sort, using their own criteria to place similar behaviours together, forming multiple groups (Barnett, 2004; Dobbie, 2013). Once the sort was completed, participants described and explained their groupings. Each session was audio recorded and transcribed to capture participant category descriptions. The behaviours placed into each group were listed and entered into a 44x44 co-occurrence matrix. Participants completed a sociodemographic survey after completion of the sorting task.

3. Results

First we will discuss the analytical process applied to the data (section 3.1 and 3.2), then we will interpret the results of the analyses as a whole (section 3.3 and 3.4).

3.1. Overview of analytical approach

The 32 participants produced 201 groups through the MSP, each group consisting of behaviours perceived as similar in some way. We used a multi-step approach to examine how often each of the behaviours were grouped together and the constructs participants used to determine similarity. First, multidimensional scaling analysis (MDS) was used to represent the perceived similarity of behaviours spatially. Second, hierarchical clustering identified interpretable clusters of behaviours. Combining these two methods illustrates data structure by clustering frequently co-occurring behaviours together, allowing patterns in the data to be highlighted (Bartholomew, Steele, Galbraith, & Moustaki, 2008; Villagra-Islas & Dobbie, 2014). Third, content analysis of the descriptions participants used to label each group produced 26 constructs. The frequency of construct use per behaviour was analysed with categorical principal components analysis (CATPCA), allowing clusters of similar behaviours to be categorised by their distinguishing constructs (Dobbie & Green, 2013).

3.2. Analytical process

To investigate *which* water saving behaviours were perceived as similar, the co-occurrence of behaviours in groups produced by the Multiple Sort Procedure was recorded in a 44 x 44 co-occurrence matrix. Classical multidimensional scaling analysis (MDS) was used to analyse the co-occurrence matrix and identify similar behaviours through spatial representation (Lattin, Green, & Carroll, 2003) within a Euclidean model (Norusis, 2008). MDS allows items (behaviours in this case) to be mapped onto a visual representation according to frequency of co-occurrence, or perceived similarity, with all other items under consideration; two items positioned closely are seen as similar, two items that are far apart are dissimilar (Norusis, 2008). As the data are non-metric, the locations do not represent actual distances, that is, if one pair of items are twice as close to each other as another pair, they are not twice as similar, just more similar (Garson, 2012).

The MDS analysis was carried out using the PROXSCAL option in SPSS (version 20) (Garson, 2012). Multiple dimension options (1–5) were trialled to assess the most interpretable solution, where stress-values are minimised (Borg & Groenen, 2005). Stress values vary between 0 and 1 to provide a goodness-of-fit measure describing how well the model created fits the data; the larger the number the worse the fit (Kruskal, 1964; Norusis, 2008). Analysis of the Multiple Sort Procedure data suggested a 2-dimensional solution was optimal, with an 'excellent' S-stress value of 0.02 (Kruskal, 1964). The solution is illustrated with a biplot (see Fig. 1); each behaviour is mapped in terms of perceived similarity to all the other 43 water saving behaviours under consideration.

An agglomerative, hierarchical cluster analysis of the co-occurrence matrix was used to define which behaviours were most frequently grouped together by study participants (Green, 2005; Villagra-Islas & Dobbie, 2014). Ward's solution provided the clearest outcome in terms of interpretability, with the shortest branches (Gordon, 1999) (see supplementary materials for the cluster analysis results illustrated in a dendrogram). This formed three main clusters (1, 2, and 3) and eight sub-clusters (1a, 1b, 1c,

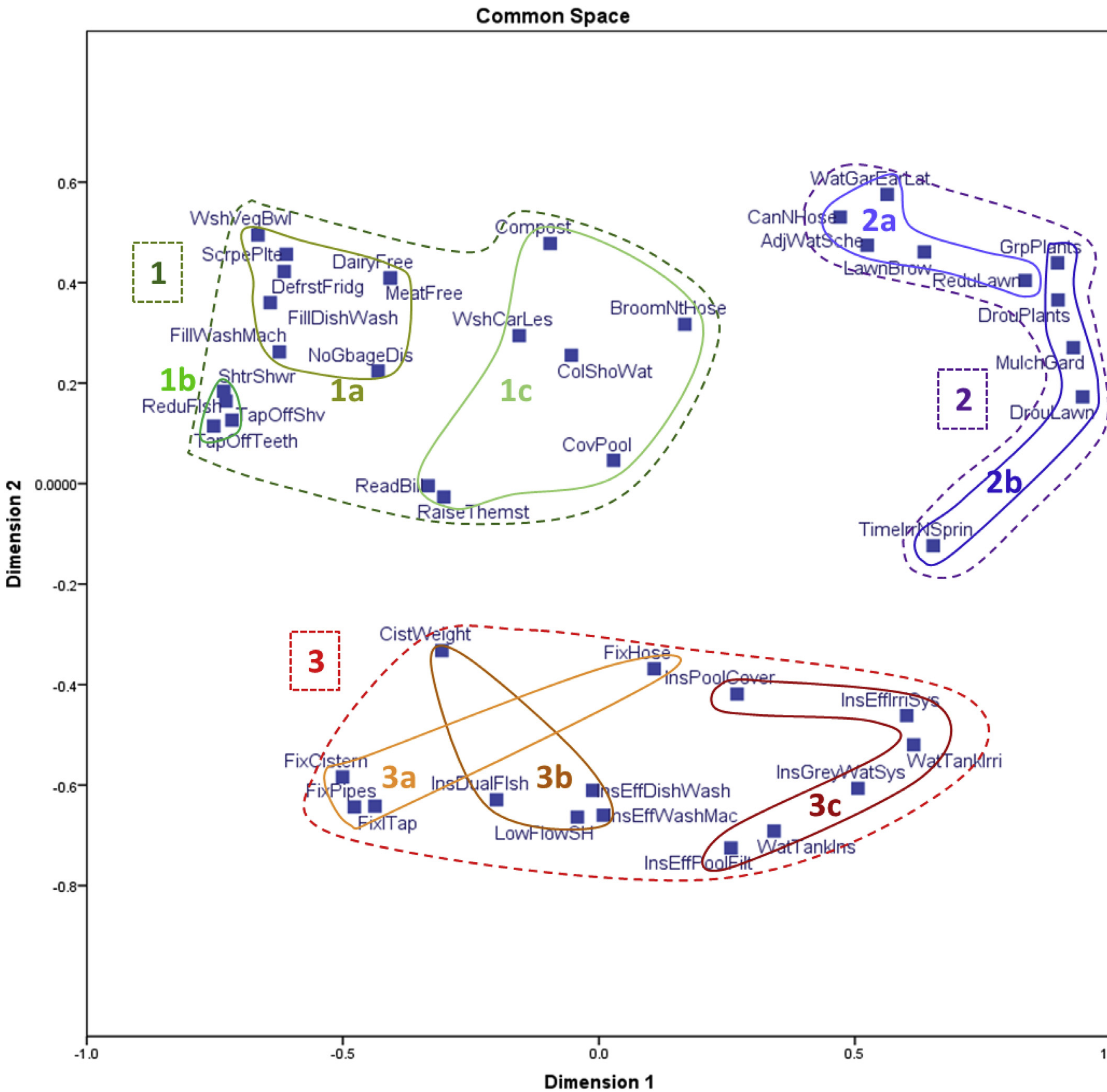

Fig. 1. Multidimensional scaling analysis (MDS) biplot maps each behaviour in terms of perceived similarity to all other behaviours. It is superimposed with the results of a hierarchical cluster analysis to define behavioural clusters. See Table 1 for full behaviour names and key.

2a, 2b, 3a, 3b, and 3c). Table 1 lists the behaviours included within each cluster. The clusters were superimposed on the MDS result biplot to allow interpretation (Fig. 1).

The descriptions given by study participants during the sort procedure were used to explore *why* particular behaviours were placed together. Thematic content analysis was used to identify the constructs underlying perceived similarity and allowed us to label the groupings produced through the cluster analysis. We used a combination of *a priori* constructs from behaviour categorisation literature (Section 1.1 and 1.2) and inductively defined constructs (Drisko & Maschi, 2015). Two researchers coded the data, coding independently (inter-coder reliability = 66%), jointly reviewing codes and completing a third round of coding (inter-coder reliability = 95%) (Bryman, 2015; Stolarova, Wolf, Rinker, & Brielmann, 2014).

Study participants used 432 terms in total to define their behaviour groups, with an average 2.15 constructs per group. The content analysis refined this list into 31 descriptive constructs, arranged into five themes. The frequency with which each construct was used was recorded in a contingency table (Table 2). '*Location*' themed constructs made up 28.17% of participant responses, followed by '*Behaviour type*' (24.43%), '*Ease of participation*' (24.14%), '*Behavioural goal*' (17.79%), and '*Personal practices and preferences*' (5.47%). We selected constructs by their frequency of use to label the behaviour clusters in Fig. 1. The primary (most frequently used) descriptors allowed differentiation between the three main

Table 1
Summary of cluster analysis results describing which household water saving behaviours were grouped together through MSP. Data from the thematic content analysis highlight the constructs most frequently used by participants to describe why behaviours were seen as similar.

Cluster Code (Fig. 1)	Behaviour Number (Fig. 2)	Behaviour Code (Fig. 1)	Full behaviour name	Most frequently used constructs (Table 2)
1				CURTAILMENT
1a	7	DairyFree	Go dairy-free one day a week	Curtailment
	28	MeatFree	Go meat-free one day a week	Inside
	42	ScrpePlte	Scrape plates clean of food	Kitchen
	43	WshVegBwl	Wash vegetables in a bowl of water	
	11	DefrstFridg	Defrost food in the fridge overnight, rather than under a running tap	
	26	FillDishWash	Fill the dishwasher for every wash	
	36	FillWashMach	Only wash full loads of clothes	
	34	NoGbageDis	Do not use an in-sink garbage disposal unit	
1b	2	TapOffTeeth	Turn off tap when brushing teeth	Curtailment
	18	TapOffShv	Turn off tap when shaving	Inside
	37	ShtrShwr	Take a shorter shower	Bathroom
	14	ReduFlsh	Reduce frequency of toilet flushing	
1c	9	ReadBill	Read the water bill to monitor water use	Curtailment
	24	RaiseThemst	Raise the thermostat on evaporative air conditioners to 24 °C	Inside
	6	BroomNtHose	Use a broom, not a hose, to clean outside spaces	Outside
	38	WshCarLes	Wash the car(s) less often	
	23	ColShoWat	Collect shower warm-up water in a bucket	
	20	Compost	Compost kitchen scraps and add to garden	
	27	CovPool	Keep swimming pools covered when not in use	
2				OUTSIDE
2a	13	DrouPlants	Plant native or drought-tolerant plants	Outside
	22	GrpPlants	Group plants with similar water needs together	Garden
	40	MulchGard	Use a 5–10 cm layer of mulch on garden beds and potted plants	Efficiency
	44	DrouLawn	Replace 'thirsty' species of turf with drought-resistant varieties	
	35	TimeIrrNSprin	Use timer-controlled drip irrigation, rather than a sprinkler system	
2b	10	WatGarEarLat	Water the garden in the early morning or evening	Outside
	12	AdjWatSche	Adjust watering schedules according to weather conditions	Garden
	15	CanNHose	Water the garden with a watering can, not a hose	Curtailment
	3	LawnBrow	Allow lawn to go brown	
	5	ReduLawn	Reduce the area of lawn	
3				EFFICIENCY
3a	32	FixTap	Fix leaking taps (house-wide)	Maintenance Efficiency
	41	FixPipes	Fix leaking pipes (house-wide)	
	8	FixCistern	Fix leaking toilet cistern	
	4	FixHose	Fix leaking hoses or irrigation systems	
3b	1	InsEffWashMac	Buy a water efficient (4-star or above) front-loader washing machine	Efficiency Financial cost
	19	InsEffDishWash	Buy a water efficient (4-star or above) dishwasher	Inside
	16	LowFlowSH	Install a low-flow showerhead	
	29	InsDualFlsh	Replace a single flush toilet cistern with a dual flush system	
	30	CistWeight	Use a cistern weight if don't have a dual flush toilet	
3c	17	InsPoolCover	Install a pool cover	Efficiency
	25	InsEffPoolFilt	Install a water efficient pool filter	Financial cost Outside
	31	WatTankIrri	Install a rainwater tank to supply irrigation water	
	39	InsEffIrriSys	Install a water efficient targeted irrigation system	
	33	InsGreyWatSys	Install a grey water system to reuse laundry water in the garden	
	21	WatTankIns	Install a rainwater tank to supply water for use in toilet and laundry	

behaviour clusters (1, 2, and 3 in Fig. 1), but secondary and tertiary descriptors had to be incorporated to distinguish between the eight sub-clusters (1a, 1b, 1c, 2a, 2b, 3a, 3b, and 3c) (see Fig. 1 for the clusters and Table 1 for the associated constructs for each cluster).

Finally, results from the two datasets; the multidimensional scaling analysis/cluster analysis describing *which* behaviours group together and the thematic content analysis exploring *why* they are seen as similar, were combined using categorical principal components analysis (CATPCA), with optimal scaling and variable principal normalisation (Dobbie & Green, 2013). As with standard principal components analysis, CATPCA allows data dimensions to be reduced into 'principal components' which account for the maximum variance in the data (Jolliffe, 2002). The categorical method allows application to categorical data that do not have a linear relationship (Linting, Meulman, Groenen, & van der Kooij, 2007). This facilitates analysis, for example to identify underlying components within the data (Starkweather & Herrington, 2016); in this case, the main constructs used to describe groups of similar behaviours.

When running CATPCA (SPSS 22), '*Reuse Water*', '*Save Energy*', '*Laundry*', '*Time cost*' and '*Protect Water Quality*' had very little variance ($<$or $=$ 0.1) or no variance. As they could not be used to distinguish between groups they were removed from the analysis (see Table 2). After trialling the analysis with 1–5 dimensions on the remaining 26 constructs, a two-dimensional solution was selected as the most meaningful with high internal consistency (Cronbach's alpha $=$ 0.985, accounting for 72.62% of variance) (Dobbie, 2013; Starkweather & Herrington, 2016). Each construct is illustrated as a vector within a biplot (Fig. 2); vector length indicates the relative frequency of construct use (the higher the

Table 2
Contingency table of proportional frequency of constructs used by participants when describing groups of similar behaviours. Constructs marked with * had a marginal impact on variance within the data so were removed from the CATPCA analysis.

Theme	Construct	Sample terms used by participants	Frequency of use (%)	Variance explained though CATPCA
Location	Outside	Outside, outdoors, yard	9.02%	0.42
	Garden	Garden, lawn, yard	7.33%	0.41
	Inside	Inside, indoors, in the house	6.22%	0.92
	Bathroom	Bathroom, shower, toilet, bath	2.05%	0.33
	Kitchen	Kitchen	2.00%	0.72
	Pool	Pool, swimming pool	1.19%	0.24
	Laundry*	Laundry	0.36%	0.10
		TOTAL	28.17%	
Behaviour Type	Curtailment	Habit, daily, routine, chore	10.05%	1.18
	Efficiency	Install, purchase, buy, technology, innovation	9.83%	0.72
	Maintenance	Monitor, maintain, fix	4.55%	0.45
		TOTAL	24.43%	
Ease of participation	Financial cost	Financial cost, expensive, money	5.41%	0.74
	Self-efficacy	Able to do by myself, anyone can do	5.02%	0.74
	Cognitive effort	Thinking, planning, plan, organise	4.66%	0.53
	Low cost	Low cost, no cost, easy, simple	3.39%	0.59
	Resource required	Requires resources, needs resources, takes effort	2.66%	0.37
	External assistance	Outside help needed, expertise, use a professional	1.50%	0.40
	Time cost	Time cost, takes time	0.75%	0.02
	Physical effort	Physical effort, labour, physically change something	0.75%	0.30
		TOTAL	24.14%	
Behavioural goal	Save water	Saves water, reduces water use	11.63%	0.97
	Food preparation	Food, making food	2.11%	0.90
	Cleaning	Clean, rubbish, waste disposal	1.22%	0.37
	Wasting water	Don't waste water, stop wasting water (unnecessarily), prevent water waste	1.05%	0.27
	Save energy*	Saves energy, reduces energy used	0.78%	0.00
	Save money	Saves money	0.75%	0.29
	Protect water quality*	Don't pollute	0.14%	0.04
	Reuse water*	Grey water, recycle water	0.11%	0.00
		TOTAL	17.79%	
Personal practices & preferences	Doesn't apply	Doesn't apply, not relevant	1.44%	0.24
	Don't know	Don't know how it relates to water saving, not sure	1.39%	0.64
	Currently practice	I do this, something I do	1.36%	0.36
	Do not practice	Don't do	0.86%	0.19
	Don't agree	Should not be done, not effective, don't agree with	0.42%	0.52
		TOTAL	5.47%	

frequency, the longer the vector) and vector direction is determined by the location of the behaviours the construct was used to describe. SPSS allows incorporation of the behaviour location coordinates from the multidimensional scaling analysis as a fixed configuration (Dobbie, 2013; Villagra-Islas & Dobbie, 2014). The biplot in Fig. 2 therefore combines data illustrating *which* behaviours are seen as similar and *why* they are seen as similar, as determined by the descriptive constructs. Section 3.2 below summarises the dimensions identified in Fig. 2.

3.3. Which behaviours are seen as similar?

To investigate Research Question 1, '*Which household water saving behaviours are seen as similar?*' study participants were asked to group behaviours they saw to be similar. The results are illustrated visually in Fig. 1. The more frequently behaviours were grouped together during the sort procedure, the closer they are positioned in the biplot and thus the more perceptually similar they are. Co-occurring behaviours are listed fully in Table 2.

Behaviours in Cluster 1 are mostly indoor curtailment-type (or habitual) behaviours. The diet-related behaviours, going meat-free or dairy-free one day per week, were always grouped together, so had perfect co-occurrence. Other kitchen or food-related behaviours were also grouped together (Cluster 1a), with efficient appliance use. Bathroom-related behaviours 'turn off taps', 'reduce flushes' and 'taking shorter showers' grouped with nearly 100% co-occurrence in Cluster 1b. Cluster 1c differs as it spreads out and conflates some indoor behaviours, including adjusting air conditioner thermostats, or reading the bill, with outdoor behaviours such as washing the car less and composting scraps. This may reflect different constructs being used to define Cluster 1c compared with other groups.

Cluster 2 comprises outdoor garden and plant-related behaviours. Efficiency-type behaviours in Cluster 2a are concerned with plant and lawn choices, installation of mulch and efficient irrigation systems. Cluster 2b includes curtailment behaviours regarding outdoor water use practices and reducing garden water requirements.

Cluster 3 contains efficiency and maintenance behaviours; Cluster 3a includes the repair of leaks around the home. The asymmetric appearance of the group is due to one behaviour ('fix hoses') being sorted as an outdoor behaviour, away from the indoor fixing of pipes, taps and cisterns. Cluster 3b contains indoor efficiency behaviours, with dishwasher, washing machine and low flow showerhead installation clustering closely together, while cistern weight installation is further away. Finally, Cluster 3c contains outdoor efficiency behaviours relating to water tanks, irrigation systems and pool filters.

3.4. Why are behaviours seen as similar?

Participant descriptions of the behaviour groups created

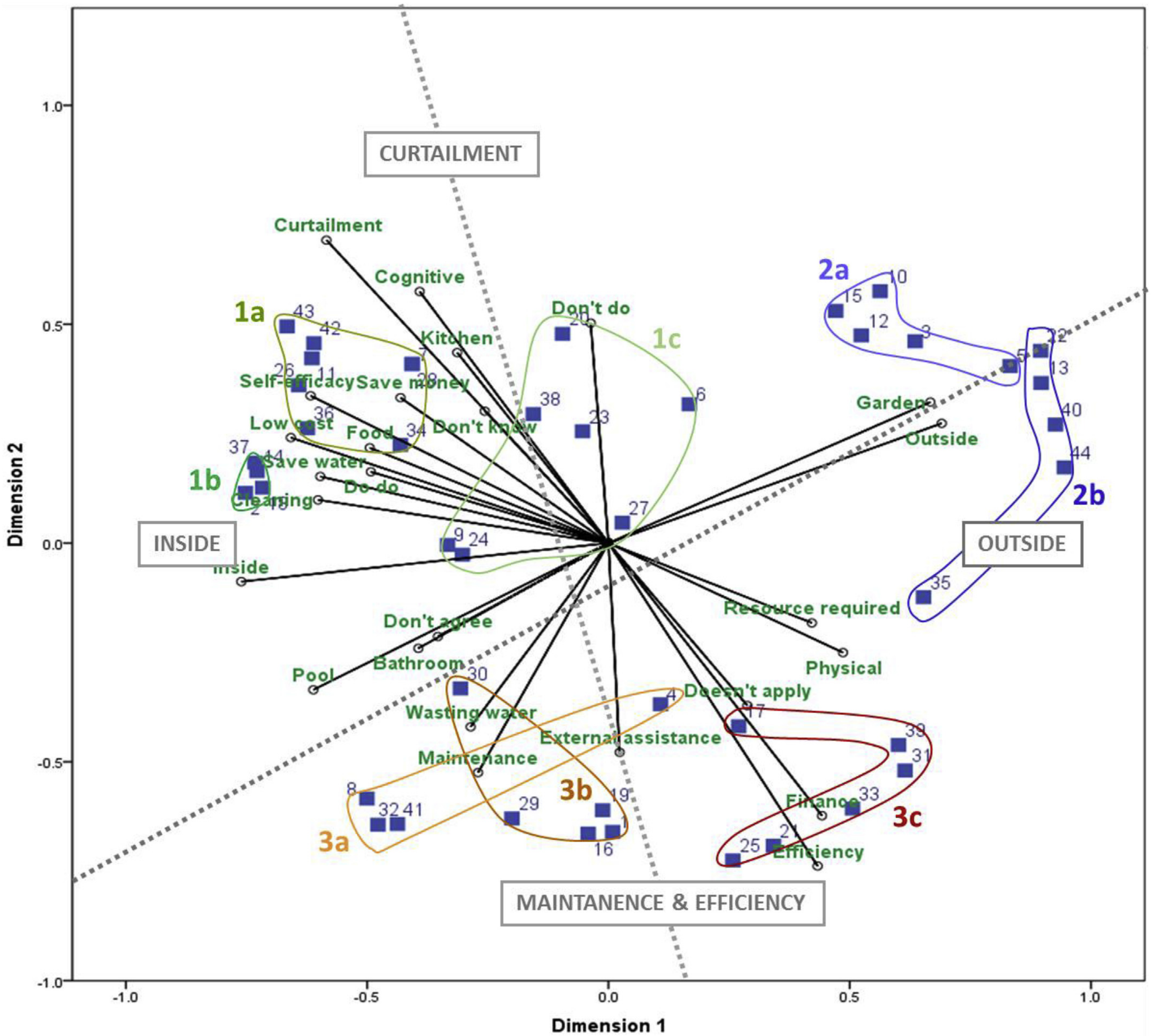

Fig. 2. CATPCA biplot of constructs used by participants to define behavioural similarity, superimposed on the behaviour co-occurrence clusters produced from Multidimensional Scaling Analysis. The most important distinguishing constructs regarding behaviour type and location are highlighted in boxes. See Table 1 for the key to sub-cluster and behaviour code numbers.

through the sort procedure underwent content analysis to provide insight for Research Question 2; 'W*hat criteria do householders use to determine perceptions of similarity?*' The most frequently applied constructs study participants used to differentiate between groupings relate to the physical location of the behaviour, type of behaviour and the effort required for behaviour participation.

3.4.1. Behaviour location

Behaviour location accounted for over 28% of constructs (see Table 2), suggesting location is an important dimension for perceived similarity in water saving behaviours. The division between indoor- and outdoor-located behaviours was most clear, with 'Outside' or 'Garden' making up 16% and 'Inside', 'Bathroom', 'Kitchen', 'Laundry', making up over 10% of descriptors. The indoor-outdoor division can be seen in Fig. 1. Behaviours in Clusters 1a, 1b and 1c (see Table 1 for the key) were all described as indoor locations. Behaviours within Clusters 1a (kitchen) and 1b (bathroom) fall closely together, indicating strong perceptions of similarity. In contrast, behaviours in Cluster 1c are widely spaced, suggesting they are seen as less similar than behaviours in the kitchen and bathroom clusters. Some Cluster 1c behaviours are described as indoor and others as outdoor; this suggests that location is of secondary importance to behaviour type when considering behaviours in Cluster 1c (see 3.2.2).

'*Outdoor*' behaviours are grouped closely within Cluster 2a and Cluster 2b (Fig. 1). The outdoor installation behaviours in Cluster 3c are an exception, they also have behaviour type as the main descriptor ('*Maintenance*' or '*Efficiency*'). The division between indoor and outdoor is confirmed within Fig. 2, with the constructs '*Garden*' and '*Outside*' forming a distinct group linking to Clusters 2a and 2b. The construct '*Pool*', is unexpectedly located opposite the other outdoor-related constructs. This may be because of the types of behaviours (efficiency and maintenance) that relate to swimming pool management.

3.4.2. Behaviour type

The second most frequently applied construct to define similarity within clusters relates to behaviour type (24.43%) (Table 2). This is demonstrated in Figs. 1 and 2; Clusters 1a, 1b and 1c were described as curtailment, Cluster 3 related to a combination of efficiency and maintenance behaviours and Cluster 2 was primarily related to outdoor location but divided into Clusters 2a ('*Curtailment*') and 2b ('*Efficiency*'). The significance of behaviour type suggests it may form a second major dimension for householder perceptions of similarity of water saving behaviours.

3.4.3. Participation effort

The third most commonly used construct to define similarity within clusters involved the ease of participation, including the effort involved in participation (24.14%) (Table 2). Although terms relating to ease of participation do not seem to be important enough to distinguish between clusters in Fig. 1, the location of ease constructs in Fig. 2 is interesting. For example, Cluster 1, '*Curtailment*', is also described as '*Low cost*', requiring '*Cognitive effort*', and relating to '*Self-efficacy*'. This implies behaviours are seen as easy to do, but require thought or planning. In contrast, behaviours within the '*Maintenance*' Cluster (3a) were also described with '*External assistance*' and the '*Efficiency*' clusters (3b and 3c) were described with '*Financial cost*', thus illustrating potential barriers to participation.

3.4.4. Behavioural goal

Behaviour outcomes, or goals, were used to define similarity within some clusters (17.79%) (Table 2). Every behaviour in the study was described with the construct '*Save water*' (11.63%) by study participants in the sort procedure. This is unsurprising as all behaviours under consideration were selected as water conservation behaviours (see Kneebone et al., 2017 for details). Behavioural goal constructs, such as '*Cleaning*', '*Food preparation*' and '*Save money*' all related to curtailment behaviours, whereas '*Prevent water wastage*' was used when describing maintenance behaviours (see Fig. 2). Previous research has suggested that, depending on how an individual perceives goal pursuit, promoting behaviours with a common goal could lead to spillover (Fishbach, Dhar, & Zhang, 2006).

3.4.5. Personal practices and beliefs

The least frequently used constructs related to participant personal beliefs and practices. Interestingly, the results suggest '*Behaviours I do*' and '*Behaviours I don't do*' are perceived differently. This supports findings from a previous sort procedure study investigating perceived similarity of pro-environmental behaviours (Austin et al., 2011). Behaviours that were not seen as personally relevant to participants were placed together (notably pool-related behaviours in Cluster 3c (Fig. 1). The response '*Don't know*' was used in regard to the diet-related behaviours, '*Go meat/dairy-free one day a week*'; this suggests an information-based intervention could help promote these behaviours.

4. Discussion

The findings of this study suggest that the two most important dimensions of behavioural similarity for water saving behaviours are 'Location' (indoor versus outdoor behaviours), and 'Behaviour type' (curtailment, efficiency or maintenance practices). 'Ease of participation', 'Behavioural goals' and 'Personal beliefs' were also used to determine similarity, but were not as frequently applied, suggesting that they are of lesser importance. These findings complement previous research on energy-saving behaviours (e.g. Karlin et al., 2014).

Studies on energy saving behaviours have shown that location is an important theme impacting how people categorise actions related to energy saving (Boudet et al., 2016; Gabe-Thomas, Walker, Verplanken, & Shaddick, 2016). For water related behaviours, the significance of location could relate to the different services provided by household water consumption inside and outside the home. Specifically, water inside the home is used to fulfil the basic functions of '*cleanliness, comfort and convenience*', including food preparation, cleaning clothes and personal hygiene (Shove, 2004). Outside, water is used for irrigation, maintenance or car washing within the yard, garden, driveway or balconies (Syme, Shao, Po, & Campbell, 2004). Outdoor water use is affected by seasonality and geography (Gifford, 2008; Syme et al., 2004; Troy, Holloway, & Randolph, 2005) and has previously been targeted in Australia through water restrictions and social marketing campaigns (Syme et al., 2004). Our findings suggest that outdoor water saving behaviours are not seen as similar to indoor behaviours; campaigns focussing on outdoor water conservation may therefore preclude spillover to indoor water saving.

Behaviour type also appears to be important in assessments of similarity. This supports previous research distinguishing between curtailment and efficiency behaviours (e.g. Barr et al., 2005; Boudet et al., 2016; Karlin et al., 2014). Our findings suggest a clear division in perceptions between curtailment and efficiency behaviours, as they mapped onto opposite sides of the biplot (Figs. 1 and 2). An unclear division between efficiency and maintenance behaviours may be due to the overlap between efficiency/maintenance and location constructs, with the relative importance of each construct varying between behaviours. Despite this, participant behavioural descriptions seem to support the trichotomous division of efficiency/curtailment/maintenance, as proposed by Karlin et al. (2014).

Ease of participation also seems important to study participants, particularly regarding financial, cognitive and physical effort of behaviour adoption. This finding corroborates previous use of all three measures of effort of participation to assess the likelihood of behavioural adoption (Kneebone et al., 2017). Behaviours also grouped in terms of self-efficacy, whether participants felt they were able to participate in them (Lauren, Fielding, Smith, & Louis, 2016), and whether behaviours were currently enacted (Austin et al., 2011).

4.1. Implications for behaviour selection for future water demand management campaigns

The concept of spillover suggests that to maximise the effectiveness of future household water demand management campaigns, decision makers should select key actions perceived as similar to, and thus able to be catalysed by, householders' existing behaviours. To do so, we need to understand audience perceptions of similarity. Our direct investigation of householder perceptions of similarity allowed us to bypass the use of researcher-led categorisation or participation-based assessments of behavioural similarity. The data revealed that, in terms of householder perceptions, behavioural practice was not particularly salient for assessing similarity; only 2.3% of the constructs produced related to current activities. Location and behaviour type were much more important attributes for perceptions of behavioural similarity. This supports the idea that audience perceptions of similarity cannot be measured or understood through investigation of current practice alone (Thøgersen, 2004).

Understanding patterns of perceived similarity for behaviours may help selection of effective choices for resource consumption reduction campaigns, through targeting groups of perceptually similar behaviours. This study identifies some themes or constructs relating to water conservation behaviours to potentially focus on. Policy makers should consider promoting behaviours which take place in the same location, are of the same categorical type or involve the same kinds of effort in participation, as existing behaviours to increase the chance or rate of adoption through the spillover effect.

4.2. Study limitations

Although the study sample size is well within best practice guidelines for sort procedures (Tullis & Wood, 2004), participants did not form a representative sample. They were more highly educated and culturally diverse than a proportionally representative sample would provide. Additionally, they were all recruited from Melbourne, Australia, which has a particular water context and history that may affect perceptions. However, the alignment between participant behaviour groupings with previous behavioural taxonomies goes some way to providing confidence in the findings. Nevertheless, future research with samples from other geographies and testing the approach with different behaviours is required to assess the generalisability of the results. The content analysis procedure presumes that researchers involved in the coding understood participant cluster descriptions accurately, preventing misinterpretation of participant comments. Interpretation accuracy was assisted by the lead researcher facilitating the sort procedure with study participants and thus being able to clarify participant comments. For future application of the methodology, we would recommend applying Krippendorff's alpha and Cohen's kappa to ensure sufficient intercoder reliability levels.

This paper's main aim is to inform future studies investigating the effectiveness of leveraging off existing behaviours to encourage participation in additional, similar, behaviours. A trial comparing the adoption of behaviours perceived as similar versus behaviours seen as dissimilar to current practices could test the potential role of similarity in spillover. The nature of behaviours selected for a future study could reflect the various dimensions of similarity identified through this study, investigating whether adoption rates are influenced by promoting behaviours with the same location, type, participation effort, or goal as existing behaviours.

5. Conclusion

Using a sort procedure, study participants arranged water saving behaviours into similar groups based primarily on behaviour location (indoor or outdoor), and behaviour type (efficiency, curtailment or maintenance). A combination of multidimensional scaling analysis (MDS) with categorical principal components analysis (CATPCA), permitted investigation into which behaviours are seen as similar and why they are seen as similar. The method used provides a replicable procedure to study perceptions of similarity for water-related, or other pro-environmental behaviours. Understanding which behaviours are seen as similar and why may assist researchers investigating catalytic behaviour change and the existence of spillover.

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Appendix B. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jenvp.2017.10.007.

References

Austin, A., Cox, J., Barnett, J., & Thomas, C. (2011). *Exploring catalyst behaviours: Summary report to the Department for Environment, Food and Rural Affairs*. London: Brook Lyndhurst for Defra.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. Macmillan.

Barnett, J. (2004). The multiple sorting procedure (MSP). In G. M. Breakwell (Ed.), *Doing social psychology research* (pp. 289–304). John Wiley & Sons.

Barr, S., Gilg, A. W., & Ford, N. (2005). The household energy gap: Examining the divide between habitual-and purchase-related conservation behaviours. *Energy Policy, 33*, 1425–1444.

Bartholomew, D. J., Steele, F., Galbraith, J., & Moustaki, I. (2008). Multidimensional scaling. In D. J. Bartholomew, F. Steele, J. Galbraith, & I. Moustaki (Eds.), *Analysis of multivariate social science data* (pp. 55–81). CRC press.

Bem, D. J. (1967). Self-perception: An alternative interpretation of cognitive dissonance phenomena. *Psychological Review, 74*(3), 183.

Borg, I., & Groenen, P. J. F. (2005). MDS fit measures, their relations, and some algorithms. In I. Borg, & P. J. F. Groenen (Eds.), *Modern multidimensional scaling: Theory and applications* (pp. 247–260). Springer Science & Business Media.

Boudet, H. S., Flora, J. A., & Armel, K. C. (2016). Clustering household energy-saving behaviours by behavioural attribute. *Energy Policy, 92*, 444–454.

Brewer, M. B., & Lui, L. N. (1996). Use of sorting tasks to assess cognitive structure. In N. Schwarz, & S. Sudman (Eds.), *Answering questions: Methodology for determining cognitive and communicative processes in survey research* (pp. 373–385). San Francisco: Jossey-Bass.

Bryman, A. (2015). *Social research methods*. Oxford University Press.

Burger, J. M. (1999). The foot-in-the-door compliance procedure: A multiple-process analysis and review. *Personality and Social Psychology Review, 3*, 303–325.

Chollet, S., Lelièvre, M., Abdi, H., & Valentin, D. (2011). Sort and beer: Everything you wanted to know about the sorting task but did not dare to ask. *Food Quality and Preference, 22*(6), 507–520.

Clarke, J. M., & Brown, R. R. (2006). Understanding the factors that influence domestic water consumption within Melbourne. *Australian Journal of Water Resources, 10*(3), 261.

Cooper, J. (2007). *Cognitive dissonance: 50 years of a classic theory*. London: Sage.

CSIRO and Bureau of Meteorology. (2016). *State of the climate 2016*. www.csiro.au/state-of-the-climate Accessed November 2016.

Department of Environment, & Food & Rural Affairs. (2008). *Framework for pro-environmental behaviours*. London: Department for Environment, Food and Rural Affairs.

Dillard, J. P., Hunter, J. E., & Burgoon, M. (1984). Sequential-request persuasive strategies. *Human Communication Research, 10*(4), 461–488.

Dobbie, M. F. (2009). *Public perceptions of victorian freshwater wetlands: Preference, health and cultural sustainability*. PhD thesis. Australia: University of Melbourne.

Dobbie, M. F. (2013). Public aesthetic preferences to inform sustainable wetland management in Victoria, Australia. *Landscape and Urban Planning, 120*, 178–189.

Dobbie, M., & Green, R. (2013). Public perceptions of freshwater wetlands in Victoria, Australia. *Landscape and Urban Planning, 110*, 143–154.

Dolnicar, S., & Hurlimann, A. (2010). Australians' water conservation behaviours and attitudes. *Australian Journal of Water Resources, 14*(1), 43–53.

Drisko, J. W., & Maschi, T. (2015). Basic content analysis. In J. W. Drisko, & T. Maschi (Eds.), *Content analysis*. New York: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780190215491.003.0002.

Festinger, L. (1957). *A theory of cognitive dissonance*. Stanford, CA: Stanford University Press.

Fielding, K. S., Russell, S., Spinks, A., & Mankad, A. (2012). Determinants of household water conservation: The role of demographic, infrastructure, behavior, and psychosocial variables. *Water Resources Research, 48*(10).

Fishbach, A., Dhar, R., & Zhang, Y. (2006). Subgoals as substitutes or complements: The role of goal accessibility. *Journal of Personality and Social Psychology, 91*(2), 232.

Freedman, J. L., & Fraser, S. C. (1966). Compliance without pressure: The foot-in-the-door technique. *Journal of Personality and Social Psychology, 4*(2), 155–202.

Gabe-Thomas, E., Walker, I., Verplanken, B., & Shaddick, G. (2016). Householders' mental models of domestic energy consumption: Using a sort-and-cluster method to identify shared concepts of appliance similarity. *PLoS One, 11*(7), e0158949.

Gardner, G. T., & Stern, P. C. (2002). *Environmental problems and human behavior*. Boston, MA: Pearson Custom Publishing.

Gardner, G. T., & Stern, P. C. (2008). The short list: The most effective actions US households can take to curb climate change. *Environment: Science and Policy for Sustainable Development, 50*(5), 12–25.
Garson, G. D. (2012). *Multidimensional scaling*. Asheboro, NC: Statistical Associates Publishers.
Gifford, R. (2008). Toward a comprehensive model of social dilemmas. In *New issues and paradigms in research on social dilemmas* (pp. 265–279). Springer US.
Gifford, R. (2014). Environmental psychology matters. *Annual Review of Psychology, 65*(1), 541–579.
Gordon, A. D. (1999). Classification. *Monographs on Statistics and Applied Probability, 82*.
Goudie, A. S. (2013). *The human impact on the natural environment: Past, present, and future*. John Wiley & Sons.
Graymore, M., Wallis, A., & O'Toole, K. (2010). Understanding drivers and barriers: The key to water use behaviour change. *Water Science and Technology: Water Supply, 10*(5), 679–688.
Green, R. (2005). Community perceptions of environmental and social change and tourism development on the island of Koh Samui, Thailand. *Journal of Environmental Psychology, 25*(1), 37–56.
Gregory, A., & Hall, M. (2011). Urban water sustainability. In I. Prosser (Ed.), *Water: Science and solutions for Australia* (pp. 75–88). Melbourne, Australia: CSIRO.
Groat, L. (1982). Meaning in post-modern architecture: An examination using the multiple sorting task. *Journal of Environmental Psychology, 2*(1), 3–22.
Jolliffe, I. T. (2002). Principal component analysis and factor analysis. In I. Jolliffe (Ed.), *Principal component analysis* (pp. 150–166). New York: Springer.
Karlin, B., Davis, N., Sanguinetti, A., Gamble, K., Kirkby, D., & Stokols, D. (2014). Dimensions of conservation exploring differences among energy behaviors. *Environment and Behavior, 46*(4), 423–452.
Kazdin, A. E. (2009). Psychological science's contributions to a sustainable environment: Extending our reach to a grand challenge of society. *American Psychologist, 64*(5), 339.
Kneebone, S., Smith, L., & Fielding, K. (2017). The impact-likelihood matrix: A policy tool for behaviour prioritisation. *Environmental Science & Policy, 70*, 9–20.
Kollmuss, A., & Agyeman, J. (2002). Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research, 8*(3), 239–260.
Kruskal, J. B. (1964). Multidimensional scaling by optimizing goodness of fit to a nonmetric hypothesis. *Psychometrika, 29*(1), 1–27.
Lattin, J. M., Green, P. E., & Carroll, J. (2003). *Analyzing multivariate data*. Pacific Grove, CA: Thomson Brooks/Cole.
Lauren, N., Fielding, K. S., Smith, L., & Louis, W. R. (2016). You did, so you can and you will: Self-efficacy as a mediator of spillover from easy to more difficult pro-environmental behaviour. *Journal of Environmental Psychology, 48*, 191–199.
Levy, B. S., & Sidel, V. W. (2011). Water rights and water fights: Preventing and resolving conflicts before they boil over. *American Journal of Public Health, 101*(5), 778–780.
Linting, M., Meulman, J. J., Groenen, P. J., & van der Koojj, A. J. (2007). Nonlinear principal components analysis: Introduction and application. *Psychological Methods, 12*(3), 336.
Margetts, E. A., & Kashima, Y. (2017). Spillover between pro-environmental behaviours: The role of resources and perceived similarity. *Journal of Environmental Psychology, 49*, 30–42.
Norusis, M. (2008). Multidimensional scaling. In F. Young, & D. Harris (Eds.), *SPSS 16.0 advanced statistical procedure companion* (pp. 335–404). Prentice Hall.
Oikonomou, V., Becchis, F., Steg, L., & Russolillo, D. (2009). Energy saving and energy efficiency concepts for policy making. *Energy Policy, 37*(11), 4787–4796.
Oskamp, S. (2000). A sustainable future for humanity? How can psychology help? *American Psychologist, 55*(5), 496.
Santos, G. (2008). The London experience. In E. Verhoef, B. Van Wee, L. Steg, & M. Bliemer (Eds.), *Pricing in road transport: A multi-disciplinary perspective* (pp. 273–292). Cheltenham: Edgar Elgar.
Scott, M. J., & Canter, D. V. (1997). Picture or place? A multiple sorting study of landscape. *Journal of Environmental Psychology, 17*(4), 263–281.
Shove, E. (2004). *Comfort, cleanliness and convenience: The social organization of normality*. New Technologies/New Cultures.
Smith, L., Curtis, J., & Van Dijk, P. (2010). What the zoo should ask: The visitor perspective on pro-wildlife behavior attributes. *Curator: The Museum Journal, 53*(3), 339–357.
Starkweather, J., & Herrington, R. (2016). *Categorical principal components analysis (CATPCA) with optimal scaling*. Research and Statistical Support, University of North Texas. http://bayes.acs.unt.edu:8083/BayesContent/class/Jon/SPSS_SC/Module9/M9_CATPCA/SPSS_M9_CATPCA.htm. (Accessed November 2016).
Stern, P. C. (2000). New environmental theories: Toward a coherent theory of environmentally significant behavior. *Journal of Social Issues, 56*(3), 407–424.
Stern, P. C. (2011). Contributions of psychology to limiting climate change. *American Psychologist, 66*(4), 303.
Stern, P. C., & Gardner, G. T. (1981). Psychological research and energy policy. *American Psychologist, 36*(4), 329.
Stolarova, M., Wolf, C., Rinker, T., & Brielmann, A. (2014). How to assess and compare inter-rater reliability, agreement and correlation of ratings: An exemplary analysis of mother-father and parent-teacher expressive vocabulary rating pairs. *Frontiers in Psychology, 5*, 509.
Swim, J. K., & Bloodhart, B. (2013). Admonishment and praise: Interpersonal mechanisms for promoting proenvironmental behavior. *Ecopsychology, 5*(1), 24–35.
Syme, G. J., Shao, Q., Po, M., & Campbell, E. (2004). Predicting and understanding home garden water use. *Landscape and Urban Planning, 68*(1), 121–128.
Thøgersen, J. (1999). Spillover processes in the development of a sustainable consumption pattern. *Journal of Economic Psychology, 20*(1), 53–81.
Thøgersen, J. (2004). A cognitive dissonance interpretation of consistencies and inconsistencies in environmentally responsible behavior. *Journal of Environmental Psychology, 24*(1), 93–103.
Thøgersen, J., & Crompton, T. (2009). Simple and painless? The limitations of spillover in environmental campaigning. *Journal of Consumer Policy, 32*(2), 141–163.
Thøgersen, J., & Noblet, C. (2012). Does green consumerism increase the acceptance of wind power? *Energy Policy, 51*(0), 854–862.
Thøgersen, J., & Ölander, F. (2003). Spillover of environment-friendly consumer behaviour. *Journal of Environmental Psychology, 23*(3), 225–236.
Troy, P. N., Holloway, D., & Randolph, W. (2005). *Water use and the built environment: Patterns of water consumption in Sydney*. Sydney: City Futures Research Centre.
Truelove, H. B., Carrico, A. R., Weber, E. U., Raimi, K. T., & Vandenbergh, M. P. (2014). Positive and negative spillover of pro-environmental behavior: An integrative review and theoretical framework. *Global Environmental Change, 29*, 127–138.
Tullis, T., & Wood, L. (2004). How many users are enough for a card-sorting study? The card-sorting study. In *UPA Proceedings* (Vol. 2004).
Urban, J., & Ščasný, M. (2016). Structure of domestic energy saving: How many dimensions? *Environment and Behavior, 48*(3), 454–481.
Verplanken, B., & Aarts, H. (1999). Habit, attitude, and planned behaviour: Is habit an empty construct or an interesting case of goal-directed automaticity? *European Review of Social Psychology, 10*(1), 101–134.
Villagra-Islas, P., & Dobbie, M. (2014). Design aspects of urban wetlands in an earthquake-prone environment. *Journal of Urban Design, 19*(5), 660–681.
Vining, J., & Ebreo, A. (1992). Predicting recycling behavior from global and specific environmental attitudes and changes in recycling opportunities. *Journal of Applied Social Psychology, 22*(20), 1580–1607.
Vlek, C., & Steg, L. (2007). Human behavior and environmental sustainability: Problems, driving forces, and research topics. *Journal of Social Issues, 63*(1), 1–19.
Walton, A., & Hume, M. (2011). Creating positive habits in water conservation: The case of the Queensland Water Commission and the Target 140 campaign. *International Journal of Non-profit and Voluntary Sector Marketing, 16*(3), 215–224.
The World Watch Institute. (2016). *State of the World 2016: Can a city be sustainable?* Island Press.

Chapter 6: Synthesis of results

6.0 Introduction

As has been discussed, spillover may be a potential tool for accelerated adoption of desired behaviours by a target audience (see Chapter 1). This effect could have useful implications for water managers seeking to promote demand management as a way of securing water resources into the future. The likelihood of spillover taking place is thought to increase by the use of leverage or catalytic behaviours that trigger additional behaviour adoption. Some of the proposed mechanisms behind spillover, namely cognitive dissonance and preference for consistency, mean that perceived similarity of behaviours could be an important facilitator of spillover (Thøgersen, 2004; Thøgersen, 2012; Nilsson, Bergquist & Schultz, 2017). However, little work has been carried out on how to assess behavioural similarity (Bratt, 1999; Burger, 1999). Research that has identified behavioural characteristics that could inform similarity, such as Stern's impact of behaviours (Stern, 2000), or categorisation of energy-saving behaviours (e.g. Boudet, Flora & Armel, 2016; Karlin et al., 2014), relied upon researcher-defined categories, rather than using dimensions of similarity generated by the target audience.

The research carried out in this thesis, contributes to this literature by providing insight into householder perceptions of behavioural similarity and the criteria used by householders to define similarity. Understanding which water-saving behaviours are seen as similar by householders and why, permits additional understanding to facilitate behaviour selection, but only explains part of the process. The third research objective for this project was therefore designed to extend the work carried out on similarity and to contribute to the investigations of the spillover effect by developing a process to identify potentially catalytic behaviours. Application of a process to identify catalytic behaviours could be a useful contribution to the further investigation of spillover theory, as it closes an existing gap in understanding (Austin, Cox, Barnett & Thomas, 2011; Thøgersen & Crompton, 2009; Truelove et al., 2014). This chapter explores the approach taken to synthesise the results and outcomes of the research and thus develop a process for identifying potentially catalytic behaviours.

6.1 Synthesis approach

In order to develop a method for catalytic behaviour identification, data and insight from multiple sources was combined. The initial development and testing of the impact-likelihood matrix for behaviour prioritisation provided an understanding of which behaviours could be targeted by behaviour change programming in terms of their impact on the issue, likelihood of adoption and existing participation rates (Chapter 3). The validity and utility of data sourced to construct the matrix was investigated through a comparison of ‘expert’ water professional and ‘lay’ householders perceptions (Chapter 4).

Concerns around sample sizes in paper one (prioritisation matrix), meant that the online survey for ‘expert’ water professionals was repeated to generate additional data and increase reliability and accuracy. A second recruitment drive produced a larger number of respondents for the behaviour perception survey, resulting in 44 data sets for analysis for Chapter 5, compared to the initial 18 water professional respondents used in Chapter 4. New impact-likelihood matrices were constructed using the larger dataset, involving recalculation of perceived impacts of behaviours on water saving (from water professionals), plus existing householder data on likelihood of adoption. The updated matrix was then combined with the cluster analysis and multidimensional scaling analysis biplot research outputs from Chapter 5. These two elements identify which of the water saving behaviours under investigation are perceived as similar by householders, and why.

The research outputs from all three papers were combined to create maps of similarity to identify priority, potentially catalytic, behaviours (see Table 1).

Table 1: Summary of the research outputs used as sources of data for the synthesis diagrams.

Paper 1	Paper 2	Paper 3
Online survey of householder perceptions of behaviour characteristics (n=151): 1) Key barrier (cognitive effort, physical effort, financial cost) to behaviour adoption, 2) Likelihood of behaviour adoption. National survey of water sensitive behaviour (n=5194) 3) Existing levels of householder participation in water saving behaviours.	Online survey of water professional perceptions of behaviour characteristics: 4) Impact of behaviours on water saving.	Cluster analysis on the results of the sort procedure: 5) Identification of which behaviours are perceived to be similar by householders.

6.2 Identifying similarity pathways for behaviour selection

In order to identify potentially catalytic behaviours, the insights generated from the prioritisation and similarity studies (Chapter 3 and Chapter 5), strengthened with the additional data produced from Chapter 4, needed to be combined. This permits the understanding of which behaviours are a key priority, both in terms of their impact on water saving, the likelihood of adoption and current participation rates seen in the impact-likelihood matrix (Chapter 3) and their perceived similarity identified by the multidimensional scaling analysis from Chapter 5. The combination of research output data sets allowed the construction of graphical representations of behaviour relationships illustrated with similarity-prioritisation maps, as shown in Figures 1, 2, 3 and 4.

These diagrams show where perceptually similar behaviours are positioned relative to each other within the prioritisation matrix quadrants (see Figure 1). This allows similar behaviours to be linked, and thus potentially prioritised, in terms of householder perceptions of similarity. This novel approach therefore uses householder perceptions to select behaviours to target for intervention design and programming, rather than researcher-derived categories. Similarity links between behaviours, illustrated with coloured lines on the maps, could act as pathways for catalytic behaviour change. If two behaviours are seen as similar, but one has a higher likelihood of adoption than the other, higher likelihood behaviour could be used as a lever to encourage the adoption of the similar, lower likelihood behaviour. This process could facilitate accelerated behaviour adoption.

The links of greatest interest for potential spillover are those representing connections between low impact (little water saving) and high impact (greater water saving) behaviours, illustrated in Figure 1. Using the diagrams, it is possible to identify ‘pathways’ for behaviour adoption; from low impact, high likelihood of adoption behaviours (bottom right quadrant) to high impact, high likelihood (top right), or high impact, but low likelihood of adoption, behaviours (top left), illustrated with an arrow in Figure 2. For example, pathways illustrated in Figure 2 suggest that, ‘turning off the tap’ might be a useful lever to encourage adoption of the higher impact, but perceptually similar, ‘take a shorter shower’. Alternately, high likelihood, low impact ‘reading the water meter’ could help leverage the perceptually similar, lower likelihood, higher impact behaviour, ‘use a broom instead of a hose to clean outside spaces’. Other pathways could encourage adoption from mid-impact ‘fixing taps’ to lower likelihood, higher impact ‘fixing pipes’ and from low impact ‘installing a cistern weight’ to a range of higher impact behaviours including installing a low-flow showerhead, dual flush toilet, efficient dishwasher or efficient washing machine. These pathways could represent a route for identification of potentially catalytic behaviours; those that are seen as similar to each other, but with different likelihood of adoption and impact on water saving. From a demand management perspective, water managers should consider behaviour selection that encourages adoption of low likelihood of adoption, high impact behaviours, leveraging from low impact, high likelihood of adoption, behaviours.

The similarity-prioritisation map can be re-drawn to incorporate the data on the current levels of participation in water saving behaviours used in the prioritisation matrix (Chapter 2). This version (Figure 3) illustrates which behaviours are most commonly practised by householders, and could therefore be selected as potential catalytic behaviours for the largest number of people. As with Figure 1 and 2, the similarity pathways, illustrated with coloured lines, linking behaviours seen as perceptually similar by householders, indicate which behaviours might increase the likelihood of the spillover effect. The pathways are of particular significance where they link lower impact, but high current rate of adoption behaviours (small circle size), with higher impact behaviours.

Water managers could therefore use existing behaviours (low opportunity of uptake, illustrated with a small circle size) as levers to promote adoption of additional, more impactful, behaviour change. For example, ‘filling the dishwasher’ has a high rate of participation and could be useful to promote the perceptually similar, less commonly adopted ‘taking a shorter shower’. Installing a water efficient dishwasher or a pool cover are more commonly enacted behaviours which are perceptually similar to installation of grey water systems, rainwater tanks and efficient washing machines, and could therefore act as catalysts to promote the more impactful behaviours.

6.3 Implications for intervention design

Householder perceptions of the effort required for behaviour participation are potentially useful for the development of appropriate intervention design to facilitate spillover (Chapter 3), and can also be incorporated into the similarity-prioritisation map. The pathways connecting perceptually similar behaviours therefore also provide an indication of the highest scoring type of effort, or key barrier, potentially preventing behaviour adoption, see Figure 4. Some groups of perceptually similar behaviours have been scored with the same key barrier.

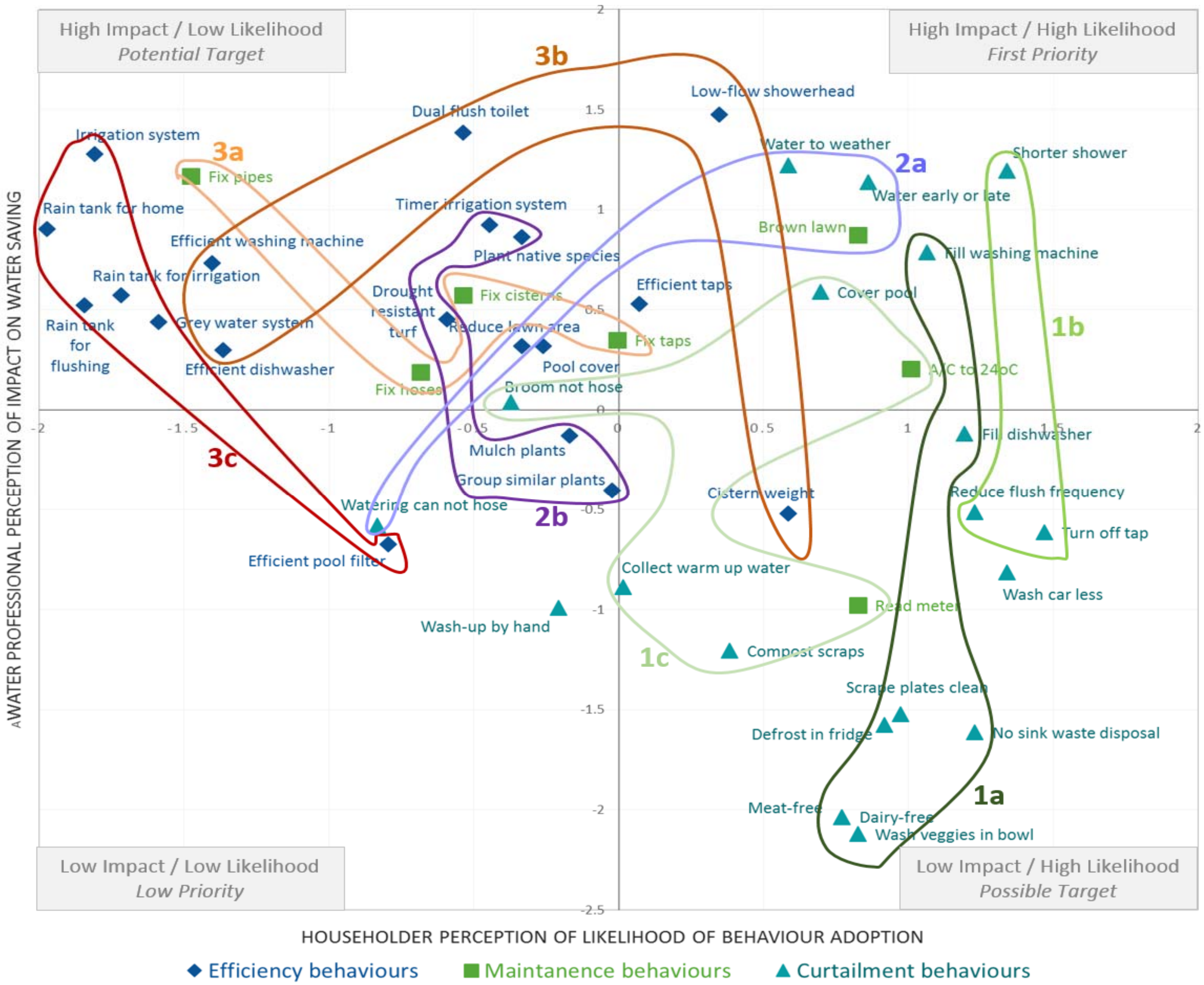

Figure 1: Behaviour prioritisation matrix, overlain with similarity cluster data (Chapter 6) to produce a similarity-prioritisation map. The cluster label coding is explained in Table 2, below.

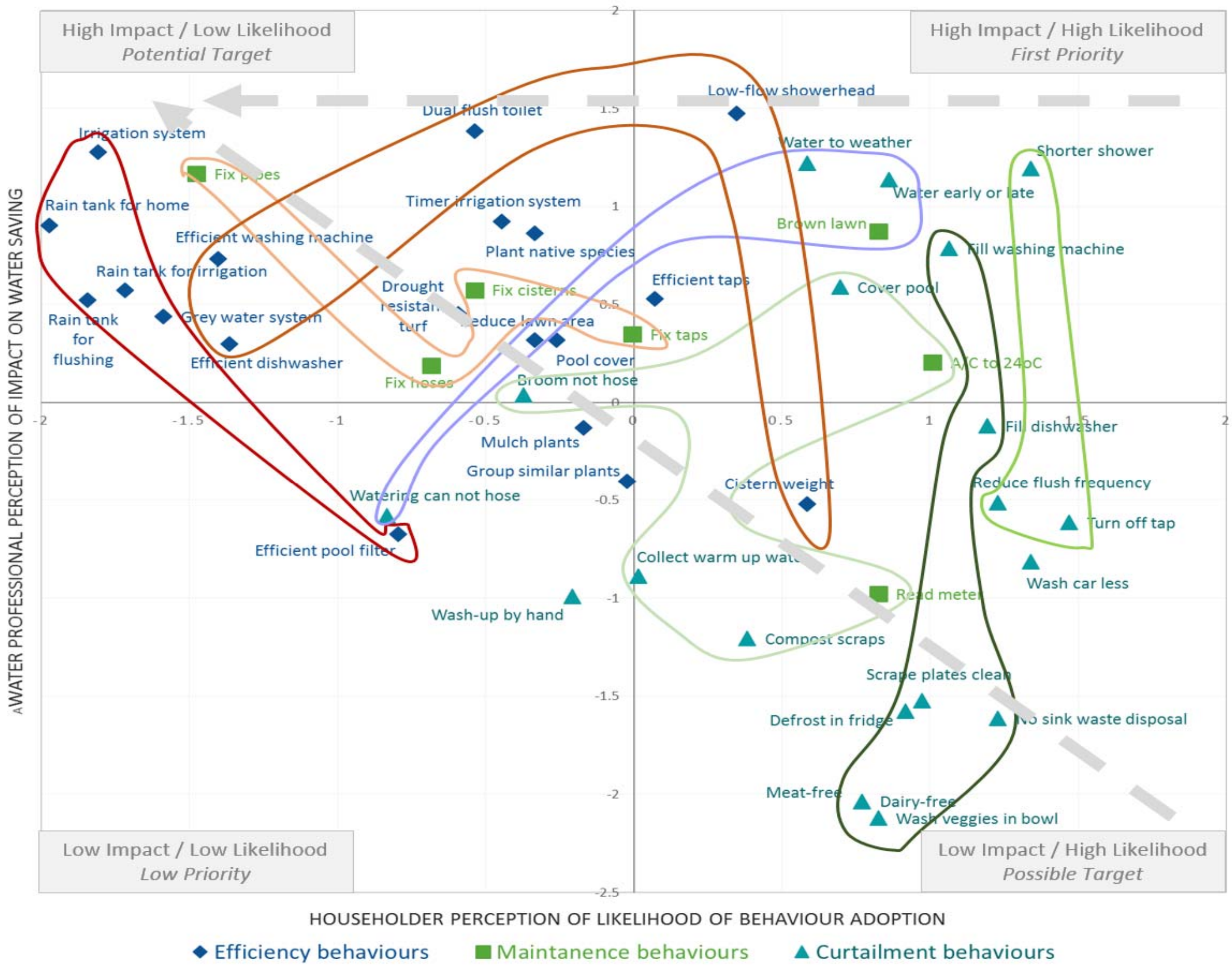

Figure 2: Simplified similarity-prioritisation map showing potentially catalytic pathways from behaviours assessed as higher likelihood of adoption, to perceptually similar behaviours with a lower likelihood of adoption.

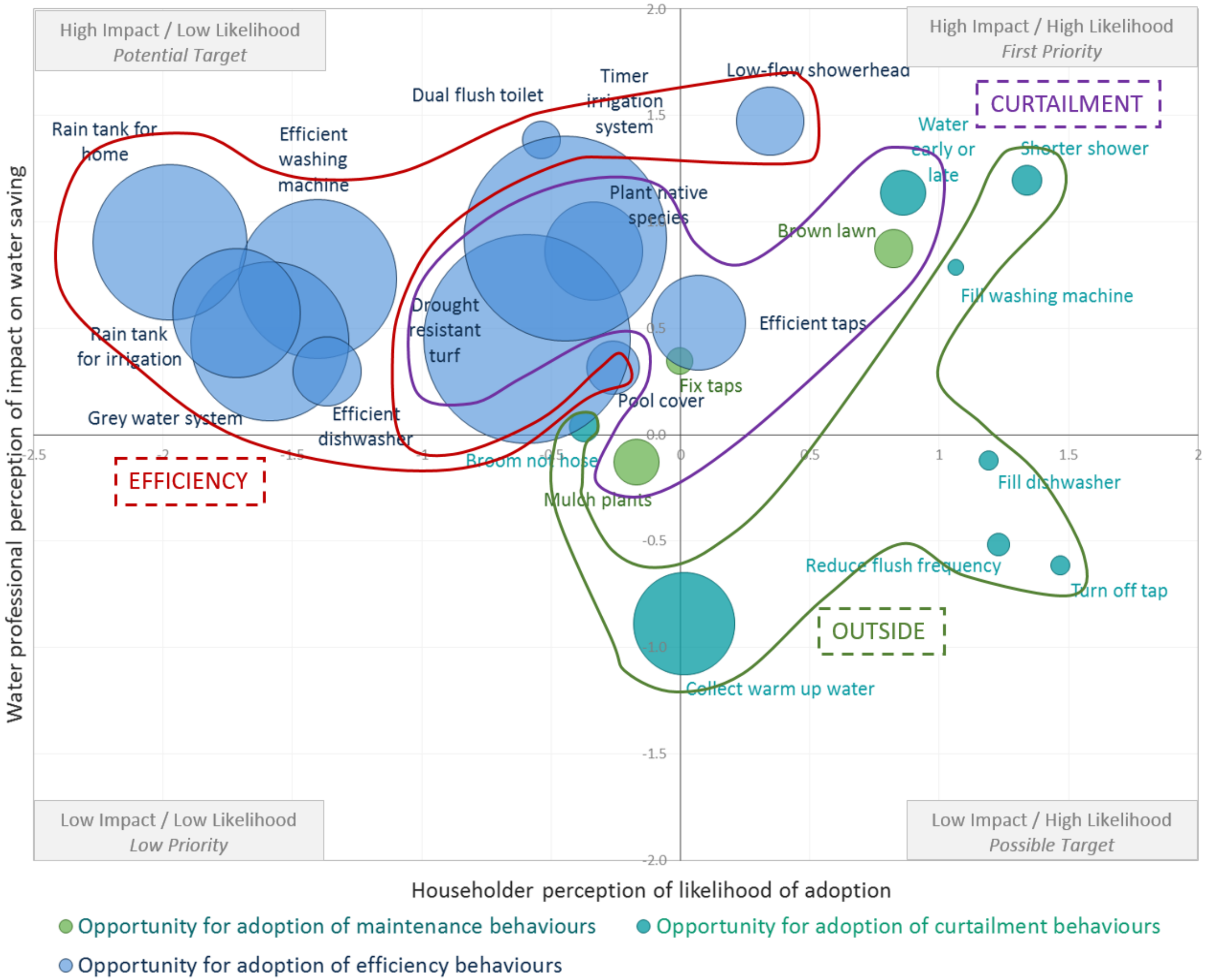

Figure 3: Existing participation rates of water saving behaviours incorporated into the similarity-prioritisation map, to identify potential catalytic and target behaviours for demand management programming.

Participation rate indicated by circle size; small circle indicates high current participation and therefore low opportunity for additional adoption.

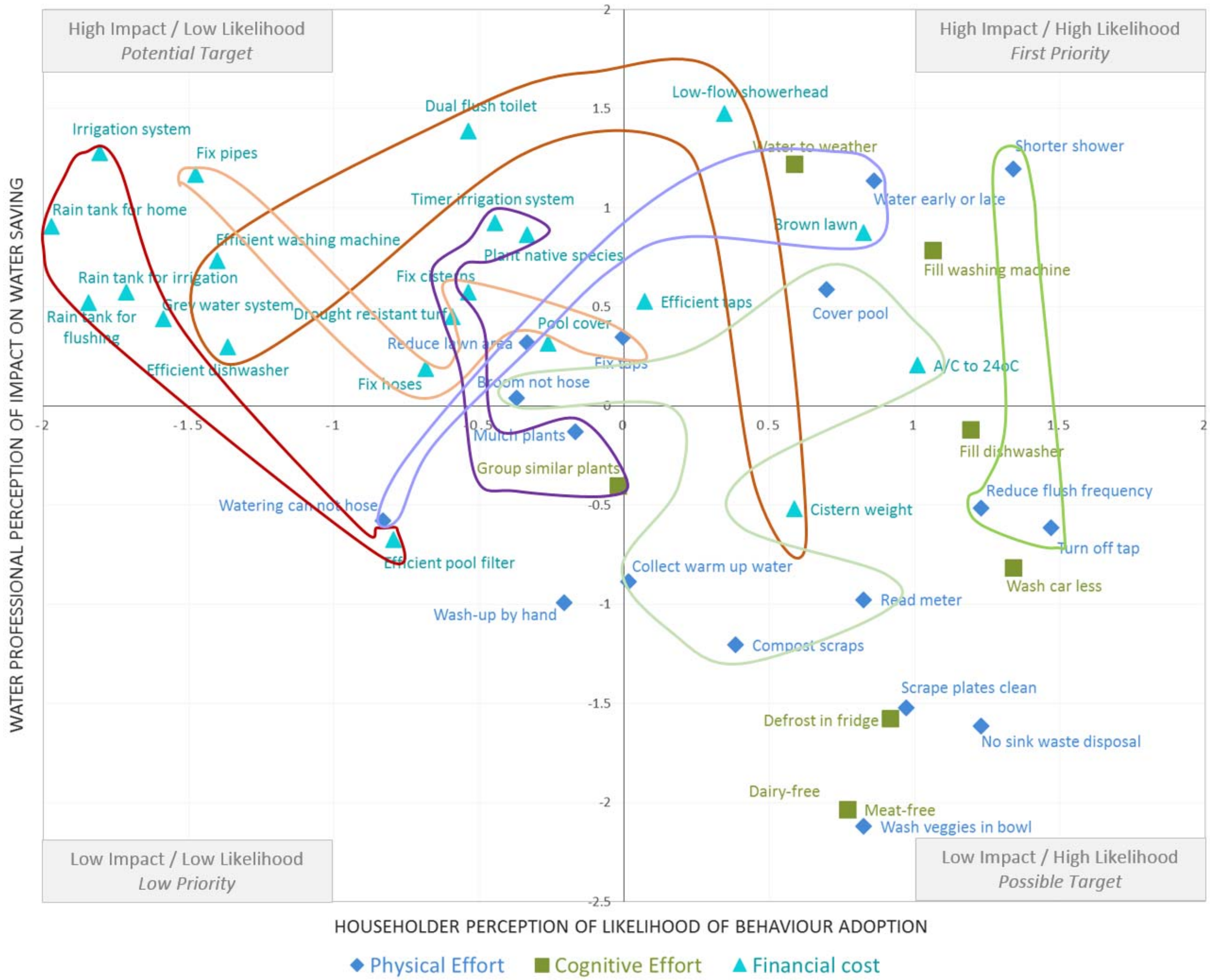

Figure 4: Similarity-prioritisation map illustrating the key barriers to behaviour adoption.

This highlights areas of consistency and divergence in the barriers to participation between perceptually similar behaviours. Intervention design should address these differences in attempting catalytic behaviour change.

For example, installation of a cistern weight, low-flow showerhead, dual flush toilet and efficient washing machine all have financial cost of adoption identified as the key barrier to participation. However, they differ across the matrix in terms of their likelihood of adoption, therefore some of these behaviours are seen as lower cost, or easier to adopt, than others. This suggests that although the same type of intervention design might apply to all of them to address the financial barrier of adoption, a more significant scale of intervention may be required for the more financially effortful, lower likelihood of adoption, behaviours.

Other groups of perceptually similar behaviours were scored with a range of different key barriers to adoption. For example, similar behaviours such as 'scraping the plates clean' and 'filling the washing machine', were assessed as having physical and cognitive barriers to adoption respectively, but almost the same likelihood of participation. Using this insight, interventions could be developed in a much more targeted manner, for example, encouraging behaviour adoption through provision of additional information or services, to overcome a cognitive barrier, or assistance and reminders to address a physical barrier. Likewise, if householders are already able to 'fix leaking taps around their property', identified as mid-likelihood of adoption but *physically* effortful, can we use intervention design to overcome the perceived *financial* barrier to the higher impact behaviours of 'fix leaking toilet cisterns' and 'fix leaking pipes'? This might include providing subsidised leak checks, an incentive scheme for purchasing parts or information around a cost-benefit analysis demonstrating the cost of water wasted through a leak with the cost of fixing a leak.

6.4 Identification of potentially catalytic water saving behaviours

The similarity-prioritisation maps illustrated in Figures 1-4 can be used to identify potentially catalytic behaviours. To be identified as a potential catalyst, a behaviour should have a higher likelihood of adoption (not necessarily high likelihood) and be perceptually similar to a potential target behaviour. Target behaviours are therefore those that are less likely to be adopted. This means that a catalyst might be more likely to be adopted, but, through being perceptually similar, could help leverage additional adoption lower likelihood behaviours, through the spillover effect. The similarity clusters mean that a target behaviour may have more than one potential catalyst and a single potential catalytic behaviour may be able to leverage more than one target behaviour. A source behaviour may also represent a potential target behaviour from a behaviour that is lower impact but higher likelihood of adoption; therefore can appear in both columns. Catalytic and target behaviours are identified in Table 2, using the similarity-prioritisation maps from Figure 1 and Figure 4.

Table 2 has been constructed considering a unidimensional direction of catalysis, assuming that decision-makers will want to select behaviours moving from low impact to high impact to maximise the effectiveness of interventions. This policy would be particularly appropriate for contexts where the behaviours being promoted are new to the target audience and there is little or no current participation. In such situations, stakeholders could be encouraged to adopt behaviours in a chain from those behaviours classified as highest likelihood of adoption (as suggested in Figure 5 below). Each subsequent behaviour promoted would be progressively lower likelihood but higher impact on the issue than the one before. However, in some contexts where there is an existing level of behaviour participation, such as water conservation in Australia, it may also be worth targeting (multiple) lower impact behaviours, rather than restricting programming to the highest impact target behaviour. Householders already participating in the high impact behaviour may therefore be encouraged to adopt further behaviours that are lower likelihood and also lower impact, as part of a more comprehensive water conservation scheme. Catalysing 'down' to lower impact (lower likelihood) behaviours may therefore sometimes be appropriate, but only when there is a baseline performance rate.

Table 2: *Potentially catalytic and target water saving behaviours, arranged by similarity cluster.*

Source behaviour: CATALYST (higher likelihood of adoption)	**Target behaviour: PRIORITY** (higher impact on water saving)	**Key barrier to participation in target behaviour**
Similarity group: 1a (curtailment/inside/kitchen)		
Do not use an in-sink garbage disposal unit.	Scrape plates clean of food instead of pre-rinsing.	Physical effort
	Defrost food in the fridge overnight, rather than under a running tap.	Cognitive effort
	If using a dishwasher, ensure it is full for every wash.	Cognitive effort
	Only wash full loads of clothes.	Cognitive effort
If using a dishwasher, ensure it is full for every wash.	Only wash full loads of clothes.	Cognitive effort
Wash vegetables in a bowl of water, and then use it in the garden.	Go meat-free / dairy-free one day a week	Cognitive effort
Similarity group: 1b (curtailment/inside/bathroom)		
Turn off the tap when shaving or brushing teeth	Take a shorter shower	Physical effort
	Reduce the frequency of toilet flushing	Physical effort
Similarity group: 1c (curtailment/inside/outside)		

Read the meter to monitor household water use.	Keep swimming pools covered when not in use to reduce evaporation.	Physical effort
	Collect shower warm-up water in a bucket to use in the garden.	Physical effort
	Use a broom, instead of a hose, to clean outside spaces.	Physical effort
Raise the thermostat on household evaporative air conditioners to 24ºC	Keep swimming pools covered when not in use to reduce evaporation.	Physical effort
Compost kitchen scraps and add to garden, to improve the water retention of soil.	Collect shower warm-up water in a bucket to use in the garden.	Physical effort
	Use a broom, instead of a hose, to clean outside spaces	Physical effort
Collect shower warm-up water in a bucket to use in the garden.	Use a broom, instead of a hose, to clean outside spaces	Physical effort
Similarity group: 2a (outside/garden/efficiency)		
Allow lawn to go 'golden' (i.e. brown-off).	Adjust watering schedules according to weather conditions and landscape requirements.	Cognitive effort
Water the garden in the early morning or evening to reduce evaporation.	Adjust watering schedules according to weather conditions and landscape requirements.	Cognitive effort
Similarity group: 2b (outside/garden/curtailment)		
Group plants with similar water needs together.	Use a 5 – 10cm layer of mulch on garden beds and potted plants.	Physical effort
	Plant native or drought-tolerant plants.	Financial cost
	Use timer-controlled drip irrigation, rather than a sprinkler system.	Financial cost
	Replace 'thirsty' species of turf with drought-resistant varieties of grasses.	Financial cost
Use a 5 – 10cm layer of mulch on garden beds and potted plants.	Plant native or drought-tolerant plants.	Financial cost
	Use timer-controlled drip irrigation, rather than a sprinkler system.	Financial cost
	Replace 'thirsty' species of turf with drought-resistant varieties of grasses.	Financial cost
Plant native or drought-tolerant plants.	Use timer-controlled drip irrigation, rather than a sprinkler system.	Financial cost
Similarity group: 3a (maintenance/efficiency)		
Fix leaking taps (house-wide).	Fix leaking toilet cisterns.	Financial cost
	Fix leaking pipes (house-wide).	Financial cost
Fix leaking toilet cisterns.	Fix leaking pipes (house-wide).	Financial cost
Fix leaking hoses or irrigation systems.	Fix leaking pipes (house-wide).	Financial cost
Similarity group: 3b (efficiency/financial cost/inside)		
Use a cistern weight if don't have a dual flush toilet.	Install a low-flow showerhead.	Financial cost
	Replace a single flush toilet cistern with a dual flush system.	Financial cost
	Buy a water efficient (4 star or above) front-loader washing machine.	Financial cost
	Buy a water efficient (4 star or above) dishwasher.	Financial cost

Buy a water efficient (4 star or above) dishwasher.	Buy a water efficient (4 star or above) front-loader washing machine.	Financial cost
Similarity group: 3c (efficiency/financial cost/outside)		
Install a water efficient pool filter.	Install a grey water system to reuse shower and laundry water in the garden.	Financial cost
	Install a rainwater tank to supply irrigation water.	Financial cost
	Plumb the rainwater tank to the toilet for flushing.	Financial cost
	Install a water efficient targeted irrigation system.	Financial cost
	Install a rainwater tank to supply water for use inside the home.	Financial cost
Install a grey water system to reuse shower and laundry water in the garden.	Install a rainwater tank to supply irrigation water.	Financial cost
	Plumb the rainwater tank to the toilet for flushing.	Financial cost
	Install a water efficient targeted irrigation system.	Financial cost
	Install a rainwater tank to supply water for use inside the home.	Financial cost
Install a rainwater tank to supply irrigation water.	Install a water efficient targeted irrigation system.	Financial cost
	Install a rainwater tank to supply water for use inside the home.	Financial cost
Plumb the rainwater tank to the toilet for flushing.	Install a rainwater tank to supply water for use inside the home.	Financial cost

Some researchers have suggested that adoption of a single catalytic behaviour could accelerate adoption of a second behaviour, which then acts as a catalyst for a third or further behaviours, each of which is higher in impact, but lower in likelihood than the previous. This has been dubbed the ‘virtuous escalator’, and, if tested and demonstrated to occur in the field, could offer an additional route for accelerated behaviour adoption (Thøgersen & Crompton, 2009). By examining the similarity-prioritisation maps, it is possible to identify several potential chains of behaviours, starting with lower impact and higher likelihood of adoption, moving towards behaviours higher in impact, but lower likelihood of adoption. These chains of behaviours are illustrated in Figure 5. By incorporating these chains of connected behaviours into intervention design, stakeholders could be supported and encouraged to adopt multiple behaviours on the basis of an initial catalytic behaviour.

6.5 Synthesis summary

Data from all three papers were combined to produce visual representations of the similarity and potential for prioritisation of water saving behaviours. Where behaviours are seen as similar, but appear in different quadrants of the impact-likelihood matrix, the maps indicate 'pathways' for behaviour promotion. These pathways are of particular interest when behaviours are seen as similar but differ in their likelihood of adoption and impact on the issue. It may be that householders can be encouraged, through provision of appropriate intervention design, to adopt lower likelihood behaviours from the high likelihood behaviours that they may already be doing.

These data can be used to help select behaviours for behaviour change programming; in a situation where there is little existing participation, stakeholder adoption could be started through promotion of the high likelihood of adoption, low impact behaviours in the bottom right quadrant of the prioritisation matrix. However, if stakeholders are already performing behaviours located in the top right quadrant (high likelihood of adoption, high impact on the issue), it may be appropriate to target behaviours from the top left quadrant (lower likelihood), even if they are lower impact on the issue. Just because one behaviour is lower impact on the issue that another, does not mean it is low impact and not worth promoting. In such situations catalysis could work in both directions, to lower impact and higher impact behaviours. This might be particularly useful in the Australian water conservation context, with high existing rates of participation in some behaviours (see Chapter 2). In Australia, water has been on the public agenda for many years. If the dry conditions currently being experienced in some areas of the country (BoM, 2018) persist, the application of spillover effect might provide a useful tool to gain rapid change to manage demand in a drought situation.

In contexts where a problem is not yet on the public agenda, as is the case with some of the Sustainable Development Goals, it is possible to start small, engaging stakeholders initially in the low impact, high likelihood of adoption behaviours which can then be used as leverage to encourage adoption of higher impact behaviours. This approach may have a broader applicability, depending on the context. This highlights the importance of gaining a good understanding of a problem and context before developing behaviour change approaches.

Figure 5: Potential 'virtuous escalator' groups of perceptually similar water saving behaviours

Source behaviour: CATALYST — **Target behaviour: PRIORITY**

Lowest impact/highest likelihood of adoption → **Highest impact / lowest likelihood of adoption**

1) Do not use an in-sink garbage disposal unit.

If using a dishwasher, ensure it is full for every wash.

Only wash full loads of clothes.

2) Compost kitchen scraps and add to garden, to improve the water retention of soil.

Collect shower warm-up water in a bucket to use in the garden.

Use a broom, instead of a hose, to clean outside spaces.

3) Group plants with similar water needs together.

Use a 5 – 10cm layer of mulch on garden beds and potted plants.

Plant native or drought-tolerant plants.

Use timer-controlled drip irrigation, rather than a sprinkler system.

4) Fix leaking taps (house-wide). Fix leaking toilet cisterns. Fix leaking pipes (house-wide).

5) Install a water efficient pool filter.

Install a grey water system to reuse water in the garden.

Install a rainwater tank to supply irrigation water.

Install a rainwater tank to supply water for use inside the home.

References

Austin, A., Cox, J., Barnett, J., Thomas, C. (2011). *Exploring catalytic behaviours: Summary report to the Department for Environment, Food and Rural Affairs*. UK: Brook Lyndhurst.

Boudet, H. S., Flora, J. A., & Armel, K. C. (2016). Clustering household energy-saving behaviours by behavioural attribute. *Energy Policy*, 92, 444-454. doi: http://dx.doi.org/10.1016/j.enpol.2016.02.033

Bratt, C. (1999). Consumers' environmental behavior: Generalized, sector-based, or compensatory? *Environment and Behavior*, 31(1), 28-44.

Burger, J. M. (1999). The foot-in-the-door compliance procedure: A multiple-process analysis and review. *Personality and Social Psychology Review*, 3, 303-325.

Karlin, B., Davis, N., Sanguinetti, A., Gamble, K., Kirkby, D., & Stokols, D. (2014). Dimensions of conservation: Exploring differences among energy behaviors. *Environment and Behavior*, 46(4), 423-452. doi: 10.1177/0013916512467532

Nilsson, A., Bergquist, M., & Schultz, W. P. (2017). Spillover effects in environmental behaviors, across time and context: a review and research agenda. *Environmental Education Research*, 23(4), 573-589. doi: 10.1080/13504622.2016.1250148

Stern, P. C. (2000). New environmental theories: Toward a coherent theory of environmentally significant behavior. *Journal of Social Issues*, 56(3), 407-424. doi: 10.1111/0022-4537.00175

Thøgersen, J. (2004). A cognitive dissonance interpretation of consistencies and inconsistencies in environmentally responsible behavior. *Journal of Environmental Psychology*, 24(1), 93-103. doi: http://dx.doi.org/10.1016/S0272-4944(03)00039-2

Thøgersen, J. (2012). *Pro-environmental spillover: Review of research on the different pathways through which performing one pro-environmental behaviour can influence the likelihood of performing another*. Report (unpublished) produced for BehaviourWorks Australia.

Thøgersen, J., & Crompton, T. (2009). Simple and painless? The limitations of spillover in environmental campaigning. *Journal of Consumer Policy*, 32(2), 141-163. doi: 10.1007/s10603-009-9101-1

Truelove, H. B., Carrico, A. R., Weber, E. U., Raimi, K. T., & Vandenbergh, M. P. (2014). Positive and negative spillover of pro-environmental behavior: An integrative review and theoretical framework. *Global Environmental Change*, 29(0), 127-138. doi: http://dx.doi.org/10.1016/j.gloenvcha.2014.09.004

Chapter 7: Contributions, limitations and future research

7.0 Introduction

Behavioural science is clear that to be more effective in intervention design, it is important to select and focus on priority behaviours to gain insight into the drivers and barriers to behaviour adoption (Gardner & Stern, 2008; McKenzie-Mohr, Lee, Kotler & Schultz, 2011). In addition, the effectiveness or efficiency of uptake of water conservation behaviours could be assisted by targeting potentially catalytic behaviours that increase the likelihood of spillover (Thøgersen, 2004; Thøgersen & Crompton, 2009). Furthermore, understanding perceptions of similarity could therefore be an important part of identifying such catalytic behaviours and will assist in the operationalisation of spillover theory. The objectives and questions investigated in this thesis were therefore to identify and prioritise household water conservation behaviours and investigate the perceived similarity of these behaviours (see Table 1). These objectives reflect a need for water managers to select behaviours to focus resources for future demand management programs and thus help ensure sustainable water supply in Australia, despite a growing population and the challenges of climate change.

The significance of the research lies in the development of a process and tools to prioritise behaviours in terms of their characteristics for water saving and their similarity, which may facilitate behavioural spillover. This chapter synthesises the outcomes of the research, describes both the theoretical and practical contributions to knowledge, includes some limitations of the research and provides suggestions to further develop work in this area.

Table 1: Summary of the research objectives, questions, and outputs

Objective 1: Identify water conservation behaviours for adoption at a household level.	
1.1 What household water-saving behaviours could be considered for investigation?	Full method details in Chapter 2. List of 46 behaviours for use in all subsequent phases of the study
Objective 2: Develop and test a prioritisation tool to facilitate behaviour selection for behaviour change program design.	
2.1 What are the criteria for behaviour prioritisation, and how can water saving behaviours be prioritised for future demand management programs?	Chapter 3 Publication 1: Prioritisation matrix

2.2: Do householders and water professionals differ in their perceptions of the household water saving behaviours?	Chapter 4 Publication 2: Comparison of perceptions
Objective 3: Identify potentially catalytic behaviours, to facilitate operationalisation of spillover theory.	
3.1: Which of the water saving behaviours under investigation are perceived as similar by householders?	Chapter 5 Publication 3: It's what you do and where you do it.
3.2: Why are the behaviours seen as similar; specifically, what criteria do householders use to determine perceptions of similarity?	Chapter 5 Publication 3: It's what you do and where you do it.
3.3 How can the results from behaviour prioritisation matrix and similarity assessment be combined to identify potentially catalytic behaviours?	Chapter 6: Synthesis of outcomes

7.1 Summary of findings

Currently, water managers lack the decision-making tools needed to prioritise household water saving behaviours for demand management programming into the future. This research project has considered three research objectives to help address the practical aspects of this issue; first, potential behaviours were identified, second, developed a prioritisation process and identified appropriate sources of data to use in the prioritisation process, and third, identified potentially catalytic behaviours that may help accelerate behaviour adoption, through investigating perceived similarity of water conserving behaviours.

1) Identified a variety of water conservation behaviours for adoption at a household level.

A multimethod approach, combining two rounds of grey-literature review and input from water industry professionals, was used to create a list of 46 behaviours for further investigation. The behaviours were initially categorised as efficiency, curtailment or maintenance behaviours, through researcher-based assessment of their characteristics (Gilg & Barr, 2006; Boudet, Flora & Armel, 2016). This process did not result in a comprehensive list of all potential behaviours for water saving around the home; rather, it was intended to identify those behaviours most often referenced in the grey literature (and thus recommended to householders) and seek confirmation and additional ideas from water professionals. The list of behaviours was used in all the subsequent research described in this thesis.

2) Developed and tested a prioritisation tool to facilitation behaviour selection for behaviour change program design.

Data was collected via an online survey with householders and water professionals to generate scores for each of the 46 water saving behaviours identified. The scores quantified perceptions of behaviour impact on water saving, the likelihood of behaviour adoption and the physical, mental and financial effort required for behaviour participation. A two-by-two matrix was used to visualise the behaviours based on their impact and likelihood of adoption, two characteristics previous research has suggested as a basis for decision-making (Gardener & Stern, 2008; McKenzie-Mohr et al., 2011; Inskeep & Attari, 2014). The utility of the matrix as a decision making tool was further developed with additional layers of data, sourced from the online stakeholder surveys and existing records of household participation in water saving behaviours. These layers produced of a multi-dimensional output, incorporating the potential for further adoption of each behaviour and the key barrier to behaviour participation. This provides decision makers with details to aid behaviour selection and insight to facilitate intervention design.

The biplot matrices generated through this method allow behaviours to be mapped into one of four quadrants, depending on the scores allocated for their characteristics. Behaviours placed within the lower left are seen as low impact, low likelihood of adoption, and therefore low priority for selection. This suggests they may be difficult to engage with and do not achieve a lot. If behaviour identification has been carefully carried out, utilising evidence from reliable sources, no, or few, behaviours should fall into this quadrant. This is because any action promoted to help an issue should have at least some effect, either in terms of its potential for widespread adoption, or the impact of its adoption on the issue at hand. Assessing behaviours purely on the impact they have on addressing an issue, risks ignoring whether they are likely to be adopted by the target audience or not. Therefore low impact behaviours should be assessed in terms of likelihood of adoption before prioritisation takes place.

Behaviours placed in the lower right quadrant represent low impact on water saving but high likelihood of adoption, so are a possible target. Previous research has cautioned decision makers against promoting behaviour that might fall into this category, as they have been labelled ‘simple and painless’, with impacts that are too small to make a difference to the problem at hand (Thøgersen & Crompton, 2009). However, if enacted cumulatively, they could make a meaningful contribution in terms of water saving volumes. In addition, they are of interest as potential leverage, or catalytic behaviours, as explored in Chapter 6.

Behaviours placed in the upper left have been scored high impact on water saving but low likelihood of adoption. These are potential target behaviours, which may be challenging for the target audience to participate in; this is reflected in low participation rates. The analysis conducted in Chapter 3 allows insight into why these behaviours are low likelihood of adoption. The data collected on perceived effort involved in behaviour adoption was ranked by score, the assumption being that the highest scoring effort type offered the most significant barrier to adoption, for most of these behaviours there is a financial cost to participation. If this barrier can be addressed or removed through intervention design, the likelihood of behaviour adoption may increase (Michie, Van Stralen & West, 2011).

Finally, those placed in the upper right quadrant are the 'low hanging fruit (Inskeep & Attari, 2014), with high impact on the issue and high likelihood of adoption, so represent the first priority for decision makers. However, layering existing participation rates over the prioritisation matrix suggests these behaviours may be of reduced interest as they have high current levels of adoption. Therefore, the potential for additional water savings to be made through further promotion of the top right quadrant behaviours is reduced. This demonstrates the importance and utility of the layered approach to the matrix. Without an understanding of existing participation, water managers are at risk of prioritising and investing in promoting behaviours that have high participation levels with little additional impact likely to be achieved through promoting them.

Construction of the matrix, combining perspectives from water professionals and householders was based on an assumption that water professional would have superior insight about the impact of behaviours on water saving and householders perceptions of effort involved in behaviour adoption were of greater importance than water professionals perceptions. However, a key concern was that the position of behaviours might be different if the roles were reversed and householder perceptions were used to assess impact of behaviours and water professionals assessed the effort of behaviour adoption. Therefore, a second round of analysis was undertaken to compare scores from the two stakeholder groups and check for consistency or divergence in perspectives. Results showed there was agreement across stakeholder perceptions of behaviour characteristics, regardless of behaviour type. Where significant differences did arise, it was for a minority of behaviours. This means that decision makers could, on the whole, use data sourced from professionals in the field (their colleagues), complemented with some householder data, to generate a reliable picture of stakeholder perceptions of water saving behaviour impact and likelihood of adoption.

It is hoped that the relatively straightforward method and process of combining multiple sources of data into a single matrix provides a practical means to support any decision maker seeking to select a priority behaviour. The water data used to test the approach should generate insight to assist water managers in their consideration of target behaviours to future demand management programming.

3) Identified potentially catalytic behaviours, to facilitate operationalisation of spillover theory.

Developing a method in response to research Objective 3 involved answering three further research questions;

> 3.1: Which of the water saving behaviours under investigation are perceived as similar by householders?
>
> 3.2: Why are the behaviours seen as similar; specifically, what criteria do householders use to determine perceptions of similarity?
>
> 3.3 How can the results from behaviour prioritisation matrix and similarity assessment be combined to identify potentially catalytic behaviours?

Investigations into which behaviours are seen as similar and why involved a participant-led sort procedure, whereby cards of 44 of the water saving behaviours were arranged into groups by perceived similarity (two behaviours were omitted accidentally during the sort procedure trial). The number of groups, numbers of cards allocated to each group and the rationale for doing so was entirely determined by the participant. Analyses using a combination of multidimensional scaling analysis, cluster analysis and categorical principal components analysis, permitted behaviours to be mapped in terms of their perceived similarity and illustrated with the dimensions, or characteristics, upon which assessment of similarity was made. This resulted in the behaviours being categorised into eight groups of ‘similar’ behaviours. The dimensions of similarity were determined by location of enactment, i.e. inside vs. outside the house, and behaviour type, i.e. curtailment, efficiency or maintenance behaviours. Further detail is described in Chapter 5 of this thesis. The outputs of the similarity assessment were combined with the data and findings from Chapter 3 and Chapter 4 to identify potentially catalytic behaviours, as discussed and explored in Chapter 6.

7.2 Empirical, theoretical and applied contributions

The outcomes of the research summarised above offer empirical, theoretical and applied contributions to knowledge. This section describes these contributions as they relate to each of the research key objectives and thesis chapters.

The work carried out to achieve Objective 1 permitted production of a ‘shortlist’ of 46 water saving behaviours around the home, reported in chapter three. This list was generated through interrogation of the literature and contribution from professionals and experts within the water industry. Given that water conservation can be achieved through a large variety of behaviours (e.g. as reported in Manning et al., 2013), having a ‘short list’ allows investigation that otherwise could not take place. The short list provides water managers with a practical starting point for behaviour selection. It also formed the basis of investigations throughout the rest of the research program.

The short list behaviours were used to investigate research Objective 2, regarding prioritisation of behaviour and reported in Chapter 3. The 46 behaviours were initially investigated for their impact on water saving, likelihood of adoption and barrier to participation, through online surveys conducted with water professionals and householders. These data enabled the behaviours to be placed within a decision-making biplot, the impact-likelihood matrix, to provide clear indications of which behaviours may be of particular utility or interest for promotion through future demand management programming. This is particularly useful as identifying focal behaviours to target is an important part of intervention design for behaviour change (McKenzie-Mohr et al., 2011; McKenzie-Mohr & Schultz, 2014; Gardner & Stern, 2008).

The data and behaviour placement within the matrix form a practical contribution, which could be used by water managers during strategic planning for householder engagement. The process of data collection, mapping the matrix and identifying behaviours for prioritisation, extends existing literature on behaviour selection based on key characteristics, including impact on the issue and likelihood of behaviour adoption (McKenzie-Mohr et al., 2011; McKenzie-Mohr & Schultz, 2014). The impact-likelihood matrix could be used as a tool and applied in other contexts where conservation programs are needed and there are multiple potential behaviours under consideration. It provides an alternative approach to behaviour selection than existing recommendations involving a single figure ranking as used in, for example, Community Based Social Marketing (McKenzie-Mohr, 2000; McKenzie-Mohr et al., 2011).

The process behind construction of the impact-likelihood matrix was further strengthened through research reported in Chapter 4. An expanded water professional data source means that the second set of matrices generated (presented in Chapter 6) have increased reliability for use and applicability of the findings by decision makers. The differences found, primarily relating to maintenance behaviours and perceptions of physical, compared with financial, effort involved in behaviour adoption, highlight the importance of stakeholder engagement during the behaviour selection process. The outcomes provide a practical contribution to knowledge, demonstrating the robustness of the data used to create decision matrices and demonstrating the appropriate data source for the prioritisation process.

Addressing Objective 3 has produced empirical, theoretical and applied contributions to knowledge. Investigating householder perceived similarity of behaviours has generated knowledge about which water saving behaviours are seen as similar (illustrated in Table 1, Chapter 5) and why they are seen as similar. These findings address a gap in the literature about what behaviours are seen as similar, and how similarity can be determined (Bratt, 1999; Thøgersen & Ölander, 2003; Thøgersen, 2004; Truelove et al., 2014). The method used, both to collect and analyse data, is highly replicable and again could be applied to other contexts where multiple behaviours are known, but perceptions of similarity are not. Application of this method would extend existing research into householder behaviour categorisation and perceptions of behaviour (e.g. Austin, Cox, Barnett & Thomas, 2011; Gabe-Thomas, Walker, Verplanken & Shaddick, 2016; Margetts & Kashima, 2017). The research also represents the first time this approach has been used to assess perceptions of behaviour, rather than previous applications that have examined public perceptions of architecture, consumer products or landscapes (e.g. Green, 2005; Dobbie, 2013; Dobbie & Green, 2013). The outcomes of the similarity assessment contribute to the growing body of work on categorisation of behaviours. The results support categorisation of resource conservation behaviours into three main types, curtailment, maintenance and efficiency, as proposed by Karlin et al. (2014).

Finally, synthesis of the results allowed identification of potentially catalytic behaviours that may increase the likelihood of the spillover effect occurring and thus potential acceleration of water saving behaviour adoption by householders. The results provide an indication to water managers of the optimal behaviours to trial and test as priorities in future demand management programmes; particularly those behaviours that could act as initial levers to start householders on a route of behavioural adoption. From an empirical perspective, the process created again offers opportunity for future adoption. The combination of data from multiple sources, combined through a specific analysis approach, presents a repeatable method to enable the identification of potentially catalytic behaviours. This is an important step in the operationalisation of spillover theory (Thøgersen, 2004; Truelove et al., 2014; Nilsson, Bergquist & Schultz, 2017).

The combination of behaviour-related biplots, the impact-likelihood matrix and the multidimensional scaling analysis biplot to identify catalytic behaviours provides a visual representation of the main theoretical contribution from the research. The outputs suggests that adding perceptions of similarity provides an additional dimension to behaviour selection, according to this similarity-prioritisation hypothesis. Ultimately, the research outputs could be used to help inform behaviour selection for future water demand management campaigns. In addition, the processes and methods used to generate such insights can be replicated to use in other behavioural contexts to facilitate behaviour prioritisation. Finally, investigating perceived similarity could be an invaluable aspect of the operationalisation of spillover theory, with its associated potential benefits to increase the efficacy of behaviour change programming through behaviour acceleration, activated through similarity-related mechanisms of behaviour change (Thøgersen, 2012).

7.3 Research limitations

The research detailed within the thesis is subject to certain limitations that may affect the generalisability of the findings. The limitations associated with each specific research question are described in the publications within Chapters 3 (section 4), 4 (section 4.1) and 5 (section 4.2), with the main limitations reiterated here for clarity.

The construction of matrices in Chapter 3 was based on the assumption of effort acting as a reliable proxy for likelihood of adoption. This assumption was based on indications from existing research, but could be checked through comparison with scores generated through other measures of likelihood, such as stated intention, previous behaviour participation or direct questioning over the likelihood of adoption (Jorgensen, Greymore & O'Toole, 2009; McKenzie-Mohr et al., 2011). The reliance on subjective, rather than objective, data for behavioural impact is an issue that may be avoided in future studies, depending on the behaviours at hand. Behaviours in other contexts may have a clear link to measurable outcomes relating to the issue, for example recycling waste rather than disposing of it results in measurable decreases in weight of waste generated (e.g. Varotto & Spagnolli, 2017). Similarly, the carbon dioxide emissions of participating in certain behaviours is known, so reducing or altering behaviours can result in a calculable reduction in emissions (Berners-Lee, 2011).

As studies on household water end-use patterns continue, and smart meter data is matched with self-report diaries or other measures of behaviour, the quality and extent of information available for assessment of behaviour impact on water saving will improve (Beal, Stewart, Spinks & Fielding, 2011; Beal, Stewart & Fielding, 2013). Some of these studies may also generate additional insight on household participation rates in water saving behaviours, which could extend the calculations on opportunity for behaviour adoption. Indeed, a second round of data elicitation from water professionals for investigation in paper two, started to address this issue. These more accurate measures could update and replace the current subjective, perceptual data to construct more accurate prioritisation matrices and generate a potentially more reliable result for water managers.

One of the key issues with investigating water conservation behaviours is the diversity of variables that affect water use and may also impact on perceptions of water conservation behaviours. The water conservation research examines a wide range of variables, from household location, size and demographics (Fielding, Russel, Spinks & Mankad, 2012; Domene & Saurí, 2006), price of water (Grafton, Ward, To & Kompas, 2011), billing practices (Randolph & Troy, 2011), attitudes (Dolnicar & Hurlimann, 2010), identity (Gatersleben, Murtagh, & Abrahamse, 2012; Lauren, Smith, Lois & Dean, 2017), water literacy (Dean, Fielding & Newton, 2016), environmental context, personal history and experiences (Gilbertson, Hurlimann & Dolnicar, 2011) and so forth. The data collected from water professionals and householders for Chapter 3 and Chapter 4 was sourced from respondents across Australia, i.e. from a variety of water contexts. This consideration by itself means that respondent experiences, perceptions and behavioural practices may also vary widely. Ideally, all variables that could potentially affect personal behaviour and perception of behaviour would be measured and controlled for within the data collection and analysis. For this series of studies, such an approach was impractical, but future iterations, particularly if applying the process for behaviour selection, should take these variables into consideration as part of data collection.

Finally, the aim of the research was to develop a process, both to identify and prioritise water conservation behaviours and examine ways to identify potentially catalytic behaviours. The outcomes are currently untested and it is unknown whether the behaviours identified through the process help facilitate spillover or not. The applicability of the process developed therefore needs to be assessed through further investigation, as described below.

7.4 Future research

The outcomes of this research in terms of a process to identify potentially catalytic behaviours prepares the ground for future work investigating the applicability and utility of spillover theory. By being able to understand which behaviours might be expected to increase the likelihood of spillover, through similarity-related mechanisms, studies can test if behaviour adoption is accelerated or if interventions are more effective between behaviours of greater perceived similarity than those of lower perceived similarity when interventions focus on behaviours that are similar. Now that water conservation behaviours have been assessed, these can be trialled to investigate the potential of promoting similar vs. non-similar / dissimilar water saving behaviours on household water consumption. In addition, the process may be applied to other groups of behaviours where similarity may play a useful role in adoption, for example around waste disposal, energy conservation or other pro-environmental behaviours.

Perceptions of similarity vary from individual to individual, with personal identity playing a role in whether an individual sees two behaviours as similar or not (Austin et al., 2011). Therefore, consumers lacking a water conservation 'identity' may perceive different, or fewer, similarities between two water saving behaviours, compared to a consumer who does have a water conservation identity. If consumers do not perceive two water saving behaviours as similar, it becomes less likely that sensations of cognitive dissonance would arise following the adoption of one out of two water saving behaviours and therefore there would be reduced motivation to participate in the second behaviour (Thøgersen, 2004). Future work focussed on understanding how perceptions of similarity of water saving behaviours might vary by householder water-saving identity would allow more targeted promotion of water saving behaviours.

Finally, the key hypotheses could be explored through accessing existing datasets, for example, analysis of data for behaviour co-occurrence. This data on pre-existing activities could also be compared with the list of potential catalytic behaviours and the ‘virtuous escalator’ chains of water saving behaviours identified in Chapter 6. This could help confirm the utility of behavioural roadmaps to encourage householders to adopt a succession of desirable behaviours (Thøgersen & Crompton, 2009).

Although the study was based upon the premise of positive spillover (see section 11), future programs promoting potentially catalytic behaviours for household adoption should ensure incorporate rigorous monitoring to ensure that behaviour change occurs in the direction required. If the promotion of similar behaviours triggers the mechanisms proposed for negative spillover, this could have a deleterious effect on the program aims for water conservation. Although records of water conservation behaviour adoption do not suggest that negative spillover is an important issue (see section 1.4), rebound of water consumption has been measured upon removal of water restrictions (e.g. Beal, Makki & Stewart, 2014). Water managers should keep this possibility in mind when implementing interventions.

7.5 Conclusion

The 17 Sustainable Development Goals, designed to tackle the environmental, social and economic inequalities of the planet, demonstrate a clear need to create comprehensive change in patterns of consumption and human behaviour. The impacts of environmental degradation, poverty, poor health and lack of access to fair judicial process affect daily life for billions of people; change is urgently needed (Griggs et al., 2014). Many of the issues being tackled by the SDGs are caused, or exacerbated, by mis-management and over-exploitation of resources, led by patterns of human over-consumption (Griggs et al., 2014). The contributions of behavioural science to manage consumption practices in particular has been an important area of research for many years (e.g. Thøgersen, 1995; Brown & Cameron, 2000; Jackson, 2005; Steg, 2015). The SDGs provide ample opportunity for behavioural science to develop strategies and approaches to help create the rapid and impactful change needed. The spillover effect is one method proposed to accelerate the rate of change, leveraging more rapid behaviour adoption off new or existing behaviours, via various psychological pathways (section 1.3). Engaging stakeholders with behaviour change can also lead to increased policy support and thus help fuel further change in the direct required (Thøgersen & Noblet, 2012).

This research project was designed around exploring potential operationalisation of spillover within one context – relevant to many of the SDGs: water consumption. Australia faces significant challenges to its water resources (Delworth & Zheng, 2014; Skinner, 2017). Demand management programs will form a necessary part of the approach to ensure long-term sustainability of the country's water supply (Beal, Gurung & Stewart, 2016). Householders are an important consumer of Australia's freshwater supplies and thus a key stakeholder for consideration in demand management programming (Australian Bureau of Statistics, 2013). Householders use water supplies to meet essential and lifestyle requirements, and may participate in a wide range of different behaviours to save water around the home (Shove, 2003; Manning et al., 2013). Within the Australian water consumption context, householders' existing water-saving practices may provide a baseline of potential behaviours to leverage additional change off. For some of the other SDGs, this baseline of positive behaviours may not exist, so commencing behaviour interventions applying spillvoer effect could be more challenging.

References

Austin, A., Cox, J., Barnett, J., Thomas, C. (2011). *Exploring catalyst behaviours: Summary report to the Department for Environment, Food and Rural Affairs*. London: Brook Lyndhurst for Defra.

Australian Bureau of Statistics. (2013). *Environmental Issues: Water use and Conservation, March 2013* (cat.no. 4602.0.55.003). Retrieved from: www.abs.gov.au/ausstats/abs@.nsf/Lookup/4602.0.55.003

Beal, C. D., Gurung, T. R., & Stewart, R. A. (2016). Demand-side management for supply-side efficiency: Modelling tailored strategies for reducing peak residential water demand. *Sustainable Production and Consumption*, 6, 1-11. doi: http://dx.doi.org/10.1016/j.spc.2015.11.005

Beal, C. D., Makki, A., & Stewart, R. A. (2014). What does rebounding water use look like? An examination of post-drought and post-flood water end-use demand in Queensland, Australia. *Water Science and Technology: Water Supply*, 14(4), 561-568.

Beal, C. D., Stewart, R. A., & Fielding, K. (2013). A novel mixed method smart metering approach to reconciling differences between perceived and actual residential end use water consumption. *Journal of Cleaner Production*, 60, 116-128

Beal, C., Stewart, R. A., Spinks, A., & Fielding, K. (2011). Using smart meters to identify social and technological impacts on residential water consumption. *Water Science and Technology: Water Supply*, 11, 527-533.

Berners-Lee, M. (2011). *How bad are bananas? The carbon footprint of everything.* London: Greystone Books.

Boudet, H. S., Flora, J. A., & Armel, K. C. (2016). Clustering household energy-saving behaviours by behavioural attribute. *Energy Policy*, 92, 444-454.

Bratt, C. (1999). Consumers' environmental behavior: generalized, sector-based, or compensatory? *Environment and Behavior*, 31(1), 28-44. doi: 10.1177/00139169921971985

Brown, P. M., & Cameron, L. D. (2000). What can be done to reduce overconsumption? *Ecological Economics,* 32(1), 27-41. doi: http://dx.doi.org/10.1016/S0921-8009(99)00093-2

Burger, J. M. (1999). The foot-in-the-door compliance procedure: A multiple-process analysis and review. *Personality and Social Psychology Review*, 3, 303-325.

Dean, A. J., Fielding, K. S., & Newton, F. J. (2016). Community knowledge about water: Who has better knowledge and is this associated with water-related behaviors and support for water-related policies? *PLoS One, 11*(7), e0159063.

Delworth, T. L., & Zeng, F. (2014). Regional rainfall decline in Australia attributed to anthropogenic greenhouse gases and ozone levels. *Nature Geoscience*, 7, 583. doi: 10.1038/ngeo2201

Dobbie, M. F. (2013). Public aesthetic preferences to inform sustainable wetland management in Victoria, Australia. *Landscape and Urban Planning*, *120*, 178-189.

Dobbie, M., & Green, R. (2013). Public perceptions of freshwater wetlands in Victoria, Australia. *Landscape and Urban Planning*, *110*, 143-154.

Dolnicar, S., & Hurlimann, A. (2010). Australians' water conservation behaviours and attitudes. *Australian Journal of Water Resources, 14*(1), 43-53.

Domene, E., & Saurí, D. (2006). Urbanisation and water consumption: Influencing factors in the metropolitan region of Barcelona. *Urban Studies*, *43*(9), 1605-1623. doi: 10.1080/00420980600749969

Fielding, K. S., Russell, S., Spinks, A., & Mankad, A. (2012). Determinants of household water conservation: The role of demographic, infrastructure, behavior, and psychosocial variables. *Water Resources Research*, *48*(10). doi: 10.1029/2012WR012398

Gabe-Thomas, E., Walker, I., Verplanken, B., & Shaddick, G. (2016). Householders' mental models of domestic energy consumption: using a sort-and-cluster method to identify shared concepts of appliance similarity. *PloS one*, *11*(7), e0158949.

Gardner, G. T., & Stern, P. C. (2008). The short list: The most effective actions US households can take to curb climate change. *Environment: Science and policy for sustainable development*, 50(5), 12-25.

Gatersleben, B., Murtagh, N., & Abrahamse, W. (2012). Values, identity and pro-environmental behaviour. *Contemporary Social Science*, 1-19. doi: 10.1080/21582041.2012.682086

Gilbertson, M., Hurlimann, A., & Dolnicar, S. (2011). Does water context influence behaviour and attitudes to water conservation? *Australasian Journal of Environmental Management*, *18*(1), 47-60. doi: 10.1080/14486563.2011.56616010.1029/2009WR008408;

Gilg, A. and S. Barr (2006). Behavioural attitudes towards water saving? Evidence from a study of environmental actions. *Ecological Economics,* 57(3): 400-414.

Grafton, R. Q., Ward, M. B., To, H., & Kompas, T. (2011). Determinants of residential water consumption: Evidence and analysis from a 10-country household survey. *Water Resources Research*, 47(8), W08537.

Green, R. (2005). Community perceptions of environmental and social change and tourism development on the island of Koh Samui, Thailand. *Journal of Environmental Psychology*, *25*(1), 37-56.

Griggs, D., Stafford-Smith, M., Gaffney, O., Rockström, J., Öhman, M.C., Shyamsundar, P., Steffen, W., Glaser, G., Kanie, N. and Noble, I. (2013). Policy: Sustainable development goals for people and planet. *Nature*, 495 (7441), p.305.

Inskeep, B. D., & Attari, S. Z. (2014). The water short list: The most effective actions US households can take to curb water use. *Environment: Science and Policy for Sustainable Development*, 56(4), 4-15.

Jackson, T. (2005). *Motivating Sustainable Consumption : a review of evidence on consumer behaviour and behavioural change*. Guildford, Surrey: Sustainable Development Research Network.

Jorgensen, B., Graymore, M., & O'Toole, K. (2009). Household water use behavior: An integrated model. *Journal of Environmental Management, 91*(1), 227-236.
doi: http://dx.doi.org/10.1016/j.jenvman.2009.08.009

Karlin, B., Davis, N., Sanguinetti, A., Gamble, K., Kirkby, D., & Stokols, D. (2014). Dimensions of conservation: Exploring differences among energy behaviors. *Environment and Behavior*, 46(4), 423-452.

Lauren, N., Smith, L. D. G., Louis, W. R., & Dean, A. J. (2017). Promoting spillover: How past behaviors increase environmental intentions by cueing self-perceptions. *Environment and Behavior*, 0013916517740408. doi: 10.1177/0013916517740408

McKenzie-Mohr, D. (2000). New ways to promote proenvironmental behavior: Promoting sustainable behavior: An introduction to community-based social marketing. *Journal of Social Issues*, 56(3), 543-554.

McKenzie-Mohr, D., Lee, N. R., Kotler, P., & Schultz, P. W. (2011). *Social marketing to protect the environment: What works?* Sage Publications.

McKenzie-Mohr, D. & Schultz, P. W. (2014). Choosing effective behavior change tools. *Social Marketing Quarterly*, 20(1): 35-46.

Manning, C., Hargroves, K., Walker, M., Lange, J., Igloi, S., Bruce, G., & Desha, C. (2013). *Dry Tropics water smart: A community based approach to residential outdoor water consumption.* Australian Water Association Conference. Perth.

Margetts, E. A., & Kashima, Y. (2017). Spillover between pro-environmental behaviours: The role of resources and perceived similarity. *Journal of Environmental Psychology*, *49*, 30-42.

Michie, S., Van Stralen, M. M., & West, R. (2011). The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implementation Science*, 6(1), 42.

Nilsson, A., Bergquist, M., & Schultz, W. P. (2017). Spillover effects in environmental behaviors, across time and context: a review and research agenda. *Environmental Education Research*, 23(4), 573-589. doi: 10.1080/13504622.2016.1250148

Randolph, B., & Troy, P. (2011). Factors in energy and water consumption. In P. Newton (Ed.), *Urban Consumption* (pp. 215): CSIRO.

Shove, E. (2003). Converging conventions of comfort, cleanliness and convenience. *Journal of Consumer Policy*, *26*(4), 395-418.

Skinner, R. M. (2017). Water policy in a time of climate change: Coping with complexity. *Public Administration Review*, 77(1), 13-16.

Steg, L. (2015). *Environmental psychology and sustainable consumption*. In L.A. Resich & J. Thøgersen, (Eds.), Handbook of Research in Sustainable Consumption, pp. 70-83. Edward Elgar Publishing.

Stern, P. C. (2000). New environmental theories: toward a coherent theory of environmentally significant behavior. *Journal of Social Issues*, *56*(3), 407-424. doi: 10.1111/0022-4537.00175

Thøgersen, J. (1995). Understanding of consumer behaviour as a prerequisite for environmental protection. *Journal of Consumer Policy*, 18(4), 345-385.

Thøgersen, J. (2004). A cognitive dissonance interpretation of consistencies and inconsistencies in environmentally responsible behavior. *Journal of Environmental Psychology*, 24(1), 93-103. doi: http://dx.doi.org/10.1016/S0272-4944(03)00039-2

Thøgersen, J. (2012). *Pro-environmental spillover: Review of research on the different pathways through which performing one pro-environmental behaviour can influence the likelihood of performing another*. Report (unpublished) produced for BehaviourWorks Australia.

Thøgersen, J., & Crompton, T. (2009). Simple and painless? The limitations of spillover in environmental campaigning. *Journal of Consumer Policy*, 32(2), 141-163. doi: 10.1007/s10603-009-9101-1

Thøgersen, J., & Noblet, C. (2012). Does green consumerism increase the acceptance of wind power? *Energy Policy*, 51, 854-862.

Thøgersen, J., & Ölander, F. (2003). Spillover of environment-friendly consumer behaviour. *Journal of Environmental Psychology*, 23(3), 225-236.

Truelove, H. B., Carrico, A. R., Weber, E. U., Raimi, K. T., & Vandenbergh, M. P. (2014). Positive and negative spillover of pro-environmental behavior: An integrative review and theoretical framework. *Global Environmental Change*, 29(0), 127-138.

Varotto, A., & Spagnolli, A. (2017). Psychological strategies to promote household recycling. A systematic review with meta-analysis of validated field interventions. *Journal of Environmental Psychology*, *51*, 168-188. doi: https://doi.org/10.1016/j.jenvp.2017.03.011