A Participatory Mixed Methods Approach to Researching Household Water Use In Gosford, Australia

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Abstract

This paper argues that a participatory mixed methods approach is more suitable to develop insights into everyday water practices than conventional quantitative end-use studies or stand-alone qualitative behavioural studies. Combining quantitative and qualitative studies provides accurate data on the prevalence and impact of practices, as well as insights into the meanings inherent in household practices. Further, we argue that co-participation in practices during the research is a critical methodological addition to help participants to access meanings and to correlate quantitative data with practices. Our argument is illustrated with reference to a household water use study of forty-eight homes from Gosford City, Australia between May 2008 and July 2009.

Introduction: The role of mixed methods

In Sydney, households are responsible for 72 percent of urban water consumption (Sydney Water Corporation, 2011). Water in Australia is a limited resource, which is increasingly threatened by drought, climate change and population growth (Climate Commission, 2011). Consequently, water demand management is an important focus for organisations that manage water systems, particularly those with a large residential customer base.

The traditional approach to water demand management in Australia used quantitative studies and models of household water end-use to identify the most cost-effective interventions (White and Fane, 2002), which were often technological. There is a large and constantly growing body of quantitative end-use studies in Australia and overseas that identify the volume and location of water use within residents' homes (Roberts, 2005; Loh and Coghlan, 2003; Mayer *et al*., 2004). This quantitative work has been very successful in identifying suitable technological interventions to reduce household water use, such as retrofits of low-flow showerheads and dual-flush toilets. However, as the most obvious technological interventions have been taken up, organisations responsible for managing water supply systems have become increasingly interested in behavior change initiatives as a way of delivering additional household water savings (Syme *et al*., 2000; Gilg and Barr, 2006).

This new focus on shifting household behavior prompted qualitative studies looking at the social and behavioural aspects of residential water use (Allon, 2006; Staats *et al*., 2004; Dolnicar and Hurlimann, 2009). This qualitative work provides insights into individual motivations for water use that can be used to design behavior change initiatives. However, stand-alone qualitative work suffers from two important limitations. First, individuals are not always able to accurately recall or reconstruct their water-using behavior. For example, individuals often fail to accurately estimate shower duration (Roberts, 2004). Second, there is typically a gap between the behaviours that an individual values or claims to engage in, and those that they actually engage in (Blake, 1999; Shove and Walker, 2010). This value-action gap is at least partly due to complex webs of material infrastructure and social norms that shape individual behavior. These limitations undermine the accuracy and reliability of qualitative data as the sole basis for designing interventions to reduce household water use.

Clearly, there is a role for mixed methods research that combines the accuracy and reliability of quantitative data on water consumption with qualitative insights into the motivations and reasons for household water use. Mixed methods research provides a more comprehensive view of household water use that tells us not only where and how water is used throughout the home but also why residents consume water. This broader perspective should support design of more effective household water demand management programs. However, only a few Australian studies to date have simultaneously collected quantitative water end-use data and

qualitative data on residents' perceptions and motivations for household water use (O'Toole *et al*., 2009; Fielding *et al*., 2012; Willis *et al*., 2011).

While mixed methods studies are an improvement on stand-alone quantitative or qualitative studies, additional improvements can be realized by rejecting the traditional focus on researching individual behaviours and choices in isolation (Moloney *et al*., 2010; Shove *et al*., 2012). Social practice theorists contend that behaviour change theories rest on a "narrow view of social change" (Hargreaves, 2011, 80) that is "excessively individualistic and fail[s] to appreciate the ways in which, variously, social relations, material infrastructures and context are intrinsic to the performance of social practices…and not merely variables among many others within individuals' decision-making processes" (Hargreaves, 2011, 82). Behaviour change theories assume that "new social arrangements result from an accumulation of millions of individual decisions" (Shove *et al*., 2012, 2). Behaviour is taken to be a matter of choice, influenced by identifiable factors of which attitudes and beliefs are especially important (Shove *et al*., 2012, 2). In contrast, theories of practice rest on Giddens' structuration theory, which sees human agency and the structures that shape it as recursively related (Shove *et al*., 2012). According to Giddens (1986, 2), "the basic domain of study of the social sciences…is neither the experience of the individual actor, nor the existence of any form of social totality, but social practices ordered across space and time".

A social practice approach, therefore, takes the attention off individuals as agents and focuses on how both individuals and structures participate in everyday practices (Hargreaves, 2011). Instead of being the central unit of analysis, individuals become "carriers or hosts of a practice" (Shove *et al*., 2012, 7). According to Reckwitz (2002, 249):

A 'practice'…is a routinized type of behaviour which consists of several elements, interconnected to one other: forms of bodily activities, forms of mental activities, 'things' and their use, a background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge.

In their exploration of the dynamics of social practices, Shove *et al*. (2012, 14) identify three types of elements of a practice:

> *materials* – including things, technologies, tangible physical entities, and the stuff of which objects are made;
>
> *competences* – which encompasses skill, know-how and technique;
>
> *meanings* – in which we include symbolic meanings, ideas and aspirations.

In other words, social practices integrate material infrastructure such as water-using appliances, the skills to use water in various ways, and the meanings or motivations that form part of our practices. A mixed method approach is particularly well-suited for investigating social practices, as it integrates quantitative data about the operation of material infrastructure with qualitative data

about competences and meanings. We argue that an additional methodological innovation is necessary for empirical work on everyday social practices of participants' co-participation in enactment of practices. It is only in enacting a practice that a participant has full access to the meanings, materials and competences that make up that practice. Reconstructions and recollections of these elements outside the context of the practice, such as in a separate interview, may not accurately reflect the actual enactment of a practice. Having the participant lead the researcher through a practice as they enact it provides deeper insights into meanings and competences as they unfold. It also allows calibration of quantitative data by accurately identifying the metered traces of the practice. This co-participation was an important element of our method, outlined below.

Some studies have begun to apply social practice theory to investigate the everyday water practices of household water use in Australia at a conceptual level (Hand *et al*., 2005; Strengers, 2011) and international work has included empirical analysis of water use through a social practice framework (Browne *et al*., 2014). However, more empirical work is required to investigate how everyday water practices affect household water consumption, particularly in different contexts and in response to long-term drought and emergency demand management measures. To illustrate the methodological claims made above, we describe a mixed methods study of households in Gosford, Australia, that used qualitative (i.e., interviews and observations) and quantitative techniques (i.e., smart metering) concurrently to connect why residents used water with their actual water use patterns. Further, the study asked participants to enact key household practices with the researcher. The paper outlines the benefits of this methodological approach and lessons for future research.

Gosford City research project

Gosford City is part of the Central Coast region of New South Wales (NSW) and is located halfway between two important cities for the region, Sydney and Newcastle (see Figure 1). The majority of residents live east of the Sydney-Newcastle Highway, close to the coast. The community is predominantly families and retirees, low to medium income households, has an unemployment rate slightly higher than the state average, and a large commuter population who work in Sydney and Newcastle (Gosford City Council *et al*., 2008).

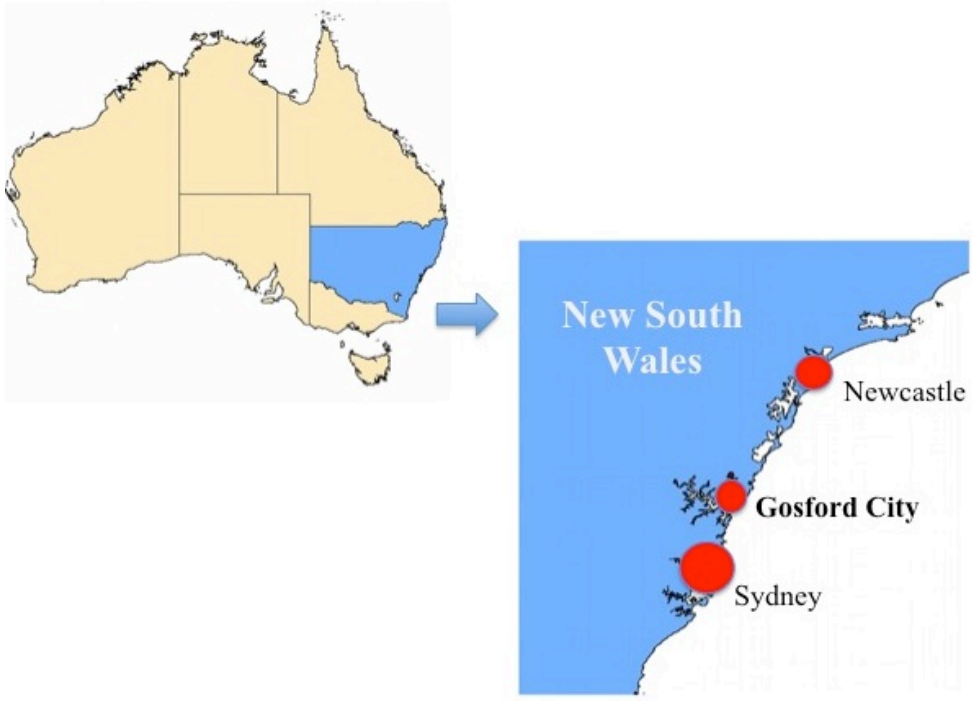

Figure 1. Gosford City, Central Coast Region. (Source: Dustin Moore, ISF-UTS, based on ABS data 2012)

Gosford City Council, which also operates as the local water authority, co-manages the Central Coast water system with Wyong Shire, the local government authority north of Gosford City. The Gosford-Wyong Councils' Water Authority services a population of over 285,200. By 2051, this figure will have increased to an estimated population of more than 463,000 customers (Central Coast Water Corporation, 2007). The residential sector consumes most of the water, and makes up approximately 78% of the customer base (Gosford City Council *et al*., 2008). Although per capita residential water usage is decreasing each year, the population increase will offset any savings. The pressure on water consumption is further heightened by increased use of aging infrastructure and the uncertainty in weather patterns resulting from climate change (Central Coast Water Corporation, 2007).

Reticulated water was first implemented in Gosford City during the 1930s and in Wyong Shire from the 1950s, eventually servicing most of the Central Coast. Water is currently drawn from four streams, stored in three small to medium-sized dams and three weirs, as well as six groundwater bores. Additional water is available, when required, via a pipeline that connects the Central Coast to the Newcastle water supply. The water supply system is the third largest in NSW (Central Coast Water Corporation, 2013).

Much of Australia recorded below average rainfall during the 1990s and 2000s, with eastern Australia affected by continuous drought from 2001 to 2009 (van Dijk et al., 2013). All capital cities and many regional towns implemented

numerous demand reduction measures, including tough water restrictions. Gosford City residents lived through extreme water shortages and drought conditions from 2001 to 2012, with total water storage levels reaching a low of 13% in May 2009 (Gosford City Council, 2012).

During this period, Gosford City Council investigated options to reduce water consumption, such as demand management measures and upgrade of aging infrastructure (Gosford City Council *et al*., 2008). Residential demand management measures included water restrictions, rebates for water-efficient devices, subsidized visits from qualified plumbers to check for leaks and install water-efficient showerheads and flow aerators for taps, as well as education and information campaigns. From October 2006 to June 2009, level four water restrictions were implemented, with all outdoor water use banned and residents restricted to using 150 litres per day before penalties were implemented (Gosford City Council, 2012). Residents consistently achieved the 150 litre target, with many households also updating their old inefficient water devices to new water efficient stock (Gosford City Council, 2012).

Research Design

Turning now to our mixed methods research project, from May 2008 to July 2009, 48 households from five suburbs participated in our study to determine how and why householders used water. One hundred and forty seven participants were involved, of which 102 were interviewed. Most of the data was collected during the period of level four restrictions, except for 10 households whose final two weeks of data were collected during level three restrictions. Each home participated in data collection for an average of four months; some were involved for a slightly longer period due to delays in data collection, household availability and equipment failure. While the sample was not statistically representative, participants were chosen to ensure inclusion of households covering the following demographic categories: free-standing houses, individually metered duplexes and units, owners, renters, single occupants, families with and without children, single-parent families, non-family group share households, pensioners, students, single and double incomes, commuters and those working from home.

Social practice theory provided an overarching theoretical frame for structuring the research design and analyzing the household water usage data. As noted earlier, social practice theories shift the focus from individuals and their behaviour to everyday practices; the unit of analysis are therefore practices or the elements that make up practices (i.e., materials, meanings and competencies) and not the individual (Shove *et al*., 2012).

The project included four data collection components. The first component used smart metering technology (i.e., high-resolution water meters and data loggers) to collect quantitative water end-use data. The methodology was informed by key end-use studies in Australia (Roberts, 2005; Cordell *et al*., 2003) and

overseas (Mayer *et al*., 2004). Each high-resolution water meter measured 14 millilitres of water flow, small enough to pick up tap events, while the data loggers recorded meter readings every 10 seconds (see Figure 2). The data was remotely sent to dedicated email addresses via the telecommunications network, then entered into a software program called Trace Wizard (Aquacraft, 2014). The researcher used the software to identify trace signatures for specific water-using events, such as toilet flushes, clothes washer cycles and showers. These events were aggregated into a water end-use profile for each household.

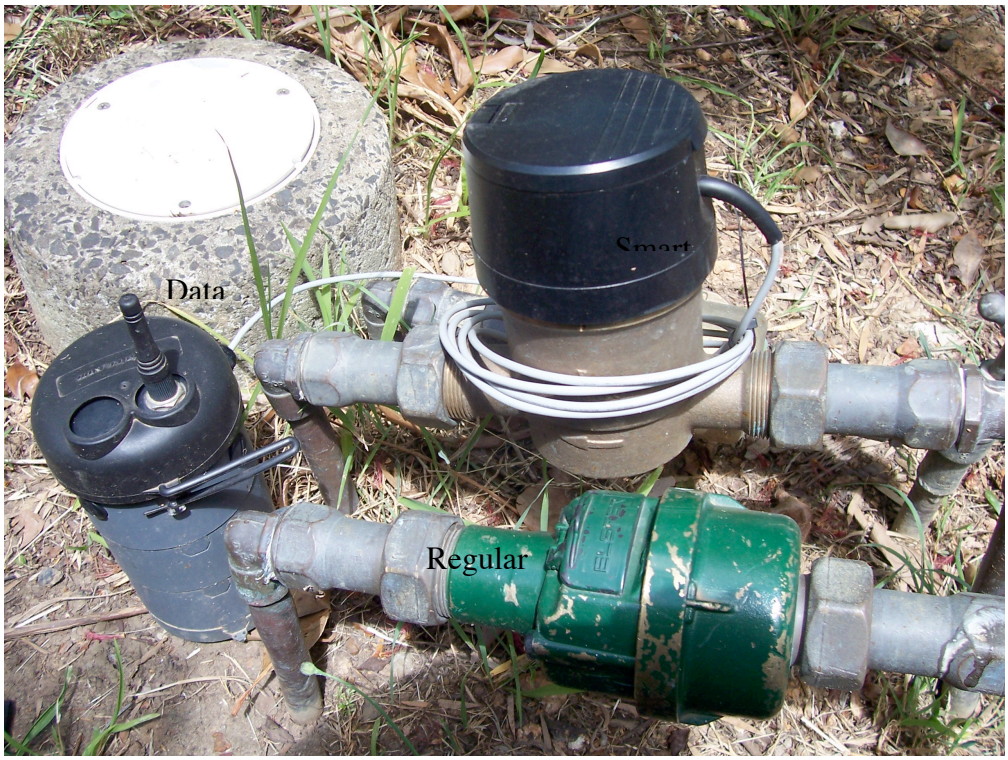

Figure 2. In-situ smart metering technology. (Source: Nicole Thornton)

After installation of the smart meters, the researcher asked participants to engage in a water audit in which they enacted key household practices that used water, including the shower and bath. This co-participation in the practices was not initially part of our method but emerged early on during the research as an important way to accurately identify the water use traces associated with each practice. By recording the time at which the practice was enacted and comparing it with the water meter data collected at that time, trace signatures of each practice were identified. In addition, enactment of each practice allowed participants to consciously access meanings and competences associated with the practice, which they could discuss more easily with the researcher. During this engagement, the researcher also collected consent forms and data about the infrastructure and appliances used in participants' homes.

The third component of data collection comprised two semi-structured interviews with one or more members of the household; the first interview of approximately one hour was conducted halfway through the study, and the second of approximately 30 to 40 minutes occurred at the end of the study when the trial of the water-saving devices (discussed later in this paper) had been completed. The first interview allowed for a rich exploration of participants' meanings (i.e., what water meant to participants) and competencies (i.e., the skills and know-how to do the practice), in the context of their everyday water use in their home and community, their water utility, and the drought and water shortages. The second interview asked participants their opinions about the shower monitors, new low-flow toilets (if applicable) and their involvement in the study.

The final data collection component was a trial of electronic shower monitors and the replacement of high-flow toilets (9+ litres) with low-flow toilets (4.5/3 litres). The intent was to identify how these specific water-saving devices performed in practice and what level of impact they had on participants' water use. The shower monitor trial and toilet replacement program tested how a change in the infrastructure potentially disrupted a routine practice, in order to save water.

The remainder of the paper focuses on three of the data collection techniques used in this study – smart metering technology (quantitative data), co-participation in practice (mixed data), and interviews (qualitative data) – in order to explore how a mixed methods approach and social practice framework can provide a more comprehensive picture of everyday water practices.

Benefits, Challenges and Lessons Learned

Smart metering technology

The smart metering technology provided data that quantified the water practices enacted in participants' homes. The metering data provided a basis to assess how everyday household practices translated into observable water consumption patterns. The data loggers were designed to collect data unobtrusively to increase the likelihood that participants would maintain their regular practices. Research has shown that participants in research studies can change their behaviour to conform with what they think is expected of them or will be acceptable to the person in charge (Silverman, 2001). Indeed, any engagement with participants has the potential to shift practices in ways that are difficult to predict. With this in mind, water meters were located on the property boundary (usually away from householders' regular movements around the home and car) which made it easier for participants to forget they were being monitored. Comments by the researcher to participants referring to the smart metering equipment were kept to a minimum throughout the study to further encourage householders to forget that their water use behaviour was being monitored. Nevertheless, at least one household did interact with their data logger to learn how the device worked. In the process, they dropped the logger, which created a hairline crack in the lid, thereby allowing

moisture to enter the sealed chamber and destroy the internal workings (and losing all their data).

Household data logging is a method that requires some engagement with householders. As such, some influence on household practices is inevitable. Other quantitative household water use studies avoid this issue by working with large amounts of aggregated water use data derived from normal meter readings taken for billing purposes. However, such studies are unable to identify short-term temporal variation in water use, which means they cannot track specific end uses. Smart metering provides the necessary resolution to identify end uses. We think the advantages of these data outweigh the small influence on household practices caused by collecting these data.

Co-participating in practice through water audits

Routines are notoriously difficult to identify and recall, because aspects of the routines become almost unconscious to the user (Geller, 2002). This is one of the key reasons why gathering high quality data about routines and practices can be a challenge for consumption and behaviour studies.

The initial design of the water audits required participants to answer basic questions about the water devices they used and when, after which only the researcher would measure estimated water flow rate, volume and duration at each device. This initial design aimed to keep participant interaction and reminders to a minimum, reduce potential changes in their water practices, and minimise feelings of inconvenience and annoyance at having to give their time to a stranger. For example, we did not ask participants to operate the clothes washer and dishwasher during the audit. Instead, participants were asked when and how often the household was most likely to use these machines (e.g., the time of day and the day/s of the week), and the model of the device was noted to collect manufacturer information on wash cycle volumes. However, after the first three water audits, we decided to increase the level of involvement from participants to increase engagement and more accurately characterize practices.

Participants found it was a natural response to show the researcher how they used water at each device and why, while they were at the device, and to discuss water-saving adaptations they had made in response to the drought or demand management measures. The site of water use acted as a visual reminder of the routines and practices participants enacted, including aspects of their water use they had forgotten until they had acted out or talked through the process with the researcher. This then provided valuable corroborating information for the smart meter water data and for the interviews. In essence, we adapted the research method so that we co-participated in household practices with the participants. Adapting the water audit in this way improved the quality and richness of the data. It ensured the data loggers captured how the householder themselves used water at each water site (such as adjusting the shower tap to the desired flow rate and

temperature at the beginning of their shower), which ensured a more accurate identification of the trace signatures left by their practices.

Water audits that included co-participation in practices also provided an opportunity to build trust and rapport with the researcher. This trust was particularly important later in the study during the interviews when personal and intimate questions were asked about residents' hygiene and toilet habits. The water audit helped householders to relax into the role of 'participant'. No participant had previous experience with a research project, so the water audits helped to clarify the purpose of the project (e.g., learning about everyday water use), what type of information the researcher was collecting (e.g., how, why and when taps or toilets were used) and what type of person the researcher was (e.g., trustworthy or untrustworthy).

Co-participation in practices also improved the subsequent interview process. Discussion of water routines during interviews sometimes took more time than anticipated, especially when there were more than two people interviewed. By including participants' routines during the audits, we freed up interview time to discuss participants' perceptions, meanings and opinions about water in their home and community.

The onsite learning meant there was a shift in the research design from using interviews to identify practices in abstract terms to observing and co-participating in practices as they were enacted during the water audit. This approach is more consistent with a social practice theory framework and certainly increased the engagement of participants relative to our initial methodological approach. Whether or not this participatory approach also delivered more reliable empirical data could be a topic for future comparative research.

Interviews

During interviews participants' answers can be constructed in a way they feel is personally or sociably acceptable (Cordell *et al*., 2003; Silverman, 2001). Therefore, it was important to ensure participants clearly understood the aim of the interviews. They were told at the start of each interview that there was no right or wrong answer to interview questions. They were asked to answer questions in their own words, without considering what they thought the researcher was expecting. This increased the likelihood that the opinions and reasons given by participants were not lost or filtered through more structured forms of qualitative data techniques, such as surveys.

To this end, a digital recorder was the only instrument used to record the conversation, and no notes were taken during the interview (although notes were taken before and after the interview based on the researcher's observations and other information deemed relevant to the interview answers). Note-taking did occasionally occur during the early interviews but had to be eliminated as it became a distraction to participants as a reminder they were being recorded. This

caused them to become nervous or concerned that they were not answering the questions correctly, and to lose their train of thought, thereby disrupting the flow of conversation and the openness of their answers.

Interviews were conducted at important stages of data collection: at the completion of the smart metering period halfway through the study and when the water-device trials were completed at the end of the study. We did this to reduce the number of reminders participants received that they were being studied. Even these limited reminders heavily influenced the behaviour in two homes, whose residents commented to the researcher how proud they were at reducing their water use since the researcher first contacted them during the recruitment stage. Although the introduction letter stated, and the researcher had explained from the first visit, that the study was interested in everyday household water use and that participants were not being asked to change their water usage, these participants interpreted the study's purpose as determining how well they had saved and used water during the drought.

As a result of their comments, the researcher began specifically to ask households if they had changed their water use since the recruitment stage, and if they understood that the project's aim was to collect information about their everyday water patterns. Most residents answered they had not actively changed their behaviour during the study, but had become more aware of their water usage at different stages of the study.

Conclusion: Rationale for Adopting a Mixed Methods Approach

This study used a concurrent mixed methods approach to integrate quantitative and qualitative data into a comprehensive analysis of everyday household water practices. Smart meters and data loggers collected quantitative data on household water use, allowing identification of water-using practices with a high degree of accuracy. Water audits encouraged participants to enact practices with the researcher so that connections could be made between these observed practices, the quantitative traces from the smart metering data, and forgotten behaviours and motivations that can occur with habitual routines. While valuable, these data alone revealed nothing about why participants engaged in particular practices. The interviews allowed mapping of the meanings and competencies that were associated with water practices. They offered a rich source of data on the decisions, motivations, opinions, know-how and meanings that were integrated into participants' everyday water practices. In combination, these three data sources created a rich, complex and diverse picture of the role water plays in household water consumption.

This combination of methods is particularly important for digging into everyday practices, which are so habitual that they can be difficult to call to mind accurately. Householders' feelings, attitudes or behaviours in relation to particular water practices may also be easily forgotten as time passes. The inclusion of

quantitative smart metering data provided an objective verification of what participants said in interviews and during water audits. The data loggers provided data that did not rely on memory or a person's awareness of their water use, and could reliably measure the frequency, duration, the time of day, and to a lesser extent, the types of water devices associated with particular water events throughout the home.

Perhaps the most important methodological innovation that emerged during the research in response to our engagement with the participants, was to have participants enact and co-participate in household practices with the researcher. This approach drew attention to the materials, meanings and competences that made up the practice at the point of enactment. However, it also highlights the tension between the desire to avoid interaction so that researchers do not influence the participants' practices, and the need to co-participate in practices if we want to gain genuine insights into the particular practice as it is enacted.

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