Using psychology to understand practice change among sugar cane growers

J Pickering[1], J Hong[1], R Stower[1], D Hong[1] & M Kealley[2]

[1] Behaviour Innovation Pty Ltd, 315 Brunswick St, Fortitude Valley, QLD 4006
[2] Queensland Cane Growers Organisation Ltd. Level 6, 100 Edward St, Brisbane, QLD 4000
Email: john@behaviourinnovation.com

Abstract. Nitrogen and pesticide runoff from sugar cane farms have been identified as modifiable factors to improve water quality entering the Great Barrier Reef. The long-term protection of the Reef is therefore linked to the behaviours of sugar cane growers across Queensland. The current study surveyed the attitudes and practices of 48 cane growers in Queensland, focusing on psychological characteristics associated with farming practices and innovation. Projects that are aligned with growers' internal values, target their sense of identity, improve their knowledge about projects, and increase their social connections may encourage the adoption of farming practices linked to improved water quality. These findings highlight the potential importance of utilising psychological science to enhance the design, delivery and evaluation of projects aimed at improving farming practices.

Keywords: behaviour change, practice change, innovation, water quality, sugar cane, Great Barrier Reef

Introduction

The Great Barrier Reef (GBR) holds great cultural and economic value in Queensland, contributing to an estimated 15-20 billion dollars of revenue annually (Brodie & Pearson 2016). In addition, the Reef is home to a large number of marine species, supporting biodiversity. As such, protecting the Reef remains one of Australia's foremost environmental priorities. Whereas anthropogenic climate change is the biggest contributor to the Reef's declining health (Hughes et al. 2017), other modifiable factors have also been identified (Department of Environment and Heritage Protection 2015a). Among these are agricultural variables such as nitrogen and pesticide runoff from sugar cane farms (Brodie & Pearson 2016). The presence of nitrogen in the water is linked to an increased risk of Crown of Thorns and algal blooms, which are among the most significant, yet modifiable, threats to Reef health. In addition, some effects of climate change, such as ocean acidification also interact with these agricultural variables. Thus, targeting cane growers' farming practices to minimise runoff from farms is a potentially powerful avenue for improving GBR water quality.

Despite knowledge of the importance of farmers' agricultural behaviours in promoting Reef health, relatively little attention has been paid to the factors that motivate farmers to change their practices. Previous research in the environmental sector has focussed mainly on farmers' adoption of conservation practices (see Greiner, Patterson & Miller 2009; Greiner & Gregg 2011; Emtage & Herbohn 2012; Larson, De Freitas & Hicks 2013). However, not all new farming practices that are adopted by growers are necessarily linked to conservation. Farming decisions need to balance an interplay of financial versus environmental benefits, as the two may not always be compatible. Growers also have different levels of engagement with issues of environmental health (Emtage & Herbohn 2012), and do not adopt new innovations simultaneously (Diederen, Meijl & Wolters 2003). Even when new practice innovations are accepted, they may not be adopted completely.

Adding to the problem, water quality measurements are recorded over a long timescale and are required to account for multiple contributors, making it hard to link any one farm or any specific practice to fluctuations in water quality (Neil et al. 2002; Brodie et al. 2012). Analyses indicate that neighbouring farms may have diverse types of soil and varying land types such as hills and marshes, meaning the same farming practices on different farms can lead to different water quality outcomes (Carroll et al. 2012). Combined with the uncertainty surrounding water quality measurement, these factors can lead to a lack of trust on the part of the growers towards scientific reports (Ahnström et al. 2009). Consequently, communications with cane growers that centre only around the issue of water quality and the GBR may be unlikely to elicit significant changes in farming practices.

Multiple approaches and initiatives targeted towards encouraging adoption of farming practices that minimise nitrogen and pesticide runoff from sugar cane farms have been previously trialled (Department of Environment and Heritage Protection 2015b). However, such initiatives rarely take a systematic approach to changing the farming practices of cane growers (Hajkowicz 2009). One exception to this is the Smartcane Best Management Practice (BMP) program. Smartcane BMP is an industry developed program consisting of modules designed to optimise cane growers' farming practices (Schroeder et al. 2008). The program targets a full suite of farming practices

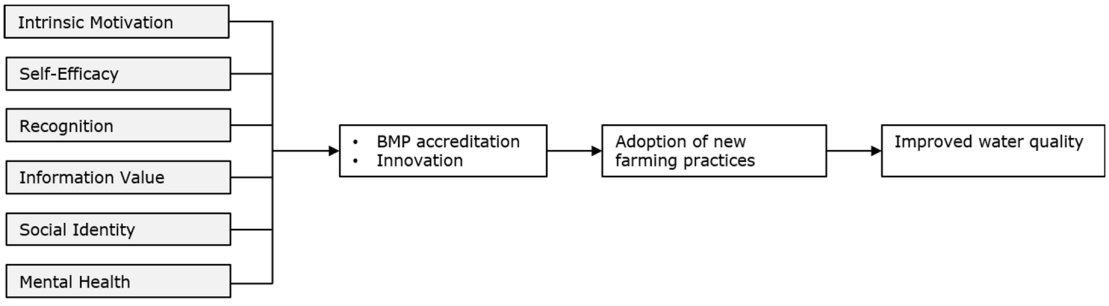
from nutrient and soil management, to business practices and sustainable production. A feature of Smartcane BMP is that is provides a tool for the industry to demonstrate its commitment to farming practices that support improved water quality (through careful nutrient management). Growers may either be completely uninvolved with Smartcane BMP (not registered), be registered for the program and self-assessed against the industry standard of practice (benchmarked), self-assessed and completing some of the modules (working toward accreditation), or have completed all required modules (accredited). These brackets also broadly correspond with the idea of non- or partial adoption versus full adoption of conservation practices. Current engagement with Smartcane BMP represents over half the area under cane production in Queensland (200,000 ha; Kealley & Quirk 2016). However, the level of accreditation is mixed, with some regions of the cane industry showing fewer than 10% of growers accredited in the program (CANEGROWERS 2016), whereas the area accredited between Ingham and Mossman is 25% (CANEGROWERS 2017). Nonetheless, the program remains one of the most widespread practice change initiatives within the cane industry, and thus provides a basis for examining cane growers' engagement with the adoption of certain farming practices.

As identified by Kealley and Quirk (2016), there is no one single driver for engagement in Smartcane BMP, rather a mix of reasons depending on a grower's personal perceptions, business drivers, access to support and connectivity to the community and industry. Beyond participation in Smartcane BMP, growers who are more innovative may be more likely to adopt a variety of practice changes, amongst which are included conservation practices. To what extent Smartcane BMP itself is associated with innovation is also worth exploring. Studying BMP adoption in conjunction with factors related to innovation may help inform what drives practice change within the industry. Thus, an opportunity exists to utilise psychological science to bring about an enhanced understanding of the factors that motivate behavioural change and innovation within the industry and use this knowledge to inform the design of evidence-based behavioural change programs.

Psychological factors related to behaviour change

There are numerous psychological factors that are known to influence behaviour (See Pickering, Hong, Hong & Kealley 2017 for a full review). However, there are a number of key factors that are likely to be especially relevant in the context of understanding cane farmers' practices. Both agricultural and psychological sources were consulted to identify potentially relevant psychological constructs. These constructs were then used to develop a model of how psychology may be used to influence practice change. Six main constructs were identified: intrinsic motivation, self-efficacy, recognition, information value, social identity and mental health. Figure 1 illustrates a proposed model of how these factors may be linked to the adoption of new farming practices and subsequently improved water quality. The idea is that by targeting a combination of these factors, adoption of new environmentally friendly farming practices can be increased. In turn, this will lead to improved water quality through the reduction of nitrogen and pesticides runoff into the GBR. For the purpose of the current study, innovation was defined as growers generating, testing, participating or utilising new implements, technologies, ideas, or farming systems on their farms that are new to their farm or district.

Figure 1. Proposed model for how psychological factors can lead to improved water quality



Intrinsic motivation. Intrinsic motivation refers to any internal factor that can motivate behaviour. In the cane industry, intrinsic motivators might include a grower's family, well-being, lifestyle, pride, or any other internal values related to their motivations for working in the cane industry (Ryan, Erickson & De Young 2003; Greiner, Patterson & Miller 2009). It is important to ensure that the desired behaviour change aligns with the internal values of the person whose behaviour is being targeted (Cerasoli, Nicklin & Ford 2014). Without this, attempting to modify behaviour

without considering internal motivations may result in reduced likelihood of a successful intervention (Ryan, Erickson & De Young 2003; Blackstock et al. 2010). Research in related settings provides support for the importance of intrinsic motivation. For example, graziers have been shown to be more motivated by lifestyle or conservation values than economic or financial reward when it came to adoption of conservation practices (Greiner, Patterson & Miller 2009).

Social identity Social identity refers to an individual's knowledge that he belongs to some kind of group, where membership of this group is associated with emotional significance (Tajfel 1974). The more strongly a person identifies with their social group, the more likely they are to abide by the rules and behaviours demonstrated by this group. Evidence already indicates sense of place of residents of the GBR catchment area was strongly tied to the importance of their natural environment. Information about new farming practices is also likely to be socially shared (Pannell et al. 2006), meaning that growers who are better connected may be more informed about the risks and benefits of these practices. A cane grower's sense of identity as a grower, especially in their connection to a specific geographical region, may be an important influence upon their ongoing willingness to adopt new farming practices.

Self-efficacy The degree of control which people feel they have over their environment is an important determinant in peoples' willingness to change behaviour. If a person does not feel that their behaviour is likely to have any impact on their environment, they are unlikely to change (Bandura 1977). In the face of a threat, feelings of control can help encourage behaviour change (Hornsey et al. 2015), and help individuals respond constructively to the threat (Greenaway et al. 2013). Highlighting elements of cane growing that are controllable may thus improve a cane grower's sense of self-efficacy, and in doing so boost their willingness to adopt new farming practices.

Recognition Feedback is essential in encouraging any form of behaviour change, and positive feedback has been shown to be more effective than negative feedback (OECD 2017). Promoting a positive sense of recognition around the cane industry and rewarding behaviours in line with the desired suite of practices, may contribute to increased desire among growers to adopt new farming practices. There is also often a lack of recognition for cane growers own knowledge of the environment (Ahnström et al. 2009; Blackstock et al. 2010). Many growers feel a strong sense of pride as custodians of the land, often accompanied by many years of farming experience (Ryan, Erickson & De Young 2003). When proposing practice changes, these elements of knowledge and pride are typically not accounted for (Blackstock et al. 2010). Assessing the extent to which growers feel recognised for their knowledge and ongoing contribution to the wellbeing of the environment may, therefore, provide insight into as to whether they feel included in the process of change, and whether this is impacts upon their willingness to participate.

Information value Forming an understanding of what is involved with the implementation of new farming practices is a crucial factor in minimising risk and encouraging adoption of the practice (Pannell et al. 2006). A study in the UK showed that when conservationists showed and explained to farmers the wildlife on their farms they were more willing to take conservation actions (Ahnström et al. 2009). Additionally, graziers who were early adopters of BMP rated improving knowledge as significantly more important than late adopters (Greiner, Patterson & Miller 2009). Evaluating the knowledge growers currently possess about their farming practices and water quality, as well as to what extent they would like to improve their knowledge could therefore provide targets for communications around farming practices.

However, information provision on its own, or solely scientific information, is not sufficient for behaviour change (Pannell et al. 2006). Information should ideally be delivered by a credible source, especially when there is minimal personal experience or high risk (Blackstock et al. 2010). Determining who growers trust might then provide an avenue for recommendations about future communications around the issue of GBR health.

Mental health Aspects of rural life, such as geographical isolation (leading to fewer social networks), economic and political factors, as well as stigma surrounding mental health problems can all increase growers vulnerability to mental health issues, including suicide (Hirsch 2006). It has been found previously that non-adoption of agri-environmental schemes may be linked to poorer mental health (Hounsome, Edwards & Edwards-Jones 2006). Climate change and other natural disasters or environmental pressures (such as the GBR) may also adversely affect the mental health of those living in rural populations (Morrissey & Reser 2007). Consequently, mental health of cane growers should also be considered when examining factors affecting success and innovation in the cane industry.

The current study

The current study seeks to investigate how psychological factors may be related to Smartcane BMP accreditation and innovation within the cane industry. Intrinsic motivation, social identity, self-efficacy, recognition, information value, and mental health were identified as specific psychological constructs of interest. How these related to Smartcane BMP accreditation as a marker of practice change, as well as innovation within the cane industry more broadly was analysed. In doing so, a potential link between psychological constructs, practice change and innovation, and water quality can be identified.

Methods

Participants

The participants for this study were 48 sugar cane farmers residing in far north Queensland, Australia. Participants were recruited via the CANEGROWERS organisation, using social media, newsletters and targeted emails. Participants completed the survey voluntarily, and their details were entered into a competition to win a bottle of *Bundaberg Master Distillers Collection Black Barrel Rum*. See Table 1 for a full summary of demographic variables.

Table 1. Means and standard deviations for the demographic variables

Variable (unit)	Mean	SD	Min	Max
Age (Years)	54.13	13.82	24	83
Years Canegrowing	27.19	16.68	1	60
Farm Size (Ha)	275.41	280.46	20	1200
Sugar cane Tonnage (per Ha)	86.68	23.96	42.85	150

Design and procedure

The questionnaire was conducted using a within-groups correlational design. Data were collected over the second half of 2016. All items were self-report. Participants were directed to complete the survey either online, over the phone, or in person. The survey took approximately 30 minutes to complete. The order of questions remained the same for each participant.

Statistical analysis

The results were analysed using IBM SPSS Statistics (version 22). Correlations were run between the identified psychological factors, Smartcane BMP accreditation and innovation questions, using Pearson's bivariate correlation (r_{pb}) and Spearman's rho (r_s) for continuous and dichotomous variables, respectively. Cronbach's alpha (α) was used to assess the internal consistency between items which formed scales.

Materials

The data for this study were collected as part of a broader study on the attitudes and practices of cane growers in Queensland. From the initial survey, items were extracted relating to the identified psychological constructs relevant to the current study.

<u>*Psychological constructs*</u> The intrinsic motivation construct included questions on how important each of the following items were to growers in terms of their importance to the future: their family, their farm's long-term survival, their children's or grandchildren's future, the GBR, and advances in scientific understanding (*1 = not very important, 5 = extremely important*). Growers were also asked if their children or grandchildren were likely to take over the running of their farm (*0 = no, 1 = yes*) and their relationship status (*0 = single, 1 = married / de facto*). Questions relating to how likely growers were to continue working in the cane industry (*1 = very unlikely, 5 = very likely*), if they had a desire to improve their farming practices (*1 = not at all true, 5 = very true*), and their level of concern for the future of the Queensland cane industry (*1 = not at all concerned, 5 = very concerned*) were also included.

The construct of social identity was formed through questions on whether growers felt they could turn to other growers for advice and if they felt part of a community of cane growers, both coded dichotomously (*0 = no, 1 = yes*). An industry identity scale was also formed (with acceptable reliability; α = .74) based how much growers identified with their mill, region, district, and the Queensland cane industry (*1 = don't identify at all, 5 = strongly identify*).

Self-efficacy was assessed through a single item asking growers how important it was to be able to control and regulate their own farming practices (*1 = not at all, 5 = very*). How responsible

growers felt for water quality personally, and how responsible the cane industry was overall (*1 = not at all responsible, 5 = biggest contributor*), as well as how responsible the cane industry was compared to other industries (*1 = much less than other industries, 5 = much more than other industries*) was also assessed.

Recognition was assessed through a dichotomous item asking growers if they wished the cane industry was better recognised for how innovative it is (*0 = no, 1 = yes*) and if they felt they the Queensland government was supportive towards cane growers (*1 = not at all supportive, 5 = very supportive*).

The information value construct was formed through comparing eight items on how influential they were in growers making changes to their farming practices (*1 = not at all influential, 5 = extremely influential*). This construct also included questions assessing growers trust for various organisations, including the Queensland Government, the Australian Government, NRM groups, the CANEGROWERS organisation, the media, scientists/researchers, other growers, mill operators, fertiliser suppliers and productivity services groups.

A mental health scale was formed based on three items surrounding the amount of stress, anxiety, and depression growers each experience in a typical week (*1 = none at all, 5 = much more than I would like*). These items were then combined to form an indication of canegrowers overall mental health. This scale had good reliability; α = .88. The scale was also reverse scored so that higher scores reflected better mental health.

Smartcane BMP accreditation and innovation Growers' Smartcane BMP attainment was assessed through a single item asking growers to report their accreditation status (*0 = not accredited, 1 = benchmarked, 2 = accredited*). Innovation was measured through three items, including growers' self-rated innovation (*1 = much less than other growers, 5 = much more than other growers*), how innovative they thought the Queensland cane industry was (*1 = not at all, 5 = very*), and how important they thought innovation in the cane industry was (*1 = very unimportant, 5 = very important*). Whether growers had a desire to learn about new farming techniques and practices was also assessed (*1 = not at all true, 5 = very true*).

Water quality Growers were asked how important they thought it was that something be done to improve water quality in the GBR (*1 = not at all important, 5 = very important*).

Results

Missing data analysis

One participant was missing more than 50% of their data and was subsequently excluded from analysis. The remaining data were missing completely at random: χ^2 (*df*, 1550) = 1138.42, p = 1.00. In all further analyses missing data were substituted using pairwise deletion (N=48).

BMP accreditation and innovation

Figure 2 provides a summary of correlations between psychological variables, BMP accreditation and innovation.

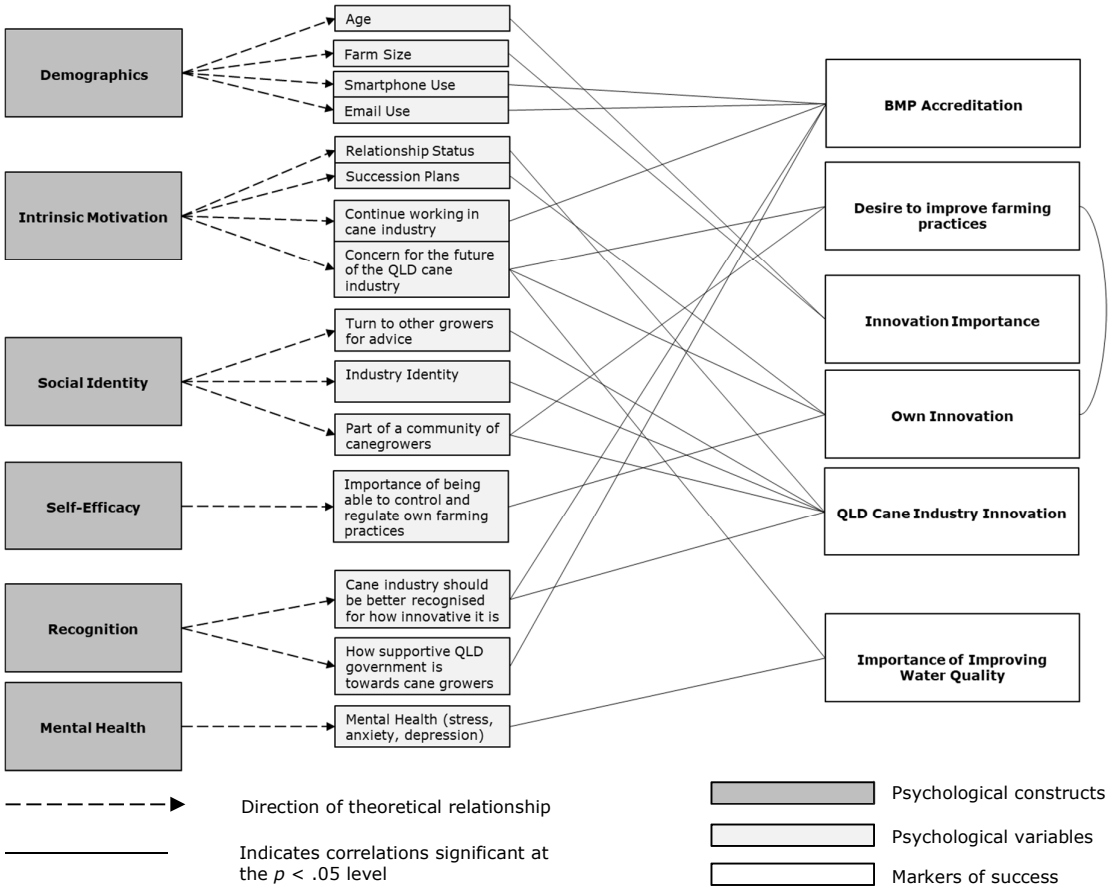
Demographics Smartphone and email use were both positively correlated with Smartcane BMP accreditation, r = .448, p = .002 and r = .323, p = .028. Innovation importance was negatively correlated with age, r_s = -.351, p = .018, but positively correlated with farm size, r_s = .304, p = .038.

Intrinsic motivators Relationship status positively correlated with perceived innovation of the Queensland cane industry, r_{pb} = .286, p = .049, such that growers who were in a relationship were more likely to rate the Queensland cane industry as innovative. Growers self-rated innovation compared to other growers was positively correlated with the possibility that their children or grandchildren would take over the running of their farm, r_{pb} = .427, p = .003.

Smartcane BMP accreditation was positively correlated with growers' likelihood of continuing to work in the cane industry, r = .380, p = .009. Concern for the future of the Queensland cane industry was positively correlated with growers' own self-rated innovation compared to other growers, r = .304, p = .045, as well as a desire to improve farming practices, r = .443, p = .003 and importance of improving water quality, r = .400, p = .009.

The importance to the future of various variables in cane growers' lives was assessed using a one-way repeated measures ANOVA with Greenhouse-Geisser correction. Importance differed significantly between variables, F (5, 180) = 21.75, p < .001. Post-hoc tests using Bonferroni correction revealed that understanding science was rated as less important than all other variables, all *ts* ≥ -5.19, *ps* < .001.

Figure 2. Correlations between psychological factors and BMP accreditation and innovation



Social identity Feeling part of a community of canegrowers positively correlated with a desire to improve farming practices, r_{pb} = .454, p = .002 and how innovative growers thought the Queensland cane industry was, r_{pb} = .445, p = .002. Industry identity and feeling like they could turn to other growers for advice also both positively correlated with ratings of the Queensland cane industry's innovation, r = .357, p = .020, and r_{pb} = .362, p = .015, respectively.

Self-efficacy How innovative growers thought they were compared to other growers positively correlated with a desire to improve farming practices, r = .443, p = .002. Importance of being able to control and regulate their own farming practices was positively correlated with industry identity, r_s = *.369,* p = .018, a desire for the cane industry to be better recognised for how innovative it is, r_{pb} = .344, p = .019 and with feeling like they could turn to other growers for advice, r_{pb} = .356, p = .019, but negatively correlated with social media use, r_s = -.358, p = .015.

The responsibility growers felt for water quality of the GBR was assessed using a one-way repeated measures ANOVA with Greenhouse-Geisser correction (although full degrees of freedom are reported here). Feelings of responsibility differed significantly depending on how responsibility was framed, F (2,88) = 11.92, p < .001. Post-hoc comparisons with Bonferroni correction revealed that growers felt significantly less personal responsibility than responsibility that was attributed to the cane industry overall, t = -5.17, p < .001, and relative to other industries t = -3.10, p <.001. There was no difference between cane industry responsibility overall and relative to other industries, t = 1.60, p = .096.

Recognition Smartcane BMP accreditation positively correlated with a desire to be better recognised, r_{pb} = .351, p = .014 and perceived government support, r = .369, p = .018. However, government support negatively correlated with concern for the future of Queensland cane, r = .342, p = .036. How innovative growers thought the Queensland cane industry was and likelihood of continuing to work in the cane industry both positively correlated with a desire for the cane

industry to be better recognised for how innovative it is, r_{pb} = .646, p < .001 and, r_{pb} = .375, p = .010, respectively.

Information value The level of influence different variables on growers' farming practices was assessed using a one-way repeated measures ANOVA with Greenhouse-Geisser correction (although full degrees of freedom are reported here). Different variables had significantly different levels of influence, F (7,217) = 6.14, p < .001. Post-hoc comparisons with Bonferroni correction showed that improving productivity was rated more influential than all other variables, all ts ≥ 3.48, all ps ≤ .042. Better access to knowledge was rated as significantly more important than other growers, t = 4.45, p = .003. No other comparisons were significant.

The level of trust growers had for different organisations in the cane industry was assessed using a one-way repeated measures ANOVA with Greenhouse-Geisser correction (although full degrees of freedom are reported here). Level of trust for different organisations was significantly different, F (9, 288) = 37.62, p < .001. Post-hoc comparisons with Bonferroni correction revealed that productivity groups, the CANEGROWERS organisation and other growers were all rated as more trustworthy than any other groups, all ts ≥ 3.83, ps ≤ .011, although there was no difference between them, all ts ≤ 1.66, all ps = 1.00. The least trusted groups were the Australian (ts ≥ -3.94, ps ≤ .035) and Queensland (ts ≥ -.879, ps ≤ .011) governments, along with the media, ts ≥ -.939, ps ≤ .002.

Mental health Mental health positively correlated with government support, r = .350, p = .036 and importance of improving water quality, r = .459, p = .004.

Discussion

The aim of this study was to explore the psychological variables associated with Smartcane BMP accreditation and innovation in the cane industry. The findings indicate that Smartcane BMP accreditation is associated with technology use, a desire to be better recognised, and government support. Smartphone and email use were both associated with Smartcane BMP accreditation. This suggests that growers who are Smartcane BMP accredited are more likely to be engaged with technology. It is likely that these growers share some underlying trait which is leading them to be more engaged overall. Identifying this factor could help with understanding drivers of success in the cane industry.

The findings also indicate that innovation in the cane industry is associated with age and farm size, family and succession plans, being able to control and regulate farming practices and social connectedness. Younger growers thought innovation in the cane industry was more important than older growers, which is in line with previous findings suggesting younger farmers are more likely to engage in conservation schemes and adopt new technologies (Ahnström et al. 2009). Growers with bigger farms were also more likely to rate innovation as more important. Farm size has previously been identified as related to innovation adoption (Pannell et al. 2006), however somewhat inconsistently (Ahnström et al. 2009). Thus, whilst farm size is related to innovation it may only play a small role in comparison to other variables.

Psychological factors

Intrinsic motivators Growers who were in a relationship were more likely to rate the Queensland cane industry as innovative, suggesting spouses and partners may be a strong protective factor in encouraging innovation. Specifically, cane growers may be driven by family motivations when it comes to innovation receptivity. This idea is further supported by the finding that growers with succession plans for their farms were also more likely to rate themselves as more innovative. This suggests that when motivated by the desire to pass on their farm to future generations, growers may be more willing to adopt new innovations. This in line with previous findings which have shown strong ties between succession plans and willingness to adopt conservation practices (Ahnström et al. 2009), acknowledging that there might be a commonality between those farmers that have succession plans and their likelihood of engaging in innovative practices.

Understanding science was rated as the least important variable in considering the future, a finding which has been reported consistently throughout the agricultural literature (Ahnström et al. 2009). In addition, the GBR was rated as neutral in terms of importance. This could reflect the combination of growers' feelings of stewardship over the land with the utilitarian actions they often need to take to maintain their farms. Although the reef is at the centre of the water quality debate, there are many other factors which are contributing to farmers' actions, such as economic viability. This interplay between connection with the land versus the practicalities of farming has previously been identified as interacting with growers' motivations for change (Ahnström et al. 2009). For example, farmers may be aware of new conservation practices, but be in an unviable economic position to trial them.

Social identity Feeling part of a community of canegrowers was associated with a desire to improve farming practices and an increased likelihood of rating the Queensland cane industry as innovative. Additionally, industry identity and feeling like growers could turn to other growers for advice were also both associated with ratings of Queensland cane industry innovation. Previous studies have shown similar links between participation in community activities and BMP adoption (Emtage & Herbohn 2012). The current study extends these findings specifically towards innovation, and thus provides evidence for the role of social identity in providing a platform for innovation within the cane industry. Thus, by encouraging growers to engage more within the cane growing community, efforts to extend innovation within the cane industry may be enhanced.

Self-efficacy Growers self-rated innovation compared to other growers was positively linked to a desire to improve farming practices. This finding is promising as it suggests a direct link between innovation and farming practices which are targeted at improving nitrogen and pesticide runoff. Cane growers rated themselves as less personally responsible for GBR water quality than they felt the cane industry was overall and relative to other industries. This suggests that there may be some diffusion of responsibility among growers, where individual growers fail to recognise their own impact on the reef or believe that the problem lies among other growers. Research has shown previously that farmers may be aware of conservation issues, but attribute them to the actions of other farmers (Ahnström et al. 2009). Consequently, future initiatives should move beyond raising awareness of an issue to designating individually goals and actions which are able to be taken to address it. In line with this, providing immediate, actionable goals for changes is likely to be more effective than broad recommendations (Blackstock et al. 2010).

Recognition A desire for the cane industry to be better recognised for how innovative it is, was linked to both how innovative growers thought the Queensland cane industry was and their likelihood of continuing to work in the cane industry. This suggests that those growers who are currently most engaged with their industry are not receiving recognition for their efforts. Integrating positive recognition for what growers have already accomplished may then encourage those growers who are engaged with the issue of water quality, but not currently acting on it to take the next step in the implementation of new farming practices (Emtage & Herbohn 2012). This may be especially effective among growers who are benchmarked in Smartcane BMP (partial adopters) but not yet fully accredited.

Information value The most influential factor on growers' farming practices was being able to improve their productivity. This suggests that interventions targeted at changing growers' behaviour should frame the benefits in terms of farming outcomes, rather than the GBR, whole noting that some growers will remain highly motivated to act in the interests of better environmental outcomes. How information is framed is thought to affect behaviour change, such that more personally relevant information encourages change more effectively (Blackstock et al. 2010). Additionally, better access to knowledge was also rated as more influential than other growers. This aligns with previous findings which suggest that greater information and awareness leads to greater behavioural change (Blackstock et al. 2010). Productivity groups, CANEGROWERS and other growers were all rated as trustworthy within the cane industry. This suggests that these groups may be effective messengers for targeted communications about the cane industry.

Mental health Growers' mental health correlated with perceived government support, such that increased support was linked to better mental health, and vice versa. However, as the data is correlational it is unclear what direction this relationship takes. Poor mental health may be contributing to negative perceptions of government communications which are unrelated to any specific government actions. Alternatively, too much negative government messaging could compound existing mental health problems. Growers with worse mental health also felt improving water quality was less important. Subsequently, improving mental health may allow for more of growers' attention to be directed towards the issue of GBR water quality. Specific ways in which mental health may be targeted needs further exploring, including what role government communications play.

Implications for water quality

Increasing growers' sense of control over their environment by creating flexible and tailored programs for change is likely to increase engagement with initiatives to change farming practices. An effort should be made to recognise growers for their already existing knowledge and contributions to the cane industry, creating a positive feedback loop wherein this feedback can boost self-efficacy and enhance internal motivations, leading to increased changes in farming practices. Growers also need to be kept informed about changes within the cane industry, in a way that is relevant to them and from trusted groups. Community engagement should also be promoted, which may increase the likelihood of changes in farming practices becoming a social norm and thus more self-sustaining. Finally, it is important that growers' mental health and

wellbeing is not adversely affected as a result of increased attention from the GBR, and that appropriate resources are provided to support growers in the adoption of new practices.

Rather than targeting farming practices directly, future approaches may benefit from adapting underlying psychological factors which influence farming practices to begin with. This could include identifying which factors are most relevant to practice change for any given grower and designing personalised, tailored interventions around them. Such an approach would focus on sustained behaviour change through targeting the causes of behaviour, rather than just actions. In doing so, practice changes are more likely to align with farmers' internal motivations and values and be framed in a way which highlights the benefits to growers themselves, thus increasing the likelihood of adoption. This means environmentally friendly farming practices are likely to be sustained, leading to long-term benefits for reef health.

Limitations and directions for future research

The sample for this study was recruited via the CANEGROWERS organisation and encompassed a relatively small number of growers from each district. Future iterations of this research will benefit from including additional growers from all parts of the cane growing community. In addition, all the measures included in the study were self-report. However, given the difficulty in assessing psychological constructs objectively, it is still likely that these results still form a representative idea of psychological constructs which may be impacting grower behaviours. Future research would benefit from experimentally varying the identified psychological constructs. Growers who score high or low on each of the psychological variables could be compared, allowing for causal inferences to be made in terms of the impact of these variables on farming practices.

Growers interpretation of what innovation means could also vary on an individual level. For example, innovation could be interpreted both as the adoption of new technologies or learning about already existing practices. Future studies should focus on providing a consistent definition on innovation within the cane industry leading to a better understanding of how it relates to practice change.

Conclusion

This study provided support for the integration of psychological variables in the design and implementation of projects targeted at changing cane growers farming practices. Intrinsic motivations, social identity, desire for control, recognition, information, and mental health were all shown to be correlated to some extent with Smartcane BMP accreditation and/or innovation in the cane industry. The lack of consideration of these factors in past projects may help to explain why adoption of practice changes has been minimal.

Consequently, future initiatives may benefit from the utilisation of psychological science to encourage farming practice change. These changes may directly or indirectly improve GBR water quality, either through changing practices such as fertiliser application, or through improving attitudes associated with water quality. The overall benefit to water quality could then decrease the environmental impact of farming practices on the GBR, ultimately helping to contribute to its increased health.

Acknowledgements

This paper is based on research funded by the Queensland Government Department of Environment and Heritage Protection. The authors are also grateful for the comments and contributions of Guy Preston, Toneya McIntosh and Irene Win Law in the initial drafts of this paper.

References

Ahnström, J, Höckert, J, Bergeå, HL, Francis, CA, Skelton, P & Hallgren, L 2009, 'Farmers and nature conservation: What is known about attitudes, context factors and actions affecting conservation?', *Renewable Agriculture and Food Systems*, vol. 24, no. 1, pp. 38–47, http://dx.doi.org/10.1017/S1742170508002391.

Bandura, A 1977, 'Self-efficacy: Toward a unifying theory of behavioral change.', *Psychological Review,* vol. 84, no. 2, pp. 191–215, http://dx.doi.org/10.1037/0033-295X.84.2.191.

Blackstock, KL, Ingram, J, Burton, R, Brown, KM & Slee, B 2010, 'Understanding and influencing behaviour change by farmers to improve water quality', *Science of The Total Environment*, vol. 408, no. 23, pp. 5631–5638, http://dx.doi.org/10.1016/j.scitotenv.2009.04.029.

Brodie, J., Kroon, F., Schaffelke, B., Wolanski, E., Lewis, S., Devlin, M., Bohnet, I., Bainbridge, Z., Waterhouse, J. & Davis, A. 2012, 'Terrestrial pollutant runoff to the Great Barrier Reef: An update of issues, priorities and management responses', *Marine Pollution Bulletin*, vol. 65, no. 4-9, pp.81-100, http://dx.doi.org/10.1016/j.marpolbul.2011.12.012.

Brodie, J & Pearson, RG 2016, 'Ecosystem health of the Great Barrier Reef: Time for effective management action based on evidence', *Estuarine, Coastal and Shelf Science*, vol. 183, pp. 438–451, http://dx.doi.org/10.1016/j.ecss.2016.05.008.
CANEGROWERS 2016, *CANEGROWERS Annual Report 2015/16*. Available from: <http://www.canegrowers.com.au/>, [9 May 2017].
CANEGROWERS 2017, *CANEGROWERS Annual Report 2016/17*. Available from: <http://www.canegrowers.com.au/>, [Accessed: 9 May 2017].
Carroll, C, Waters, D, Vardy, S, Silburn, DM, Attard, S, Thorburn PJ, Davis, AM, Halpin N, Schmidt, M, Wilson, B & Clark A 2012, 'A Paddock to reef monitoring and modelling framework for the Great Barrier Reef: Paddock and catchment component', *Marine Pollution Bulletin*, vol. 65, no.4, pp. 136–149, http://dx.doi.org/10.1016/j.marpolbul.2011.11.022002
Cerasoli, CP, Nicklin, JM & Ford, MT 2014 'Intrinsic Motivation and Extrinsic Incentives Jointly Predict Performance: A 40-Year Meta-Analysis', *Psychological Bulletin,* vol. 10, no. 4, pp.980-1008, http://dx.doi.org/10.1037/a0035661.
Department of Environment and Heritage Protection 2015a, *Reef 2050 long-term sustainability plan*. DEHP, Canberra.
Department of Environment and Heritage Protection 2015b, *Reef water quality science program, 2009-2015, Our research investment*. DEHP, Canberra.
Diederen, P, van Meijl, H & Wolters, A 2003, 'Modernisation in agriculture: what makes a farmer adopt an innovation?', *International Journal of Agricultural Resources, Governance and Ecology*, vol. 2, no. 3/4, pp. 328, http://dx.doi.org/10.1504/IJARGE.2003.003975.
Emtage, N & Herbohn, J 2012, 'Assessing rural landholders diversity in the Wet Tropics region of Queensland, Australia in relation to natural resource management programs: A market segmentation approach', *Agricultural Systems*, vol. 110, pp. 107–118, http://dx.doi.org/10.1016/j.agsy.2012.03.013.
Greenaway, KH, Louis, WR, Horsney MJ & Jones JM 2013, 'Perceived control qualifies the effects of threat on prejudice', *British Journal of Social Psychology*, vol. 53, no. 3, pp. 422–442, http://dx.doi.org/10.1111/bjso.12049.
Greiner, R & Gregg, D 2011, 'Farmers' intrinsic motivations, barriers to the adoption of conservation practices and effectiveness of policy instruments: Empirical evidence from northern Australia', *Land Use Policy*, vol. 28, no. 1, pp. 257–265, http://dx.doi.org/10.1016/j.landusepol.2010.06.006.
Greiner, R, Patterson, L & Miller, O 2009, 'Motivations, risk perceptions and adoption of conservation practices by farmers', *Agricultural Systems*, vol. 99, no. 2, pp. 86–104, http://dx.doi.org/10.1016/j.agsy.2008.10.003.
Hajkowicz, S 2009, 'The evolution of Australia's natural resource management programs: Towards improved targeting and evaluation of investments', *Land Use Policy*, vol. 26, no. 2, pp. 471–478, http://dx.doi.org/10.1016/j.landusepol.2008.06.004.
Hirsch, JK 2006, 'A review of the literature on rural suicide', *Crisis*, vol. 27, no. 4, pp. 189–199, http://dx.doi.org/10.1027/0227-5910.27.4.189.
Hornsey, MJ, Fielding KS, McStay, R, Reser, JP, Bradley, GL & Greenaway KH 2015, 'Evidence for motivated control: Understanding the paradoxical link between threat and efficacy beliefs about climate change', *Journal of Environmental Psychology*, vol. 42, pp. 57–65, http://dx.doi.org/10.1016/j.jenvp.2015.02.003.
Hounsome, B, Edwards, RT & Edwards-Jones, G 2006, 'A note on the effect of farmer mental health on adoption: The case of agri-environment schemes', *Agricultural Systems*, vol. 91, no. 3, pp. 229-241, http://dx.doi.org/10.1016/j.agsy.2006.09.001.
Hughes, T, Kerry JT, Álvarez-Noriega, M, Álvarez-Romero, JG, Anderson, KD, Baird, AH, Babcock, RC, Beger, M, Bellwood, DR, Berkelmans, R, Bridge, TC, Butler IR, Byrne, M, Cantin, NE, Comeau, S, Connolly SR, Cumming, GS, Dalton, SJ, Diaz-Pulido, G, Eakin, CM, Figueira, WF, Gilmour, JP, Harrison, HB, Heron, SF, Hoey, AS, Hobbs, JA, Hoogenboom, MO, Kennedy, EV, Kuo, C, Lough, JM, Lowe, UJ, Liu, G, Mcculloch MT, Malcom, HA, McWillia, JM, Pandolfi, JM, Pears, RJ, Pratchett, MS, Schoepf, V, Simpson, T, Skirving, WJ, Sommer, B, Torda, G, Wachenfeld, DR, Willis, BL & Wilson SK 2017, 'Global warming and recurrent mass bleaching of corals', *Nature,* vol. 543, no. 7645, pp. 373-377, 10.1038/nature21707
Kealley MJ & Quirk MF 2016, 'Smartcane BMP - Understanding drivers and building momentum for best management practice uptake in the Queensland sugarcane industry', *Proceedings of the International Society of Sugar Cane Technologists,* vol. 29.
Larson, S, De Freitas, DM & Hicks, CC 2013, 'Sense of place as a determinant of people's attitudes towards the environment: Implications for natural resources management and planning in the Great Barrier Reef, Australia', *Journal of Environmental Management*, vol. 117, pp. 226–234. http://dx.doi.org/10.1016/j.jenvman.2012.11.035.
Morrissey, SA & Reser, JP 2007, 'Natural disasters, climate change and mental health considerations for rural Australia', *Australian Journal of Rural Health*, vol. 15, no. 2, pp. 120–125, http://dx.doi.org/10.1111/j.1440-1584.2007.00865.x.
Neil, DT, Orpin, AR, Ridd, EV & Yu BF 2002, 'Sediment yield and impacts from river catchments to the Great Barrier Reef lagoon: a review', *Marine and Freshwater Research,* vol. 53, no. 4, pp. 733-752, http://dx.doi.org/10.1071/MF00151.
OECD (2017) *Behavioural Insights and Public Policy Lessons from Around the World*. Available at: http://www.oecd-ilibrary.org.ezproxy.library.uq.edu.au/docserver/download/4217091e.pdf?expires=1488932010&id=id&accname=ocid177546&checksum=1786E30A91C258A0CE187B1B554F1BEE (Accessed: 8 March 2017).
Pannell, DJ, Marshall, GR, Barr, N, Curtis, A, Vanclay, F & Wilkinson, R 2006, 'Understanding and promoting adoption of conservation practices by rural landholders', *Australian Journal of Experimental Agriculture*. vol 46, no. 11, pp. 1407-1407. http://dx.doi.org/10.1071/EA05037.

Pickering, JA, Hong, J, Hong, D & Kealley, MJ, 2017, 'Applying behavioural science to the Queensland sugar cane industry and its relationship to the Great Barrier Reef', *Rural Extension and Innovation Systems Journal*, vol. 13, no. 2, pp. 1-10.

Ryan, RL, Erickson, DL & De Young, R 2003, 'Farmers' motivations for adopting conservation practices along riparian zones in a mid-western agricultural watershed', *Journal of Environmenal Planning and Management,* vol. 46, no. 1, pp. 19-37, http://dx.doi.org/10.1080/713676702

Schroeder, B, Calcino, D, Hurney, A, Smith, R, Panitz, J, Cairns R, Wrigley, T & Allsopp, P (2008) *SmartCane Principles of Best Management Practice*. Available at: http://www.canegrowers.com.au/icms_docs/70456_BMP_Principles_of_BMP.pdf (Accessed: 9 May 2017).

Tajfel, H 1974, 'Social identity and intergroup behaviour', *Social Science Information*, vol. 13, no. 2, pp. 65–93, http://dx.doi.org/10.1177/053901847401300204.