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The Rate of Adoption of Agricultural Innovations

Service Design Research Working Paper 02-12

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Victoria
The Place To Be

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Table of Contents

Executive Summary

Predicting and estimating the extent and rate of adoption is central to assessing the benefits to be had from research into agricultural innovations and evaluating the success of marketing and extension programs. Predicting rates of adoption, and how they might be influenced, requires an in-depth, detailed understanding of the adoption process.

The question arises then, as to how to best characterise the adoption process of primary producers. After reviewing the literatures on consumer and organisational purchasing Wright (2011) argued that a prudent approach to modelling adoption decisions by producers would be to assume the full operation of the most extensive of decision-making models. Consequently, given producers are not professional organisational buyers, Wright (2011) concluded that the dual-process models of consumer decision making proposed by Bagozzi (2006a, b) would be most suitable for modelling adoption decisions by producers, and subsequently rates of adoption, as these are the most comprehensive.

In the dual-process models goal desire plays the key role in determining the urgency that is attached to an adoption possibility. In these models goal desire is, to a greater or lesser degree, influenced by anticipated emotions, anticipatory emotions, and affect towards the means of achieving goals. Wright (2011) argued the influence of these factors would depend on the type of innovation under consideration: incremental, modular, architectural or radical (Henderson and Clark 1990). These factors may be relatively trivial in the case of incremental and modular innovations but critically important in the case of architectural and radical innovations. This suggested that a classification of innovations into types of innovations such as incremental, modular, architectural and radical would be most informative about the rate of adoption to the extent that they condition intensities of motivation to adopt: that is, goal desire.

In this paper we report on a preliminary investigation into the associations between type of innovation and anticipated emotions, anticipatory emotions, and affect towards the means. Qualitative and quantitative data in relation to these variables were collected from a small sample of grain farmers in the Wimmera and southern Riverina. The results indicated there were significant associations between the complexity of an innovation and measures of the strength of anticipated emotions, anticipatory emotions, and affect towards the means.

The results indicate that goal desire can play an important role in the rate with which agricultural innovations are adopted. They also indicate that the dual-process model shows promise as a method for predicting the rate of adoption of agricultural innovations. Furthermore, unlike other models in the literature, the dual-process model has the potential to provide a rich description of the factors influencing the rate of adoption of innovations and, as a consequence, provide guidance as to how rates may best be influenced.

1. Introduction

Wright (2011) argued that predicting the rate of adoption of agricultural innovations, and how this might be influenced, requires an in-depth, detailed understanding of the adoption process; more so than is the case in regard to predicting the extent of adoption. This is because the extent of adoption merely requires understanding the circumstances in which an innovation will create a net relative advantage whereas the rate of adoption depends on the strength of the motivation of producers to adopt, which may partly be a function of the magnitude of relative advantage, as well as the actions necessary to implement adoption. As a consequence, and because producers cannot be regarded as professional purchasers, the case was made by Wright (2011) that the adoption of agricultural innovations should be treated as an individual purchase decision rather than an organisational purchase decision.

Wright (2011) concluded that models of consumer purchasing were the most appropriate as a foundation for predicting the rate of adoption of agricultural innovations. Wright (2011) advocated for a dual-process model of consumer purchasing proposed by Bagozzi (2006a) on the grounds that this model was the most comprehensive in considering the factors that might influence purchase (adoption) decisions, and that this model was the most realistic in distinguishing between those factors that motivate an individual to consider whether to adopt an innovation (goal setting) from those factors that influence the implementation of the decision to adopt (goal striving), once such a decision is reached. An important implication of this model is that the adoption of innovations will be considerably delayed where there is insufficient motivation to even consider adoption.

Wright (2011) also observed that as the adoption of more complex innovations may be expected to involve greater effort and risk, the factors that might influence the motivation to consider adopting agricultural innovations might vary depending on the complexity of the innovation. In dual-process models (Bagozzi 2006a) goal desire plays the key role in determining the urgency that is attached to considering the possibility of adoption, both in terms both of promptness and persistence of attention. In these models, goal desire can be influenced by anticipated emotions, anticipatory emotions, and preferences about the means of achieving goals. These factors may be relatively trivial in the case of quite simple innovations; hence for simple agricultural innovations goal setting would depend primarily on producers' evaluations of the time paths, and reliability, of the costs and benefits of adoption.

On the other hand, these factors may be critically important in the case of more complex innovations; hence goal desire would depend on variables such as social values, social norms, dispositional resistance to change, perceptions of outcome control and self-efficacy, as well as producers' evaluations of the time paths, and reliability, of the costs and benefits of adoption.

This suggests that a classification of innovations into types ranging from simple to complex such as incremental, modular, architectural and radical (Henderson and Clark 1990) will be most informative about the rate of adoption, to the extent that the type of innovation conditions the intensity of motivation to adopt.

In this report the objective is to begin testing, by interviewing a small sample of producers, whether the dual-process model proposed by Bagozzi (2006a) might explain the adoption of agricultural innovations. In particular, we wish to test whether the adoption of simple and complex innovations is associated with differences in the strength of some of the key emotional factors that might influence goal desire and therefore, the motivation to adopt innovations.

In the next section we summarise the Bagozzi (2006a) dual-process model of consumer adoption and the Henderson and Clark (1990) classification of innovation types. More detailed descriptions of these may be found in Wright (2011) and Kaine et al. (2008), respectively.

2. A dual-process model of adoption

The dual-process model proposed by Bagozzi (2006a) builds on the extensive literature linking resistance to change as a personal disposition, which is the opposite of innovativeness, with the likelihood and speed of adoption (Bagozzi and Lee 1999; Oreg 2003; Ram and Sheth 1989). The focus in much of this literature has been on linking resistance to change to the likelihood of adoption, the likelihood of adoption being represented by the intention to adopt such as in the Theory of Reasoned Action and the Theory of Planned Behaviour (see Bagozzi 1992; Bagozzi and Warshaw 1990). However, adoption involves both a decision to adopt, which is intention, and the translation of that intention into behaviour, which may not occur (Bagozzi and Lee 1999). The concept of 'goal striving' was developed to link intention with behaviour (Bagozzi 2007; Bagozzi and Dholakia 1999; Bagozzi and Lee 1999). Consequently, the dual-process model of consumer response to innovations has two components: goal setting and goal striving.

The dual-process model is shown in idealised form in Figure 1.

2.1 Goal setting

In the dual-process model the first process triggered by awareness of an opportunity to achieve a goal is a sequence of reflective, deliberative processes: consider-imagine-appraise-decide (Bagozzi 2006a). 'The decision-maker first considers the goal, meaning they attend to and elaborate the opportunity, they imagine the implications of succeeding and failing to achieve the goal, and then appraise the personal relevance of these possible alternative outcomes' (Wright 2011: 13). This process determines the degree of interest the decision-maker has in achieving a goal, that is, goal desire. Insufficient interest halts any move to the cognitive use of attitudes and norms. Presumably, the greater the time and effort envisaged in adopting an innovation, the correspondingly greater goal desire must be to provoke movement beyond goal desire to goal intention, and onto behavioural desire and intention.

Goal desire determines whether a *goal* will be adopted.

Bagozzi (2006a) proposes there are five elements in the consider-imagine-appraise-decide process. Two of these elements are positive and negative anticipated emotions. These emotions result from imagining success and failure, respectively, in goal attainment and their personal emotional consequences. These emotions could include happiness, excitement and pride or disappointment, anger and sadness. The likelihood of success or failure is not considered with anticipated emotions.

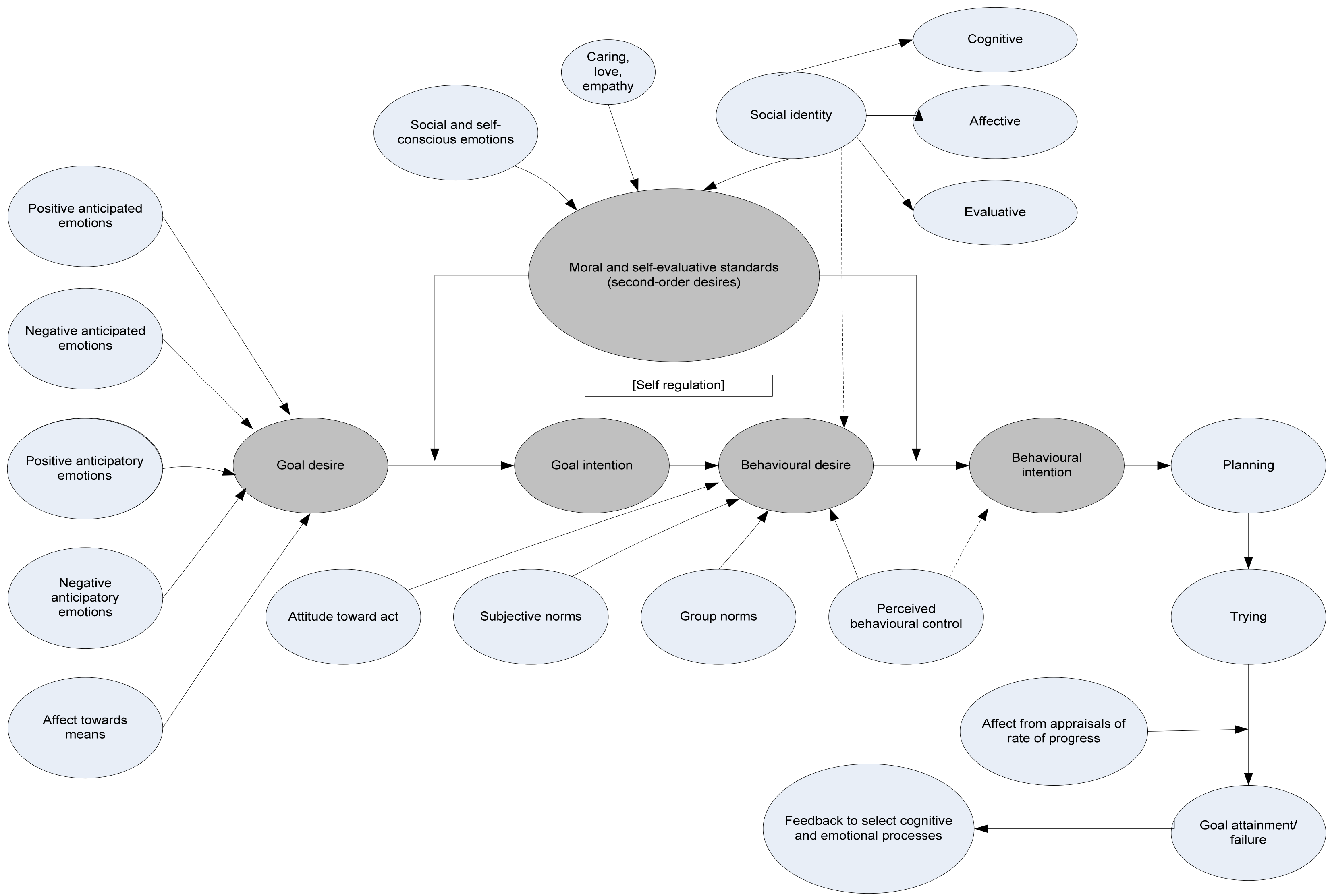

Figure 1: Key Variables and Processes in the Dual-Process Model
Source: Bagozzi (2006a: 15)

Another two elements in the consider-imagine-appraise-decide process are *anticipatory emotions*. These emotions can be positive or negative and are emotional responses to the prospect of a future event. The emotions involved are hope and fear and depend in part on the perceived probability of an event, that is, success or failure, occurring (Wright 2011).

The final element in the process is *affect towards the means of striving* for the goal. This is the personal emotional appeal of the methods, processes, actions and so on required to pursue the goal (Bagozzi 2006a).

The consider-imagine-appraise-decide process leads to acceptance or rejection of the goal as a basis for acting or not.

> *As antecedents to decision making these emotional responses to a novel action, and affect towards the means of striving to achieve the goal, act as a gateway to further consideration of its adoption…. Action is not triggered by reasons to act (e.g., favourable attitudes and norms) unless motivation to act, as goal desires and behavioural desires, is present to transform reasons to intentions.*
>
> (Wright 2011: 15).

Naturally, a number of personality traits may influence goal desire including: self-efficacy, response efficacy, and causal and responsibility attribution processes. Self-efficacy and response efficacy will impact on anticipatory emotions while responsibility attribution will impact on anticipated emotions (Wright 2011).

In principle, the relative advantage offered by an innovation could also influence goal desire via its impact on anticipated emotions. That is, the degree of happiness and excitement associated with an outcome will be influenced by the magnitude of a successful outcome (Bagozzi 2007).

Moving through the model, goal desire is converted into some goal intention: a commitment to act to achieve the goal. This commitment to the goal must then be translated into a set of specific behaviours to be implemented, which is action or behavioural desire. The factors that moderate the translation of goal intention into behavioural desire are those identified in earlier, mainstream models of consumer behaviour such as the Theory of Planned Behaviour and its variants (Fishbein and Ajzen 1975; Ajzen 2001; 2002). These factors are attitude towards the act, social and subjective norms and perceived behavioural control.

Behavioural desire is then translated into specific behavioural intentions, which may be moderated by perceptions of behavioural control such as as self-efficacy (Bandura 1997). The transformation of goal desire into behavioural intention is also moderated by self-regulation:

> *Self-regulatory processes, which are second-order desires relative to the first-order status of goal desire or behavioural desire, involve reflection on goal or behavioural desire that can lead to cancellation, overriding or postponement of implementation, or further consideration of the desire.*
>
> Wright (2011:17)

These second-order desires are the decision-makers evaluative and moral standards that govern who they are or want to be (Bagozzi 2006a: 31). These standards interact with goal desires to regulate goal intentions, and with behavioural desires to regulate behavioural intention. These interactions may lead to the creation of goals that had not been initiated in the goal setting process (Wright 2011).

Finally, the process of goal setting has the potential to be complex and iterative, which means the process can take some time. Action will not proceed until the process of deciding has run its course (Wright 2011).

2.2 Goal striving

In the mainstream consumer behaviour literature the predictions of the outcomes of consumer choice are restricted to predicting behavioural intention. This restriction is predicated on the expectation that actual and intended behaviour are highly correlated (Bagozzi and Lee 1999). This is not always the case. The factors that influence the correlation between intended and actual behaviour are considered explicitly in the dual-process model in the goal striving component of the model. Explicit consideration of the factors that may attenuate the relationship between behaviour intention and actual behaviour is particularly important, not only in forecasting rates of adoption but also in highlighting what opportunities, if any, there may be to influence this correlation.

The first stage in the goal striving component of the dual-process model is the choice of how the behavioural intention will be fulfilled. Alternative means by which this may be done are evaluated in terms, particularly, of self-efficacy, outcome expectancy and affect, which is like or dislike of a means. These elements of appraisal need to be integrated to make a choice (Wright 2011).

The second stage is action planning. Action planning 'involves decisions as to when, where, how and how long to act. In this stage situational cues for the timing of specific actions are contemplated' (Wright 2011: 18). The third stage in goal striving is the implementation of the plan, which is the commencement of action in pursuit of the goal.

The fourth stage consists of the control processes exercised over the planned actions such as tracking progress, identifying opportunities and hindrances and revising plans accordingly, maintaining commitment and reconsidering goals, means, plans and actions in the light of experience. Appraisals of progress will lead to affective responses. For example, positive affect will evoke an intention to stay the course. A negative affect may evoke greater effort. Alternatively, it may result in changes in goals, a redefinition of success or failure abandonment of goal striving (Bagozzi 2006b).

The final stage is the outcome: adoption, trial or failure to adopt, which will generate emotions. As they are experienced, outcomes will feedback to influence goal setting for subsequent innovations.

2.3 Summary

The dual-process model proposed by Bagozzi (2006) distinguishes between goal setting, which describes the process of deciding to adopt; and goal striving, which describes the process of adopting. The goal setting process provides a foundation for identifying when motivation, and the factors that influence motivation, delay adoption. The goal striving process provides a foundation for identifying when it is implementation of the decision to adopt, and the factors that influence implementation, delay adoption.

The goal setting process clarifies the potential for the adoption of apparently beneficial innovations to be delayed by a lack of motivation. The intensity of motivation, the strength of anticipated emotions, anticipatory emotions and affect towards means, must at least match the effort anticipated in making and implementing adoption decisions.

The effort involved in adopting relatively complex agricultural innovations is likely be greater than for relatively simple innovations. Consequently, the intensity of the motivation to adopt complex innovations should, on average, be greater than for simple innovations. Hence, a first step towards assessing the usefulness of the dual-process model as a model for predicting the rate of adoption of agricultural innovations would be to test for differences in the strength of anticipated emotions, anticipatory emotions and affect towards means across complex and simple agricultural innovations. Such a test requires a rigorous method for distinguishing between simple and complex innovations.

3. Types of agricultural innovations

There are a variety of methods for classifying innovations. Wright (2011) suggested that a classification based on Henderson and Clark's (1990) framework for classifying product changes into types of innovations, which was adapted for innovations to agricultural systems by Kaine et al. (2008) was most suitable in this context. In this section we briefly describe the framework for classifying innovations into the four generic types and summarise the adaptation of the framework to classify innovations in agricultural systems.

The usefulness of the classification developed by Henderson and Clark (1990) arises from what it reveals about the magnitude of the impact of adoption of an innovation in terms of disruption to system activity, the destruction of competencies, and the need for new skills and knowledge. See Kaine et al. (2008) for more detail.

3.1 Classification of innovations

Henderson and Clark (1990) argued that a product could be conceived of as a system – a collection of components that are linked together. Henderson and Clark (1990) defined the components of a product as the physically distinct parts of a product. How the components are linked together to enable the product to function is the architecture of the product. Consequently, product innovation can be conceptualised as changes to components, the linkages between them, or both. They then suggested that innovations could be categorised into four types: incremental, modular, architectural or radical, depending on the degree of change introduced into the components and the linkages between them (see Figure 2). The distinctions between these types of innovations are a matter of degree (Henderson and Clark 1990)

Henderson and Clark (1990) provide the example of a fan to illustrate these concepts. The components of a fan include blades, electric motor, stand and a fan guard. They describe how the components of the fan are linked together to create a system for moving air in a room. For example, the blades are secured to an axle that is linked to the motor. The motor and fan assembly are fixed to a stand. The architecture defines the way the blades, engine and stand link together to create, for example, a mobile pedestal room fan (Henderson and Clark 1990).

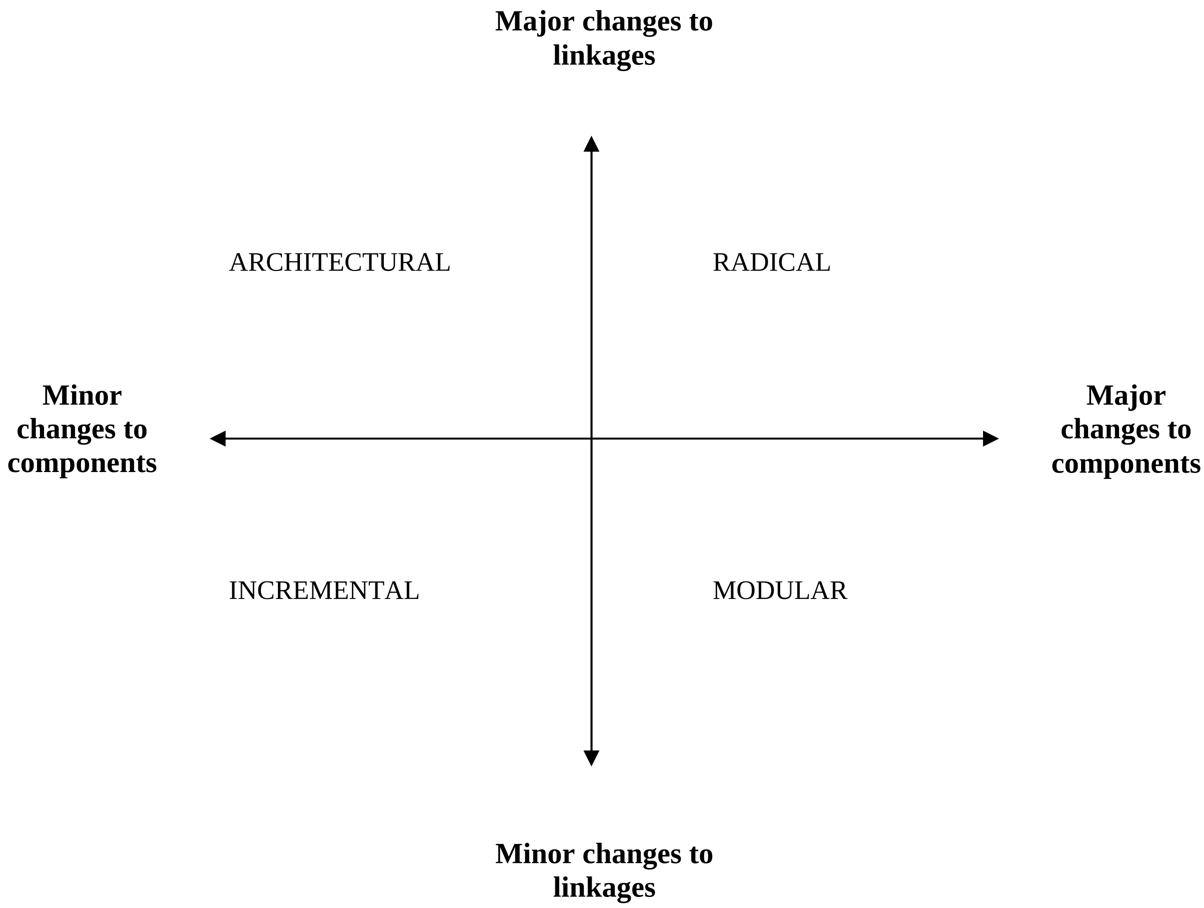

Figure 2: A Classification of Innovations

Adapted from Henderson and Clark (1990)

Henderson and Clark (1990) described how the creation, maintenance and management of a system requires specialised knowledge in regard to (1) the components of the system and the design concepts they embody; (2) how components are linked together and the design concepts embodied in the architecture of those linkages; and (3) how the components and linkages combine to influence the way in which the system functions and behaves in different environments. As a consequence:

> *Any change to the components of a system or the linkages between them involves, to some degree, the acquisition of new knowledge and the development of plans and procedures to implement the change. Consequently, the four types of innovations they identify present a continuum of change for organisations in regard to competencies, roles, responsibilities processes, policies, organisational structure and culture...*
>
> Kaine et al. (2008: 3)

According to Henderson and Clark (1990) incremental innovations introduce relatively modest changes to the components of a product leaving the links between components, that is, the product architecture, largely unchanged. Incremental innovations exploit the potential of an established design and are described as competence enhancing because they tend to build on, and extend, existing skills and reinforce the applicability of existing knowledge in regard.

Modular innovations introduce relatively substantial changes to the components of a product in that at least some existing components become obsolete because the new components are based on novel design concepts rather than simply being improvements on an established design (Henderson and Clark 1990). Generally speaking, the architecture linking the components together remains largely unchanged with modular innovation. Entirely new skills, competencies, and processes may be required to manufacture and install the new components consequently modular innovations may be competence enhancing or destroying depending on the history of the specific organisation (Gatignon et al. 2002).

Henderson and Clark (1990) define an architectural innovation as changing an established system to link the existing components together in a different way. Generally speaking, architectural innovations entail relatively minor changes in the components. Architectural innovations have been shown to create serious disruptions to organisations because architectural knowledge becomes embedded in the organisational procedures, processes and structures over time (Henderson and Clark 1990). Hence, architectural innovations not only require the acquisition of new skills and competencies, they may also require changes in the operating procedures, processes and structures of the organisations that manufacture them.

Finally, radical innovations involve a new set of design concepts that are embodied in new components that are linked together using a new architecture (Henderson and Clark 1990). Radical innovations are based on completely different scientific and engineering principles to the principles that were used in the products they supersede. The magnitude of change entailed in radical innovations means that many areas of organisational knowledge and competence are rendered irrelevant (Henderson and Clark 1990). Consequently, an organisation may have to consider new ways of thinking to adopt a radical product innovation (Smith 2000).

3.2 Classification of agricultural innovations

Henderson and Clark (1990) developed their framework to identify different types of product innovation and argued that each of these types of innovation had different consequences for the manufacturing organisation in relation to organisational skills, competencies, procedures, structures and culture. In essence their framework identifies different generic types of system innovations. Given that agricultural enterprises are systems, then agricultural innovations may also be classified into these generic types.

Kaine et al. (2008) were interested in classifying agricultural innovations into types such that there were important qualitative differences in the learning involved in implementing each type. Consequently they chose innovations to a farm sub-system as the unit of analysis for applying the concepts used by Henderson and Clark (1990), rather than specific technologies or practices.

A farm sub-system is a set of components that link together in a specific way to perform a function (Kaine et al. 2008). Different farm sub-systems are designed to perform fundamentally different functions.

> *For example, a pressurised irrigation system is a generic description of a sub-system that distributes water to plants using mechanical energy. In contrast, integrated pest management is a generic description of a sub-system for managing pests and diseases based on the use of beneficial insects and species-specific chemicals. Therefore pressure irrigation and integrated pest management are examples of two sub-system concepts; other sub-system concepts include animal health, feed management and breeding management.*
>
> Kaine et al. (2008: 10)

The components of a farm sub-system are the physically distinct elements of the sub-system. The components of a farm sub-system may include technology, techniques and practices. The architecture of the sub-system describes how the components are arranged or linked together to enable the sub-system to function. Accordingly:

> *Different sub-system concepts have different architectures and so are underpinned by different architectural principles. For example, the principle that water moves downhill under the influence of gravity underpins the arrangement and combined functioning of the components (bays, channels, gates) that form a flood irrigation sub-system. In contrast, the principle that water moves from an area of high to low pressure underpins the arrangement and combined functioning of the components (pumps, pipes, valves) that form a sprinkler irrigation sub-system.*
>
> Kaine et al. (2008: 12)

The extent of change to the components and architecture of a farm sub-system provide a basis for classifying innovations in farm sub-system into the four types of innovation: incremental, modular, architectural and radical.

Kaine et al. (2008) observed that farms consist of hierarchies of inter-related sub-systems. Consequently, incorporating new technologies or practices into a farm sub-system may require acquiring knowledge about the change to the sub-system of interest, and acquiring knowledge about how to realign sub-systems to accommodate any changes in the behaviour of sub-system that has been changed. The different types of innovation can be expected to have different effects on the interactions between sub-systems, with architectural and radical innovations having greater effects than incremental or modular (Kaine et al. 2008). As a consequence Kaine et al (2008: 13) contended that:

> *The adoption of each type of innovation could be expected to differ in:*
>
> - *The new skills and competencies needed with respect to the sub-system itself,*
> - *The skills and competencies needed to manage changes in the interactions between sub-systems and,*
> - *The skills and competencies needed to plan the implementation of the innovation.*

Put another way, qualitative differences can be expected in the time and effort involved in implementing the four different types of innovations.

3.3 Summary

The usefulness of the classification of innovations developed by Henderson and Clark (1990) arises from what it reveals about the magnitude of the impact of adoption of an innovation in terms of disruption to system activity, the destruction of competencies, and the need for new skills and knowledge. Incremental and modular innovations tend to be less disruptive of a system and to be competency enhancing, while architectural and radical innovations tend to more disruptive and competency destroying. This suggests that the motivation to adopt an innovation must change correspondingly depending on the type of innovation.

Returning to the dual-process model, anticipated emotions were identified as potentially important determinants of goal desire. It may be the case that imagined goal achievement and goal failure are perceived to have trivial emotional content with incremental and modular innovations. If this is the case then anticipated emotions will play a limited role in goal setting. Consequently, goal desire in relation to incremental and modular innovations would depend less on the strength of producers' anticipated emotions and more on their perceptions of the time paths and reliability of the costs and benefits of adoption (Wright 2011).

In contrast, it may be the case that imagined goal achievement and goal failure are perceived to have significant emotional content with architectural and radical innovations. If this is the case then the relative strength of positive and negative anticipated emotions will strongly influence goal desire.

Anticipatory emotions, too, will impact on goal desire according to the subjective probabilities of goal achievement and goal failure. As these are measures of hope and fear they will be influenced by constructs such as perceived behavioural control, dispositional resistance to change and anticipated difficulties in striving. The influence of these on goal setting may be particularly strong for architectural and radical innovations, given the demands the adoption of these types of innovations can create for new skills and knowledge.

In short, both anticipated and anticipatory emotions may play a substantial role in the adoption of architectural and radical innovations because of the complexity of these kinds of innovations, and the challenges they may pose to farmer competence. The same may be said for affect towards the means. This suggests that a classification of innovations into types such as incremental, modular, architectural and radical could be most informative about the rate of adoption, to the extent that the type of innovation conditions the role of anticipated emotions, anticipatory emotion and affect towards means and, therefore, the intensity of motivation to adopt.

Consequently, we investigated whether the adoption of simple and complex innovations was associated with differences in the strength of some of the key emotional factors that might influence goal desire and therefore, the motivation to adopt innovations.

4. Methods

To study rates of adoption of innovation we chose the wheat industry to carry out a case study. The wheat industry is of considerable economic value in Victoria and is commonly grown in western Victoria and the southern Riverina where rainfall and climate patterns have supported quality and yield over many decades.

The research was conducted in two geographical areas including the southern Riverina and the Wimmera region of Victoria. The Wimmera region was deemed to be representative of large dryland cropping enterprises and included properties within a 40 km radius of Dimboola. The southern Riverina district included properties within 50 km from the Victorian/NSW border and similarly included large dryland cropping enterprises.

4.1 Study approach

Farmers were interviewed in-person by two researchers to enable accurate manual recording of notes. We took a qualitative and quantitative approach to achieve the objectives of the research by using semi-structured interviews and scales.

4.1.1 Qualitative: semi structured interviewing

Semi-structured interviews involve a set of questions which can be asked in any order and often includes extra probing (Walter 2006). This technique is particularly useful for the exploration of perceptions and opinions because they allow the interviewee to respond to broad questions or statements with limited direction and provide opportunities for the interviewer to probe for further information (Bryman 2004).

The first part of the interviews was semi-structured, involving:

- Understanding the farm context: included property size, enterprise description, proportion of farm sown to crops.
- Understanding a less complicated innovation adopted on farm, its function in the farm system, the relative advantage it offered and the process of thinking prior to adopting the innovation.
- Understanding a more complicated innovation adopted on farm, its function in the farm system, the relative advantage it offered and the process of thinking prior to adopting the innovation.

There was extensive probing around each question. The duration of interviews was between 40 to 60 minutes.

4.1.2 Quantitative: scale development

We drew on the theory of Rogers (2003) and Gatignon et al. (2002) to gain a better understanding of the innovation type that was selected. Regarding experience with the innovation, Rogers (2003: 16) discusses trialability of an innovation as significant in its rate of adoption. He states 'An innovation that is trialable represents less uncertainty to the individual who is considering it for adoption, as it is possible to learn by doing.' Rogers (2003) also discusses the observability of an innovation as the results of which can be easily seen by others therefore the more likely it will be adopted, 'Such visibility stimulates peer discussion of a new idea, as friends and neighbours of an adopter often request innovation-evaluation information about it.' We have drawn on Rogers' insight into trialability and observability to understand how producers view it in relation to simple and complex innovations. Gatignon et al. (2002) aimed to understand innovations by developing scales and assess an innovation's locus, type and characteristic. We have used three of the Gatignon et al. (2002) Radicalness scale items to understand the producers' perception of the innovation regarding the improvement and change it had brought to the farm.

Concerning expectations about the innovation, Rogers (2003) discusses relative advantage of an innovation as the perception of an innovation being better than the one it supersedes. Furthermore, the greater the perceived relative advantage of an innovation the more likely it will be adopted more rapidly.

Scales from Gatignon et al. (2002) have been used to understand the need for new skills as a result of adopting an innovation, as well as the impact on existing skills and the impact on the farm system. These scales aim to understand if, as a result of adopting an innovation, the producer requires new skills to implement the innovation or if it is competence enhancing or destroying. Additionally, scales used to understand the innovations impact on the farm system aims to discover linkages between the architecture and components of the innovation.

Bagozzi (2006) added predictors to goal setting and striving contexts as part of a process termed CIAD 'consider-imagine-appraise-decide'. Anticipated and anticipatory emotions, along with affect towards the means and effort devoted to decision making, provide how reasons for acting influence the decisions made or the action taken. We have drawn on Bagozzi (2006) theory of explaining consumer behaviour and consumer action and applied it to determining whether it plays a motivational role in adoption of innovations.

Interviewees were asked to rate their level of agreement to statements within scales including; 'Experience with the Innovation', 'Expectations About the Innovation', 'Need for New Skills', 'Impact on Existing Skills', 'Impact on Farm System', 'Affect Towards Means' and 'Effort Devoted to Decision-making'. Likert-type scales were used where participants were invited to respond as strongly disagree, disagree, not sure, agree and strongly agree. The scales for 'Anticipated Emotions' and 'Anticipatory Emotions' asked the interviewee to rate the level of agreement for how they felt about the innovation. This was presented to them with five boxes, the first labelled 'not at all' through to 'very much'. The scale items are summarised in Tables 1 through to x.

For the data to be analysed, the scales were assigned values 1 - 5. (1=strongly disagree, 2=disagree, 3=not sure, 4=agree, 5=strongly agree). Similarly, the other scale used was assigned values from 1 (not at all) through to 5 (very much).

Table 1 Origin of scale items

Scale (and scale items)
Experience with the innovation
I found the innovation easy to trial[1]
It was easy to see the improvement in the system compared to the old one[1]
The innovation was a minor improvement over the previous technology[2]
The innovation was based on a revolutionary change in technology[2]
The innovation was a breakthrough innovation[2]
Expectations about the innovation
I didn't expect much of a worthwhile benefit from the innovation[1]
The promised a substantial improvement in performance[1]
The innovation offered a worthwhile increase in profit[1]
I expected the innovation would offer worthwhile benefits[1]
Need for new skills
Changing to the innovation involved fundamentally new concepts for me[2]
The new system required new skills which I did not possess[2]
The new system required me to develop many new skills[2]
The new system required me to learn completely new or different knowledge[2]
The new system required me to adopt different practices and procedures[2]
The new system required me to carry out a great deal of retraining[2]
Impact on existing skills
I introduced the innovation by making simple adjustments to existing technology[2]
The new system built a great deal on my existing skills[2]
The new system rendered my experience obsolete[2]
The new system built heavily on my existing knowledge[2]
My mastery of the older system did not help me master the new system[2]
Impact on farm system
Changing to the innovation led to significant changes in the linkages between my crop management, weed, soil or fertiliser management[2]
The innovation led to significant changes in the way my crop management interacts with my management of weeds, soil or fertiliser[2]
The innovation led to tighter integration between crop and weed, soil or fertiliser management[2]
The innovation made the integration of crop management with weed, soil or fertiliser management a more important factor influencing the overall performance of the farm system[2]
Anticipated emotions
If I succeeded I would be satisfied[3]   If I failed I would be disappointed[3]
If I succeeded I would be relieved[3]   If I succeeded I would be proud[3]
If I failed I would be annoyed[3]   If I failed I would be regretful[3]
If I succeeded I would be happy[3]   If I failed I would be angry at myself[3]
If I succeeded I would be excited[3]   I'd feel responsible if I failed[3]
Anticipatory emotions
I was confident[3]   I was worried[3]   I was anxious[3]   I was optimistic[3]   I was uncomfortable[3]
Affect towards means
I was satisfied with the process[3]   I disliked the process[3]
I was proud of the process[3]   I regretted the process[3]
I was annoyed with the process[3]   I feel regretful about the process[3]
I was happy with the process[3]   I was angry with the process[3]
I was excited by the process[3]   I was guilty about the process[3]
I liked the process[3]   I was disappointed with the process[3]
Effort devoted to decision-making
I spent a fair bit of time and effort thinking about the advantages and disadvantages of adopting the innovation before I made my decision[3]
I spent very little time on the decision, it was not worth spending a great deal of time and effort[3]
I spent a deal of time gathering information about the innovation before I made a final decision[3]
I relied entirely on the advice of an expert advisory in my decision to adopt the innovation[3]
I spent a great deal of time & effort thinking about how the innovation would fit into farm system[3]

Source of scale items: [1]Rogers (2003), [2]Gatignon et al. (2002), [3]Bagozzi (2006)

4.2 Participant selection

Given the privacy legislation, the research team did not have access to a database of producer names from which to draw a random sample. Instead, a mixture of techniques was employed to recruit interviewees.

We focused on the Wimmera and southern Riverina districts as these areas were well known to have wheat producers with large acreage. Interviewees were drawn from a mixture of convenience sampling and using a technique called 'snowballing' where interviewees suggest names of other people who might be willing to be interviewed. A convenience sample was drawn from producers previously involved in DPI-run farmer groups in the North East. We also used the telephone directory to identify contact details of people who identified themselves as farmers in the Yellow Pages.

Not all producers who were approached consented to be interviewed but those that did were provided with information describing the research. Interviews were then arranged at convenient locations and times. Interviews were conducted between February 2012 and April 2012 to enable avoidance of peak activity times on the farm (i.e. sowing, spraying or grain harvest).

In all cases, interviewees discussed an innovation that was less complicated and an innovation that was more complicated. In both cases the interviewee chose an innovation that had been adopted on farm. The total number of 'cases' of data was 18. Total interview number was nine.

4.3 Data analysis

4.3.1 Qualitative analysis

The 9 interview transcripts (covering 18 grains innovations) were sorted into simple and more complex innovation-types. Farm context data was summarised in tables for both simple and more complex innovations. Qualitative data was sorted under each of the survey topics and was later used to explain responses in the quantitative data.

4.3.2 Quantitative data analysis

Firstly, we determined whether interviewees consistently rated simple and complex innovations differently. We used a simple t-test to determine if differences in average ratings were statistically significant. We then used correlation analysis to investigate associations among the characteristics of innovations among types of innovations, anticipated emotions, anticipatory emotions and affect towards means. Finally, multi-dimensional scaling was used to show to location of the various innovations on a map using the procedure described by Kruskal and Wish (1991).

It should be noted that the sample size (n=18) is small and as such results should be interpreted with consideration of this. This study was preliminary and will be used to inform future studies with a much larger sample size which is more statistically rigorous.

5. Results

A total of nine farmers were interviewed between February and April 2012. Five farmers were from the Wimmera district (Dimboola and Murtoa) while four were from the Corowa district (Southern Riverina). Property size ranged from 790 hectares to 3,440 hectares with a median of 1,295 hectares (see Table 2). The median property size of the Wimmera interviewees was 1,400 hectares while the median for the Southern Riverina was smaller at 920 hectares. Cropping activities on all properties were predominantly dryland. Most of the cropping area was sown to a wheat and canola rotation in the southern Riverina, whereas barley and wheat were the main crops in the Wimmera along with various grain legumes.

5.1 Qualitative analysis

Simple innovations

In Table 3 descriptions of the simple innovations interviewees nominated are reported. Some general observations can be made regarding these less complex innovations. Four interviewees nominated changing wheat variety, often prompted by the need for better resistance to stripe rust, as their simple innovations. Another two of the simple innovations were machinery modifications to manage weed seeds as a component in the management of herbicide resistance. One innovation was a relatively simple component (stubble crushing) of a more complex innovation (stubble retention). The benefits of these innovations included greater disease resistance, improved plant health and reduced herbicide resistance as well as increased profits.

From the perspective of the interviewees these innovations required relatively modest change in the form of simply substituting seed varieties at sowing or simple alterations to equipment and machinery. With respect to changing wheat variety, interviewees tended to replace an existing variety with another variety exhibiting similar traits. This had the effect of minimising the need for changes in management practices.

A number of themes emerged during the interviews in regard to these innovations. First, interviewees generally adopted the innovation without trialling – *'We just looked at the technology and applied it'* [interviewee #1]. Interviewees often described these innovations as *'not really a breakthrough'.* They felt that the technical improvements these innovations offered were relatively minor.

Table 2 Characteristics of participants

Interviewee	*Location*	*Property size (ha)*	*Enterprise description*
1	Southern Riverina[1]	1010	Dryland with some irrigation. Winter cropping, lucerne seed production, sheep (meat/wool)
2	Wimmera	1400	Cereal, grain legumes, canola, agistment of sheep
3	Wimmera	2830	Cereal, grain legumes, canola
4	Wimmera	2000	Cereal, grain legumes, canola
5	Wimmera	1295	Cereal, grain legumes, canola
6	Wimmera	1215	Cereal, grain legumes, canola, lamb finishing
7	Southern Riverina[1]	3440	Wheat, canola, sheep and beef
8	Southern Riverina[1]	790	Canola, lupins, wheat
9	Southern Riverina[1]	830	Cereal, grain legumes, canola, sheep (meat/wool)

[1] Properties located within 15 km of Victorian/NSW border at Corowa.

Table 3: Summary of simple innovations

	Innovation	Description	Perceived benefits	Changes required
1	Double-shoot fertiliser placement	Fertiliser is placed below the seed at sowing	Plants can access fertiliser sooner after sowing and avoid fertiliser toxicity	Attachment of additional tube and storage on the seeder. Delays subsequent fertiliser application.
2	Change wheat variety	Changing from 'Yitpi' to 'Gladius'	Improved disease resistance	Alterations needed in sowing window and machinery hygiene.
3	Chaff cart	Weed seeds collected in header trash, blown into cart, dumped in piles and burnt	Reduces weed seed burden and reliance on herbicides	Buy the machinery and fit it to the header (plumbing and wiring).
4	Not applying fertiliser to crops	Has not applied any fertiliser to crops for 5 years	Significant cost savings	No fertiliser application at sowing or during the growing season
5	Change wheat variety	Change from 'Yitpi' to 'Correll'	Improved disease resistance	Substitute seed variety.
6	Change wheat variety	Change from 'Ouyen' to 'Correll'	Improved disease resistance	Substitute seed variety.
7	Adapt header to windrow ryegrass seed for burning	Header adapted to put weed seeds in a row on the ground for burning	Takes herbicide pressure off the paddock delaying resistance	Adapt trash spreader on header. Burn ryegrass rows.
8	Change wheat variety	Change from 'Lincoln' to 'Espada'	Improved yield, suits wet paddocks, good harvestability	Change seed variety. Pay forPBR rights to become registered user.
9	'Coolamon' harrow for crushing stubble	Rows of flat heavy bars dragged over stubble to break it down	Allows stubble to be retained instead of burnt.	Buy the equipment and fit to machinery.

Often the need for trialling was unnecessary as the innovation could be satisfactorily evaluated by seeing the innovation in operation on other farms, viewing at field trial results and researching the innovation: '*I didn't trial it but I read up on it, researched it*' [interviewee #1]; '*I saw the variety growing in trials down the road so in that 12 months I decided to order the seed. I'm always looking at new varieties, talking to my neighbours, looking at trial results'* [interviewee #2]; and '*You've always got your ears open to see what sort of a run others have had with that variety'* [interviewee #6].

In the case of changing wheat variety the new variety was not adopted permanently. Often the variety was only used for a few years until disease resistance failed or another variety with improved yield and other traits was subsequently released.

Second, the interviewees were usually confident that they could realise the benefits of these simple innovations. The interviewees largely believed little risk was entailed in adopting the simple innovations. We formed the impression that this meant that the intensity of anticipated emotions was relatively low: *'We were confident that we'd get an outcome – but if I failed I wouldn't be overly upset'* [interviewee #1]; and '*This is not that expensive to innovate, so risk exposure is not as high'* [interviewee #1]. One interviewee stated that if their new wheat variety had failed they would '*blame the plant breeder*' [interviewee #8].

Third, there was some evidence that the views and experiences of other farmers had an impact on the anticipatory emotions of interviewees: *'I was optimistic about it but from the time I got the seed until I harvested it I spoke to lots of people who were bagging that variety…so my confidence waned. In the end there was a yield increase. You've just got to suck it and see'* [interviewee #6]. Several interviewees spoke about how they felt about the potential for failure. They observed that failure was just part of business and needed to be accepted: '*At the end of the day I'm not risking the family farm – what's the worse case scenario? If it* [the innovation] *was worth more money then I'd have to be more rigorous* [in my decision making]' [interviewee #7].

Fourth, affect towards means did appear to play a role in the adoption process. One interviewee reported experiencing some worry and anxiety where the simple innovation required modifying expensive machinery suggesting that: *'It was somewhat uncomfortable with the header impact as it had to be ripped apart – it was hard to watch an expensive piece of machinery getting ripped apart. I also worried about the efficiency of the header'* [interviewee #3].

Fifth, in the experience of the interviewees they did not need to acquire a new set of skills to adopt the simple innovations and the impacts on farm sub-systems were relatively low, with the exception of double-shoot fertiliser: *'You get a higher rate of fertiliser under the crop – this has implications for how you manage fertiliser later in the season'* [interviewee #1].

Finally, although these innovations were considered to be relatively simple by the interviewees, there was still some effort devoted to decision-making: *'It's about knowing how significant each thing is. I choose a good accountant and good advisers'* [interviewee #7]; and '*I read about it* [ryegrass windrowing] *from the WA literature. We did one paddock. If I was investing significant amounts of money then I'd go back and double-check, but this one didn't cost any money*' [interviewee #7].

Overall, these results seem largely consistent with the suggestions made earlier in regard to the role of anticipated emotions and anticipatory emotions in the adoption of relatively incremental innovations. The results are also consistent with incremental innovations being competency enhancing.

Complex innovations

All of the complex innovations nominated by the interviewees were components of complex, multiple-step innovations such as no-till and stubble retention. These are summarised in Table 4. The perceived benefits of these more complex innovations had a much wider scope than just profits and productivity. In the case of the Wimmera, the interviewees were motivated by the need to retain organic matter and improve soil structure to prevent topsoil from being eroded. Auto-steer on machinery created a number of benefits including improved efficiency in application of farm inputs, opportunity for inter-row sowing; and reducing operator fatigue. Several interviewees were motivated to adopt these innovations for longer term benefits: *'For the first few years it wouldn't be very profitable, but there are other benefits…there are agronomic and sustainability benefits'* [interviewee #1].

From the perspective of the interviewees, these more complex innovations appeared to involve greater changes to a farm sub-system and there appeared to be greater impacts on the various farm sub-systems. Stubble retention practices were an example: '*The way I managed the crop system developed. It wasn't a significant leap, but the practices were a leap. The nutritional tie-up issues certainly impact on other systems'* [interviewee #1]; and in regards to no-till: '*You are much more reliant on herbicides than you were before'* [interviewee #2].

The implementation of these innovations commonly required the adaptation or purchase of machinery and equipment, and alterations to management practices. Often these innovations were implemented in a sequence of stages. Moving towards no-till is an example: the first stage is to retain stubble and crush or grazing it, subsequently trash floats are used to sow through stubble. This is followed by a move to direct drilling with the process completed by using auto-steer technology for inter-row sowing: *'There is a technology that matches each of the parts of the process involved in stubble retention'* [interviewee #1].

Table 4: Summary of complex innovations

	Innovation	Description	Perceived benefits	On-farm changes required
1	Stubble retention	Crop residue is retained and sown into. A direct drill method is used. Auto steer allows inter-row sowing.	Retained stubble has soil health benefits and reduces soil loss from erosion.	Machinery adjustments, machinery purchase, adjust fertiliser rates, disease carry-over to manage, increase row spacing.
2	No-till	Knocks down stubble with prickle chain then directly sows into it.	Improves soil structure, enables continuous cropping, can fatten lambs on stubble	Knocking down stubble with prickle chain & sowing into stubble. Modifying seeder to wider row spacing.
3	Auto-steer on machinery	GPS guidance system installed on machinery allowing implement to pass along the same line or offset.	Overcomes driver fatigue, allows for inter-row sowing, efficiencies in inputs.	Buy equipment, set up machinery, lease base stations.
4	Stubble mulching	Stubble is broken up and incorporated into the soil.	Benefits to overall farming system, particularly soil health.	Interviewee paid for design and make a stubble mulcher.
5	No-till	Zero till is used with single pass disc seeder that makes a small groove in the soil	Soil health benefits leading to healthy plants. Soil cover and structure improved.	Convert air seeder bar and add press wheels. Adapt machinery to auto-steer. Buy a disc seeder. Adopt procedures to manage stubble residue.
6	Direct drilling into stubble	Using direct drill sowing equipment to sow into stubble	Allows stubble to be retained, retains groundcover and protects from wind erosion.	Adapting existing equipment with trash floats.

Table 4 (continued): Summary of complex innovations

7	GPS guidance on the tractor/auto steer	See above (#3)	Allows more efficient application of inputs.	Buy equipment, set up machinery, lease base stations.
8	Auto steer	See above (#3)	Reduces driver fatigue, allows inter-row sowing, efficient applications of inputs	Significant financial cost to buy equipment, fit to machinery, set up base stations.
9	Controlled traffic	Where you attempt to put machinery on the same track as the previous time	More efficiency in application of inputs, less driver fatigue	Adapting all machinery (seeder, spray units, carts, header etc.). Modifying wheels. Setting up auto-steer.

Again, a number of themes emerged during the interviews in regard to these innovations. First, in some cases the innovations were not trialled but were evaluated extensively before adoption by, for example, seeing the innovation demonstrated locally: '*We moved straight into it* [no-till]. *We saw a neighbour and he was making money in the drought doing no-till*' [interviewee #5]; and '*It* [direct drilling] *was a big step at the time. We had it demonstrated on the property and thought it was good'* [interviewee #6].

Interestingly, the interviewees did not think complex innovations were necessarily revolutionary. This was because the innovation was, quite often, the final step in a series of incremental innovations: '*it's not really a breakthrough innovation. It was a change that evolved; it wasn't revolutionary. It wasn't just one invention'* [interviewee #2]; and '*It's an incremental benefit* [auto-steer]. *It just makes the job better. It's not a 'wow' innovation*' [interviewee #6].

Second, anticipated and anticipatory emotions played a role in the adoption of complex innovations. However, the apparently more extensive evaluation of complex innovations prior to adoption and the sequential, stepwise adoption process imparted confidence to the interviewees: '*I was confident it would work given the work we'd done looking at it'* [interviewee #1]; and '*In our TopCrop group we would go to field days. I got to be comfortable with it. There were a few of us who started to direct drill into burnt stubbles with our old combine. Then I had a combine converted to trash floats. Some crops would be direct drilled into burnt stubble and some drilled into fallow. It took about 7 to 8 years to make the shift to full stubble retention…but you don't lock yourself in*' [interviewee #2].

Introducing complex innovations over time was seen as sensible: '*You see a good idea, fiddle with it and introduce it over time when you are convinced it will work'* [interviewee #2]. It is also important to note that farmers didn't need to feel 'locked in' to no-till systems; they were still prepared to burn stubble when necessary.

In regard to anticipatory emotions, one interviewee felt confident in adopting the innovation because '*I had confidence in the people I was dealing with'* [interviewee #3].

A third theme with complex innovations was the requirement to develop new skills. In some cases these new skills were more familiarisation with the technology but in other cases the degree of reskilling was substantial: '*You absolutely had to have new practices and procedures'* [interviewee #2]; and '*It's a new language to learn, it's like using a computer'* [interviewee #3].

In several instances training or learning was seen as a gradual and continuing process: '*It progressively got more complicated. My experience took me through the* *process'* [interviewee #1]; and '*I had to change significantly what I was doing. The shift took ten years'* [interviewee #5]

Interestingly, several interviewees stated that the adoption of complex innovations had drawn on their previous experience: '*I still needed the experience of the other system'* [interviewee #5]; and '*Your experience is never obsolete'* [interviewee #6].

Fourth, many of the interviewees found it difficult to remember when they had introduced the innovation. In several cases this was because the innovation had not initially been implemented in full but had been adopted in stages: '*I still burn occasionally so it is not completely incorporated into the farm system. There are lots of technologies involved so it takes a while to fully implement something like this'* [interviewee #1]; and '*We'd been trying to find something* [that would mulch stubble] *for some time. We'd got 3 or 4 machines over a decade to try and do it*' [interviewee #4].

The effort devoted to decision-making was substantial and included speaking to the neighbour, going to seminars or field trials, and conducting substantial research on the innovation: '*There are some ideas you knock out straight away but then some things you want a technical expert on it. I read scientific papers. Then I want to talk to someone who has implemented it. I speak to scientists, then early adopters, then I find out the pitfalls'* [interviewee #6].

Overall, these results seem largely consistent with the suggestions made earlier in regard to the role of anticipated emotions and anticipatory emotions in the adoption of relatively complex innovations. The results are also consistent with more complex or radical innovations having a greater impact on the other sub-systems of the farm and requiring the acquisition of new competencies and knowledge. However, contrary to expectations the results indicate the current skills, knowledge and experience are not necessarily rendered obsolete by the adoption of complex innovations. One explanation for this may be that current skills, knowledge and experience are important to successfully integrate complex innovations with various farm sub-systems.

5.2 Quantitative analysis

To begin with we analysed the differences in the ratings given to the complex innovation and simple innovations identified by each interviewee by comparing the rating they gave on a characteristic for the complex innovation they chose with the rating they gave for the simple innovation they chose (Cooksey 1997). This analysis provided a method for detecting whether the interviewees consistently rated simple and complex innovations differently.

We then used correlation analysis to investigate associations among the characteristics of innovations including associations among types of innovations, anticipated emotions, anticipatory emotions and affect towards means.

Analysis by interviewee

In Figure 3 the average of the ratings the interviewees gave the simple and complex innovations for ease in trialling, ease in observing system improvement and type of technology change (incremental, revolutionary, breakthrough) are presented. The differences in average ratings were statistically significant for each of these characteristics except ease in trialling.[1] This confirms that interviewees had, from their perspective, identified and distinguished between innovations that were more and less complex.

In Figure 4 the average of the ratings the interviewees gave the simple and complex innovations with regard to the impact of the innovations on the architecture of the farm system are presented. The differences in average ratings were not statistically significant for any of these characteristics. We had expected that the ratings for changes to linkages and interactions in the farm system would be relatively higher for complex innovations than for simple innovations. This result may be explained if some of the simple innovations interviewees selected were more architectural in nature and not strictly incremental; and some of the complex innovations were more modular in nature and not strictly radical. There was some evidence to suggest this was the case (see Figure 13).

In Figure 5 the average of the ratings the interviewees gave the simple and complex innovations with regard to the benefits of the innovations are presented. The differences in average ratings were not statistically significant for any of these characteristics except the impact of the innovations on performance.[2] On average, complex innovations were rated more highly than simple innovations in promising a substantial improvement in performance.

[1] For trialling $t = 0.88$, $p = 0.41$; for ease of observing improvement $t = 4.40$, $p = 0.00$; for a minor improvement in technology $t = 4.64$, $p = 0.00$; for revolutionary technology $t = 4.40$, $p = 0.00$; and for breakthrough technology $t = 2.86$, $p = 0.02$.

[2] For a substantial improvement in performance $t = 3.41$, $p = 0.01$.

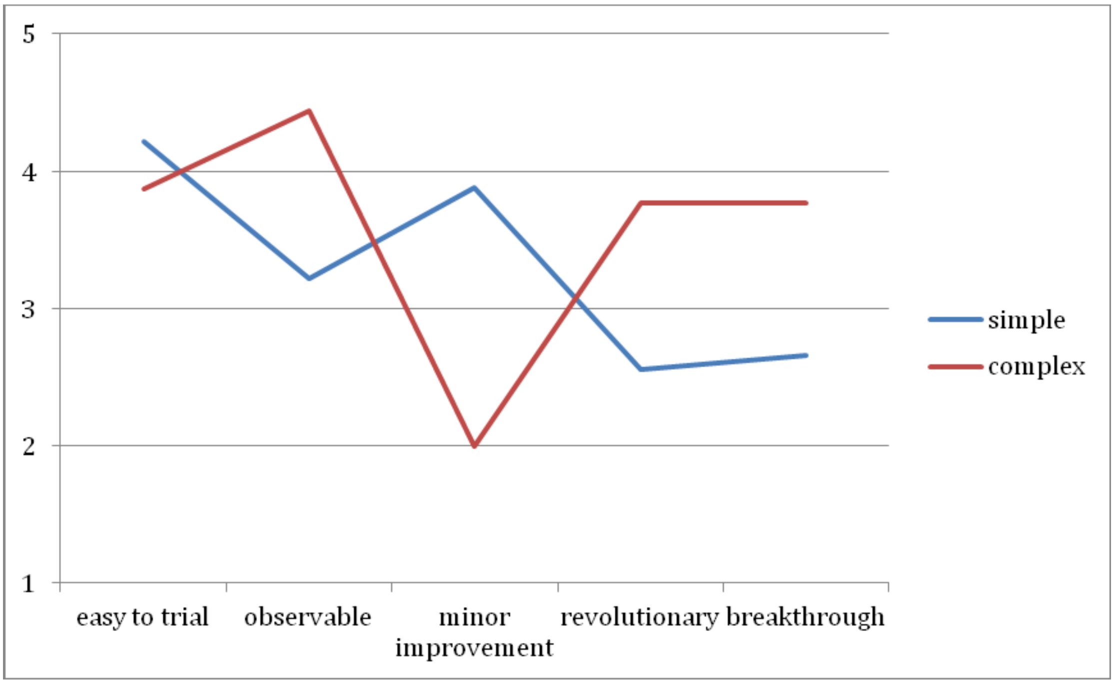

Figure 3: Profiles for type of technology change

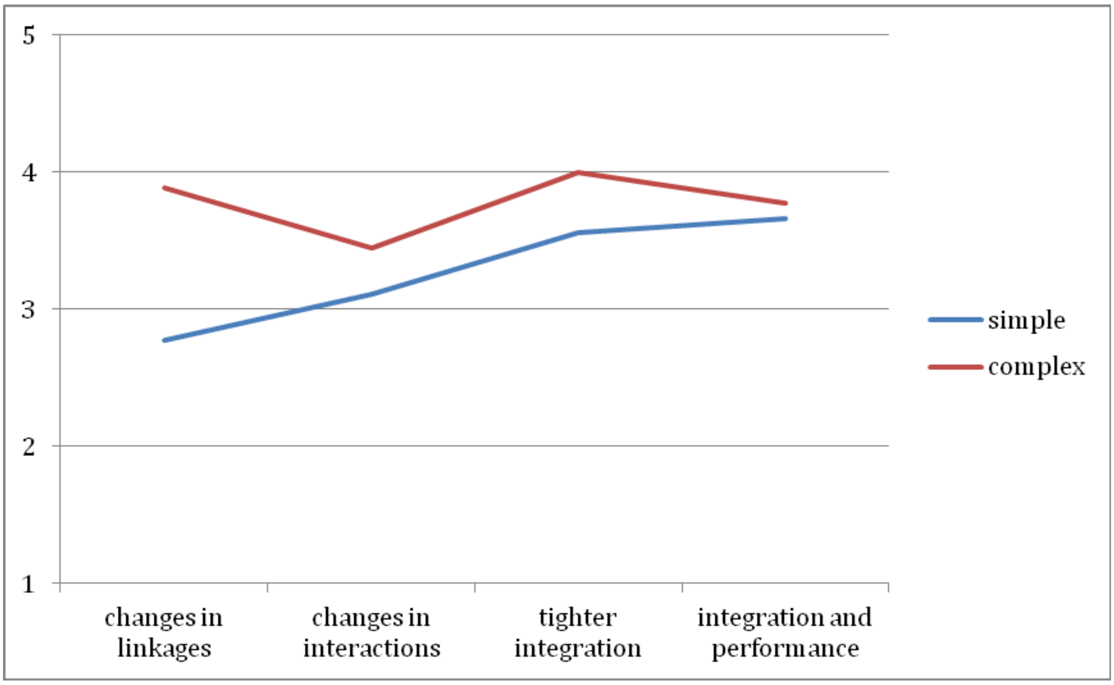

Figure 4: Profiles for impact on farm system architecture

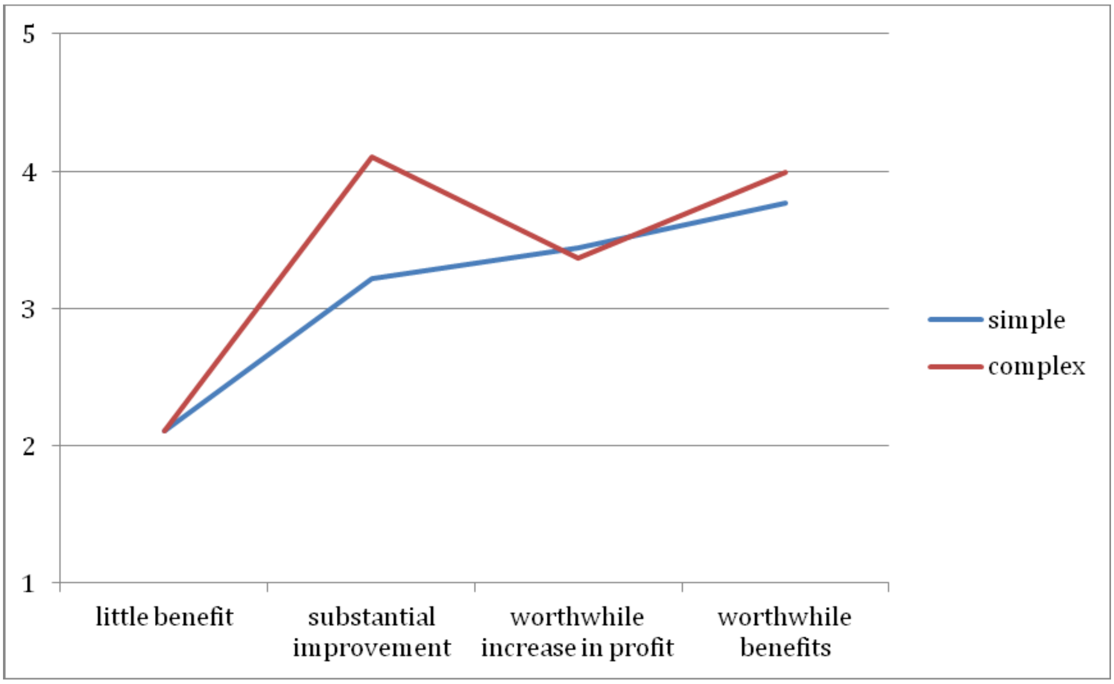

Figure 5: Profiles for benefits of innovations

Both types of innovations were rated equally in terms of offering worthwhile benefits and a worthwhile increase in profit.

On reflection, the similarity in scores for simple and complex innovations on these characteristics may mean that the use of the term 'worthwhile' was a poor choice in the statements for this scale. Common sense would suggest that a simple innovation that is relatively inexpensive might be worthwhile adopting for a relatively small benefit, whereas a complex innovation that is costly to implement might only be worthwhile adopting for a relatively large benefit. Hence, the benefits of adopting the innovations are worthwhile in both cases even though the scale of the benefits may differ substantially.

In Figure 6 the average of the ratings the interviewees gave the simple and complex innovations with regard to the need to learn and develop new skills, knowledge and practices are presented. The differences in average ratings were statistically significant for all of these characteristics.[3] This is consistent with the impressions gained from the interviews and other studies that have found that more complex innovations are more likely than simple innovations to require the acquisition of new knowledge and skills.

In Figure 7 the average of the ratings the interviewees gave the simple and complex innovations with regard to the extent to which their existing skills, knowledge and experience remained useful after they adopted the innovations are presented. The differences in average ratings were not statistically significant for any of these characteristics. This is consistent with the impressions gained from the interviews but is not consistent with other studies that have found that more complex innovations are more likely than simple innovations to render existing knowledge and skills obsolete. One explanation for these results may be that existing agricultural skills, knowledge and experience are required to integrate complex agricultural innovations into farm systems.

In Figure 8 the average of the ratings the interviewees gave the simple and complex innovations with regard to anticipated emotions are presented. The mean scores for each of the anticipated emotions were all statistically significant for simple and complex innovations indicating that these emotions were present in the adoption process. Notably, the averages are relatively high for many of the anticipated emotions. This is consistent with the proposition that such emotions may play an important motivational role in the adoption of agricultural innovations.

[3] For new concepts $t = 2.83$, $p = 0.02$; for new skills $t = 4.47$, $p = 0.00$; $t = 4.64$, for develop new skills $t = 3.16$, $p = 0.01$; for learn new knowledge $t = 2.53$, $p = 0.04$; for adopt new practices $t = 3.04$, $p = 0.02$; and for retraining $t = 3.78$, $p = 0.01$.

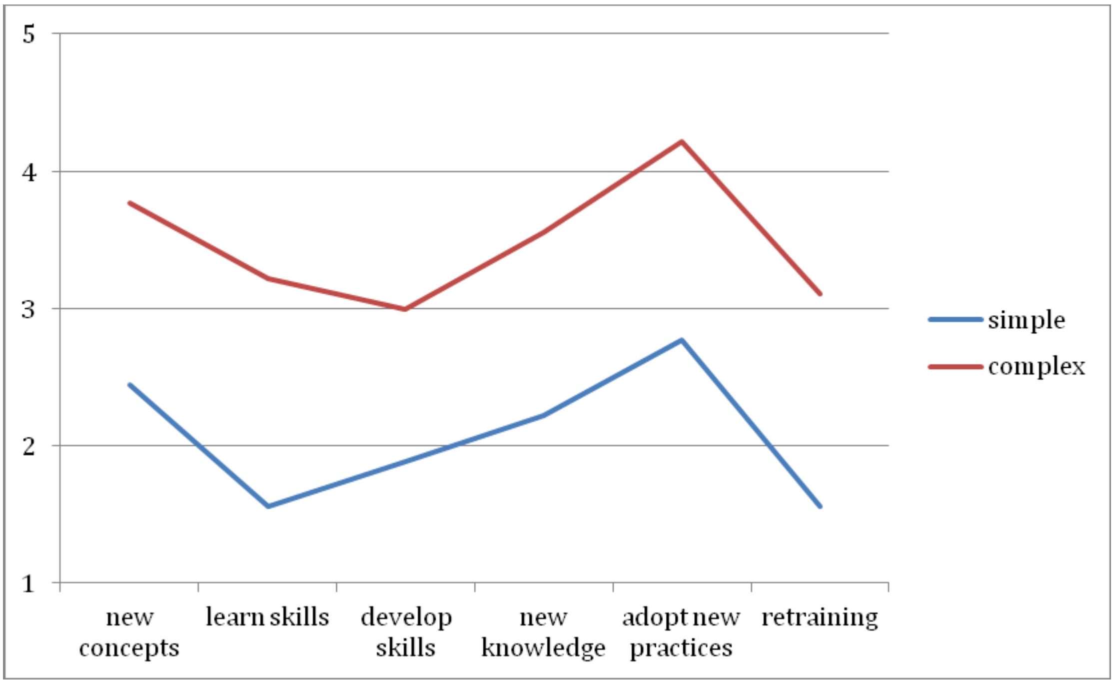

Figure 6: Profiles for current skills, knowledge and experience

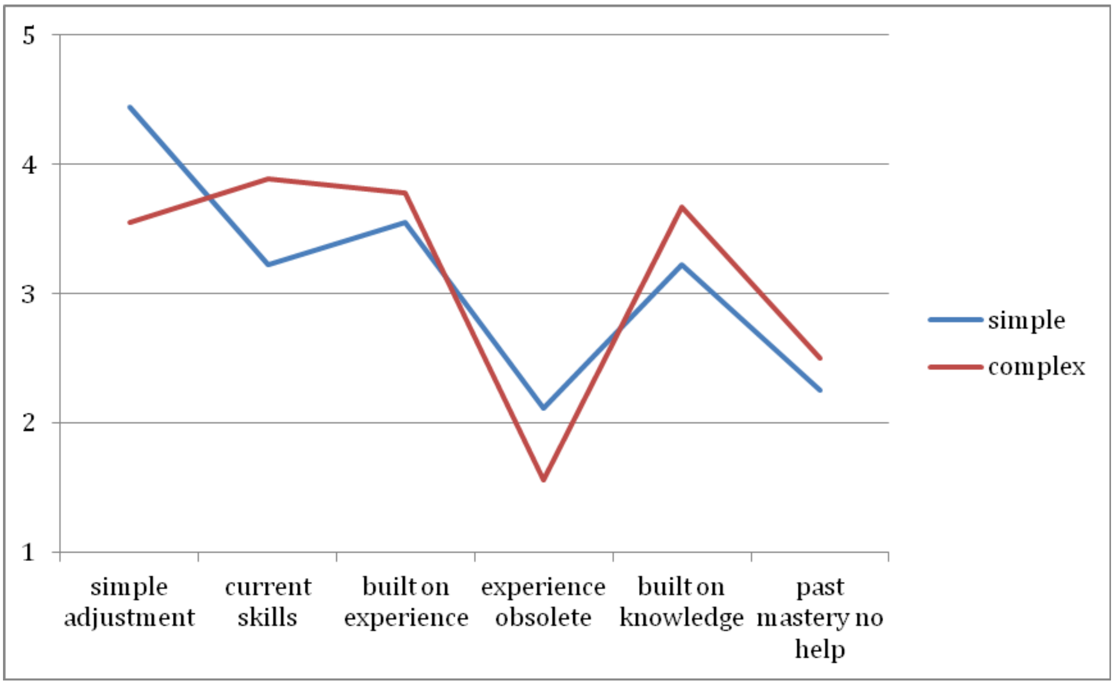

Figure 7: Profiles for new skills and knowledge

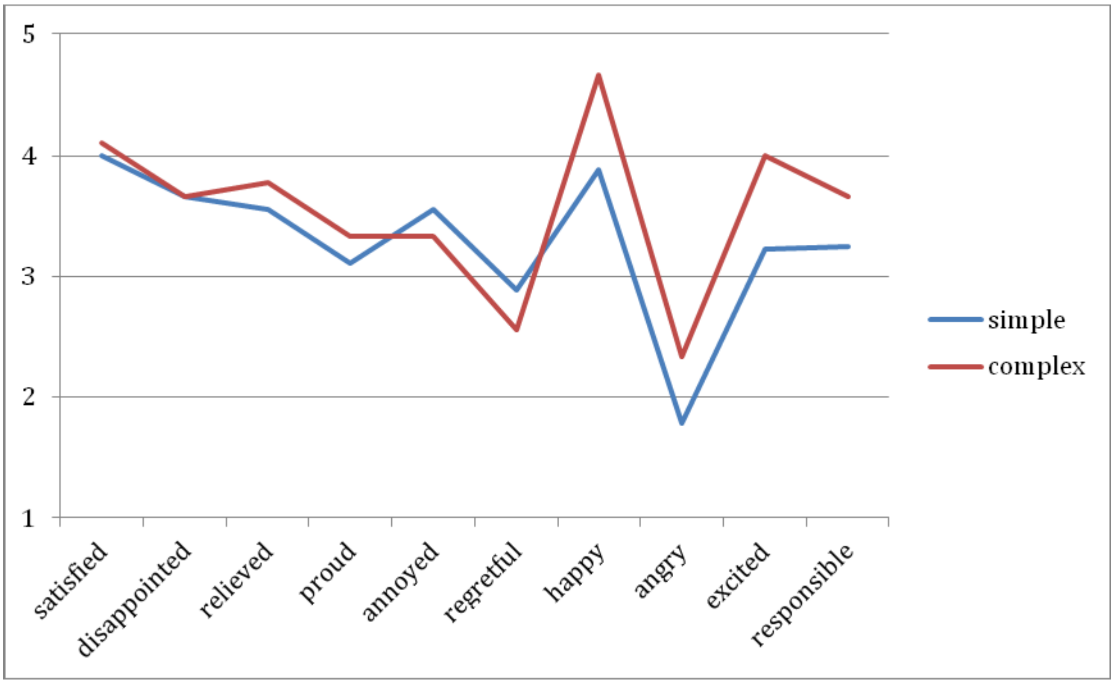

Figure 8: Profiles for anticipated emotions

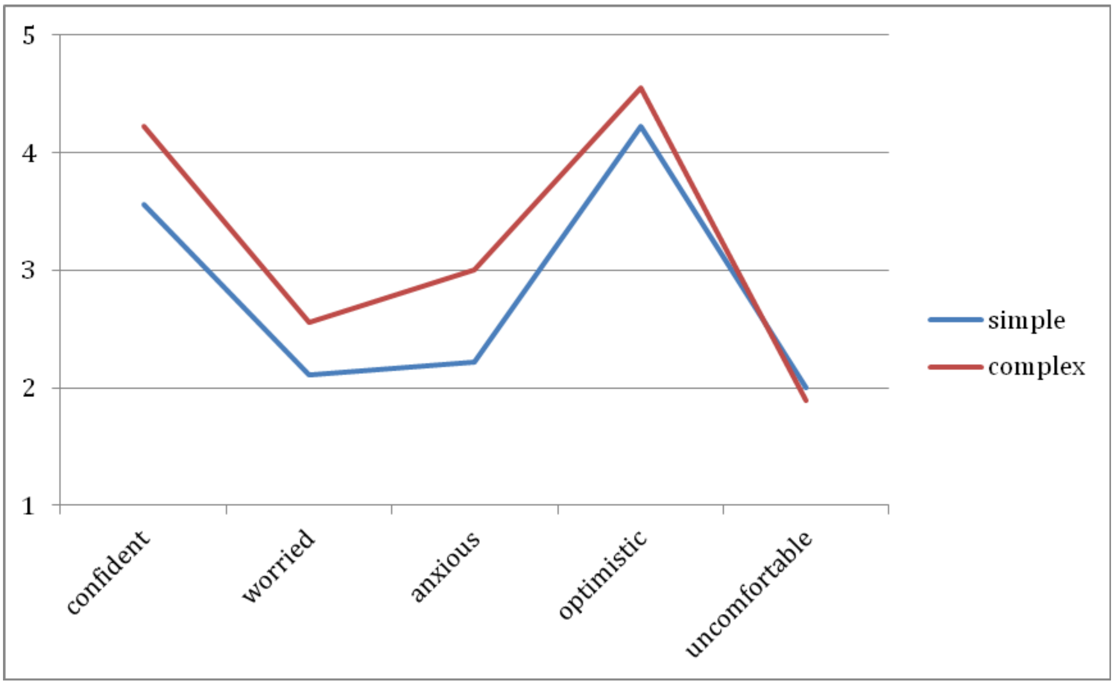

Figure 9: Profiles for anticipatory emotions

The differences in average ratings were not statistically significant for any of the anticipated emotions except for anticipating being excited by success.[4] We had expected that the ratings for anticipated emotions would, on average, be relatively higher for complex innovations than for simple innovations.

Inspection of the profiles suggest that differences in the ratings of simple and complex innovations may be more likely for relatively stronger emotions (anger, happiness, excitement) than for relatively weaker emotions (disappointment, satisfaction). This pattern of results might arise if some of the simple innovations interviewees selected were more architectural in nature and not strictly incremental; and some of the complex innovations were more modular in nature and not strictly radical. This would obscure any differences in the importance of anticipated emotions in the adoption of simple and complex innovations.

In Figure 9 the average of the ratings the interviewees gave the simple and complex innovations with regard to anticipatory emotions are presented. The mean scores for each of the anticipatory emotions were all statistically significant for simple and complex innovations indicating that these emotions were present in the adoption process. The averages are relatively high for confidence and optimism about changing to the innovation but relatively low for worry and anxiety. This is consistent with the proposition that such emotions may play an important motivational role in the adoption of agricultural innovations.

The differences in average ratings were not statistically significant for any of the anticipatory emotions. We had expected that the ratings for anticipatory emotions would, on average, be relatively higher for complex innovations than for simple innovations. Again, this pattern of results might arise if some of the simple innovations interviewees selected were more architectural in nature and not strictly incremental; and some of the complex innovations were more modular in nature and not strictly radical. This would obscure any differences in the importance of anticipatory emotions in the adoption of simple and complex innovations.

In Figure 10 the average of the ratings the interviewees gave the simple and complex innovations with regard to affect towards means are presented. The mean scores for each of the affects were all statistically significant for simple and complex innovations indicating that these emotions were present in the adoption process. The averages are relatively high for satisfaction, happiness, excitement and liking the means about changing to the innovation and relatively low for disliking, regretting or being angered by the process of change. This is consistent with the proposition that such emotions may play an important motivational role in the adoption of agricultural innovations.

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[4] For a excitement at success $t = 2.81$, $p = 0.02$.

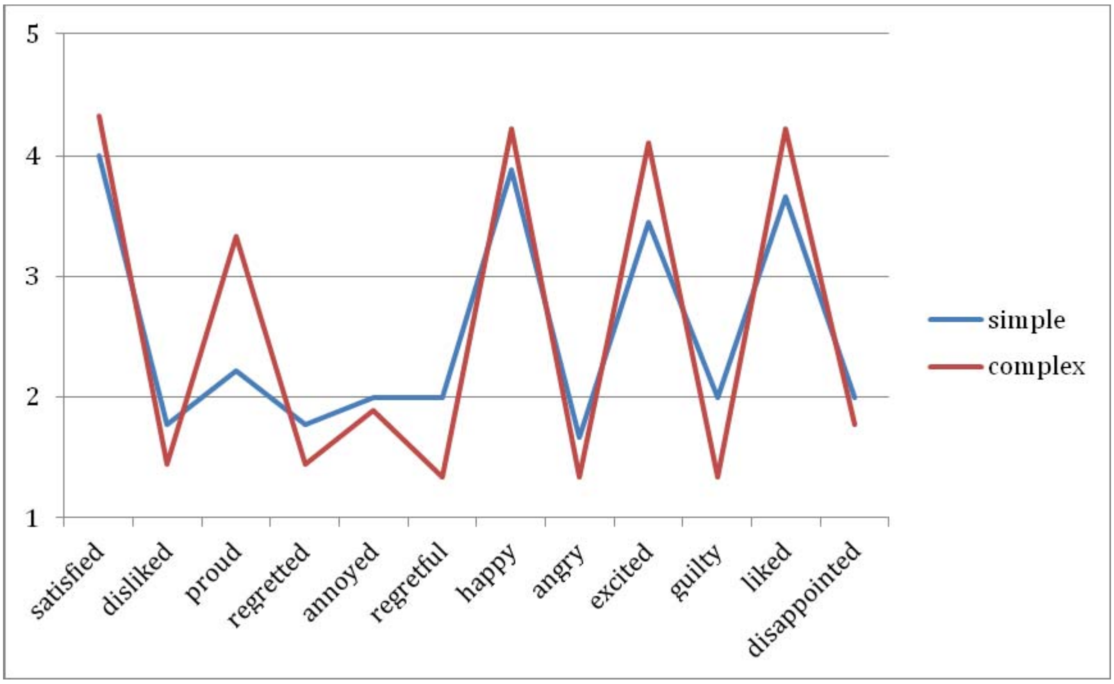

Figure 10: Profiles for affect towards means

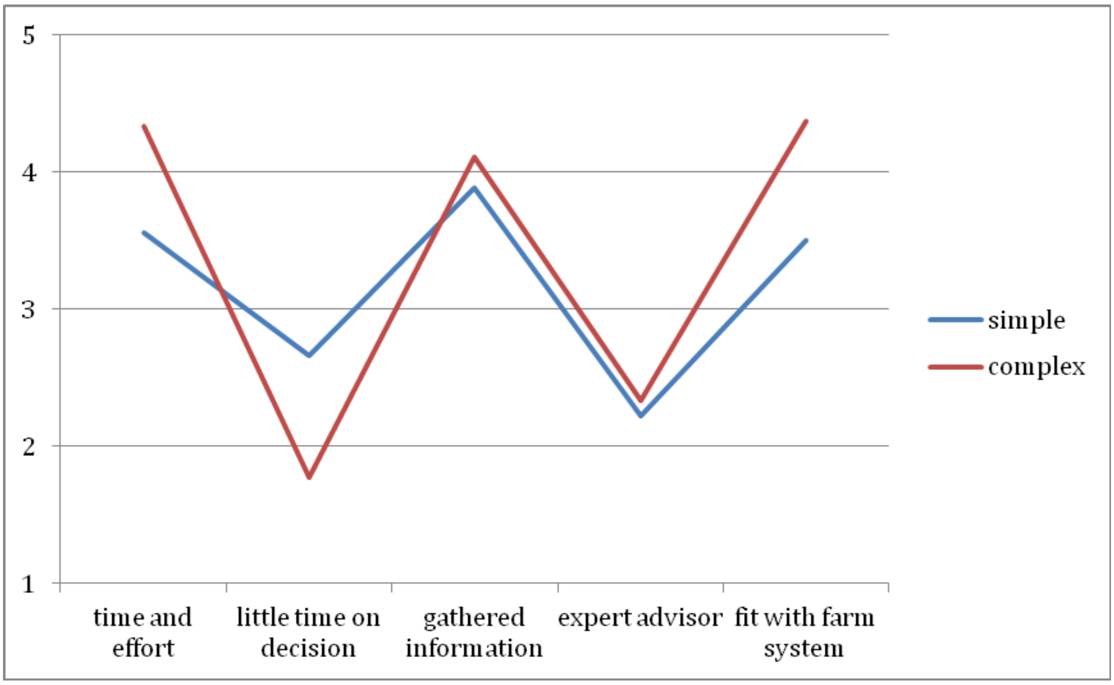

Figure 11: Profiles for decision effort

We had expected that the ratings for affect towards means would, on average, be relatively stronger for complex innovations than for simple innovations. The differences in average ratings were statistically significant for being proud, regretting and liking the process of change. This is consistent with the proposition that affect towards means may play an important motivational role in the adoption of complex agricultural innovations in particular.

In Figure 11 the average of the ratings the interviewees gave the simple and complex innovations with regard to time and effort devoted to the adoption decision are presented. We had expected that the ratings for decision effort would, on average, be relatively higher for complex innovations than for simple innovations. The differences in average ratings were not statistically significant except for time and effort thinking about how the innovation would fit into the farm system.[5] This result provides some support for the proposition that the adoption of complex agricultural innovations is more likely to invoke extensive decision-making (Assael 1998).

Finally, in Figure 12 the average of the period, in months, the interviewees gave for deciding to try and then adopt simple and complex innovations are presented. As expected that the time taken from first hearing of an innovation to deciding to try it was longer than complex innovations than for simple innovations. While the time taken from trialling to deciding to replace current technology or practice with the innovation was reported to be longer, on average, for complex than for simple innovations this result was not statistically significant.[6] This result may reflect the greater time and effort devoted to evaluation of complex innovations prior to trial. Furthermore, for some innovations interviewees reported that the boundary between trialling an innovation and deciding to implement the innovation was not necessarily clear. In some cases interviewees regarded trialling as including the process of modifying and adapting the innovation following the decision to implement the innovation.

In conclusion, the results presented here indicate that interviewees were able to correctly identify and distinguish simple and complex agricultural innovations. Complex innovations were more likely than simple innovations to require learning of new skills and competencies but current farming skills, knowledge and experience appeared equally useful in the adoption of both types of innovations. There was some evidence to suggest that complex innovations were expected to offer greater improvements in performance and were evaluated for a longer period before trialling.

[5] For time and effort thinking about advantages and disadvantages $t = 1.67$, $p = 0.13$; for little time on decision $t = 1.84$, $p = 0.10$; $t = 4.64$, for spent great deal of time gathering information before making a decision $t = 1.00$, $p = 0.35$; for relying entirely on an expert advisor $t = 0.21$, $p = 0.84$; for spending time and effort thinking how to fit in farm system $t = 2.97$, $p = 0.02$.

[6] For months from hearing of an innovation to deciding to trial $t = 3.68$, $p = 0.01$; for time from trial to replacing existing technology or practice with the innovation $t = 2.07$, $p = 0.07$.

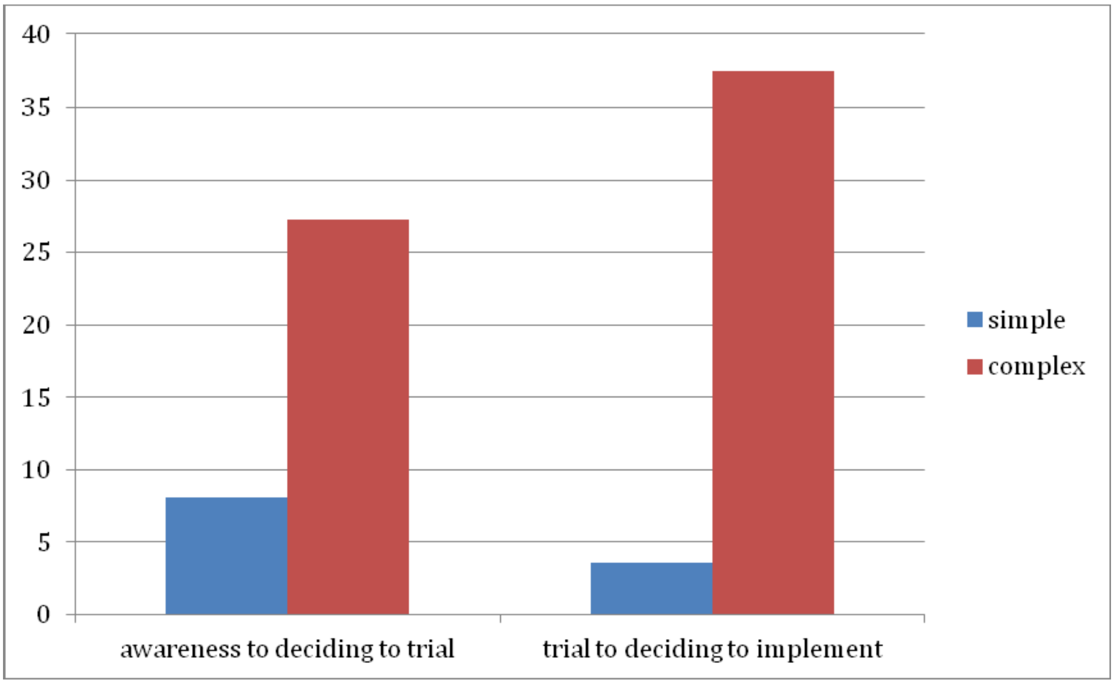

Figure 12: Mean time to trial and to implement innovations (months)

Table 5: Scale reliabilities

Scale	Items	Reliability
Innovation type	3	0.67
Need for new skills	6	0.87
Impact on existing skills	6	0.71
Impact on farm system architecture	4	0.86
Impact on performance	3	0.70
Decision effort	4	0.83
Anticipated emotions	9	0.86
Anticipatory emotions	3	0.67
Affect towards means	11	0.91

The results also provide support for the proposition that anticipated emotions, anticipatory emotions, and affect towards means may play a role in the adoption of agricultural innovations. This proposition is investigated further below.

Analysis by innovation

Correlation analysis was used to investigate associations among the characteristics of innovations including associations among types of innovations, anticipated emotions, anticipatory emotions and affect towards means.

Prior to conducting the analysis the reliability of the scales used in the interviews was investigated. The scales were for the impact of the innovation on farm performance, anticipatory emotions, affect towards means and decision effort were found to contain items with ratings that showed exceptionally low correlations with the ratings of the other items in the scale. These uncorrelated items were excluded from the subsequent analysis. The reliabilities of the resulting scales, which were judged to be satisfactory, are reported in Table 5.

In Table 6 the correlations between the scales are reported. Inspection of the table reveals first, that innovation type is correlated with the anticipated emotions and affect towards means. This result supports the proposition that these factors influence goal setting and therefore the motivation to adopt an innovation. This result also suggests that, relatively speaking, these factors may be more influential in regard to complex innovations than simple innovations. The results also reveal that, as expected, innovation type is correlated with the need for new skills and knowledge, and decision effort.

Inspection of the table shows that, as expected, anticipated emotions, anticipatory emotions and affect towards means are correlated with each other. This suggests that the stronger the emotional involvement of interviewees in anticipating the success or failure of adopting an innovation, the stronger their emotional involvement in the adoption process and the emotional involvement provoked by the chance of failure.

The results show that there is a statistically significant association between affect towards means and the type of innovation and the need for new skills as well as anticipated and anticipatory emotions. These results suggest that interviewees' emotional involvement in the process of adoption may be influenced by the need to acquire new skills and knowledge.

Table 6: Correlations between scales

Scale	Correlations								
Innovation type	–								
Impact on farm architecture	0.46	–							
Need for new skills	0.58*	0.49*	–						
Impact on existing skills	0.15	0.57*	0.11	–					
Impact on performance	0.34	0.19	0.08	0.08	–				
Decision effort	0.63*	0.78*	0.43	0.51*	0.28	–			
Anticipated emotions	0.51*	0.25	0.27	0.04	0.43	0.39	–		
Anticipatory emotions	0.39	−0.24	0.10	0.10	0.29	0.14	0.60*	–	
Affect towards means	0.52*	0.33	0.50*	0.31	0.37	0.44	0.77*	0.55*	–

Note: * denotes statistical significant association (p=0.05).

In the literature simple innovations tend to build on current skills, knowledge and experience while complex innovations tend to render current skills, knowledge and experience obsolete. This suggests there should be a negative correlation between ratings for type of innovation and ratings for the continued usefulness of current skills. We did find this to be the case. However, the results show that there is a statistically significant association between the continued usefulness of current skills, the impact of the innovation on farm architecture, and decision effort.

This raises the possibility that the implementation of more complex innovations depends on current skills, knowledge and experience because these are critical to successfully integrating complex innovations into the existing farm system. This would explain the absence of a negative correlation between ratings for type of innovation and ratings for the continued usefulness of current skills.

Earlier the possibility was raised that the innovations the interviewees had chosen may be a mix of incremental, modular, architectural and radical innovations and that, if this was the case, such a mix could mask differences between apparently simple and complex innovations. This possibility was investigated by comparing the placement of innovations in component-relationship space. This was achieved by using multi-dimensional scaling (Kruskal and Wish 1991) to map the similarity in innovations using ratings on the scales representing innovation type and impact on farm architecture.

The results of the multi-dimensional scaling analysis are shown in Figure 13 in which each innovation appears as a point in a map where the axes are the relative change in components and relationships based using average scores from the type of innovation and impact on architecture scales respectively, as proxies. The location of the axes was obtained using the regression procedure described by Kruskal and Wish (1991). The red points indicate innovations that interviewees nominated as simple while complex innovations are indicated by the blue points. Inspection of the map reveals that simple innovations included both incremental and architectural innovations while the complex innovations included both radical and modular innovations. This overlap in types may have obscured differences in the characteristics of complex, radical innovations and simple, incremental innovations.

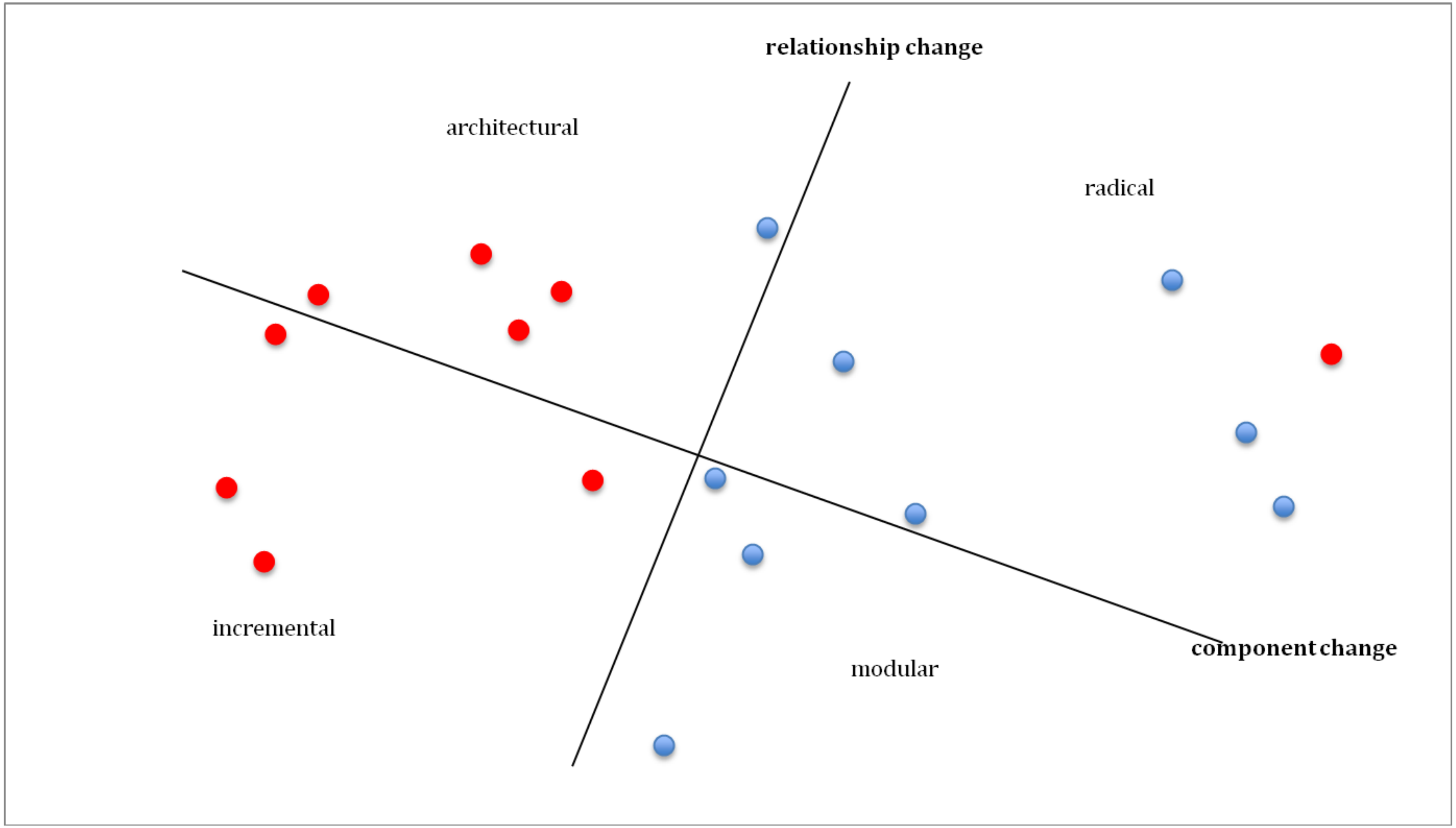

Figure 13: Mapping of innovation types

In conclusion, the results presented here provide support for the proposition that anticipated emotions, anticipatory emotions, and affect towards means may play a role in the adoption of agricultural innovations. The results support the proposition that the adoption of more complex innovations is associated with the stronger expression of anticipated emotions and affect towards means. The results also suggest that while the adoption of complex innovations is likely to require the acquisition of new skills and knowledge, the need to integrate innovations into the existing farm system means current skills, knowledge and experience continue to remain useful. There was also evidence to suggest that greater effort and time was devoted to decision-making about complex innovations, especially where the adoption of these innovations changed the architecture of the farm system.

Finally, there was evidence to suggest that interviewees had included architectural innovations in the set of simple innovations and modular innovations in the set of complex innovations. This overlap in innovation types may have obscured to some degree differences in the characteristics of complex, radical innovations and simple, incremental innovations.

6. Discussion

Predicting and estimating the extent and rate of adoption is central to assessing the benefits to be had from research into agricultural innovations and evaluating the success of marketing and extension programs. Maximising returns from investing in research and extension requires:

> *... contemplation of the factors that would favour speediest diffusion, thereby removing extensive weighing of decisions or delays in striving to adopt. That is, what determines the time span of total market uptake? What lends urgency to the adoption of an innovation? What motivates, rather than justifies, adoption? What prompts high attention to the possibility of adopting an innovation?*
>
> Wright (2011: 27)

Consequently, predicting rates of adoption and how they might be influenced requires an in-depth, detailed understanding of the adoption process. After reviewing the literatures on consumer and organisational purchasing Wright (2011) concluded that the dual-process models of consumer decision making proposed by Bagozzi (2006a) would be most suitable for modelling adoption decisions by producers, and subsequently rates of adoption, as these are the most comprehensive.

In the dual-process models goal desire plays the key role in determining the urgency that is attached to an adoption possibility. In these models goal desire is influenced by anticipated emotions, anticipatory emotions, and affect towards the means of achieving goals. Wright (2011) argued the influence of these factors would depend on the type of innovation under consideration: incremental, modular, architectural or radical (Henderson and Clark 1990). These factors may be relatively trivial in the case of incremental and modular innovations but critically important in the case of architectural and radical innovations.

Four main findings emerge from the results. First, we found that anticipated emotions, anticipatory emotions and affect towards means were present in the adoption of process for both simple and complex innovations. Also, as hypothesised, we found a significant positive correlation between the strength of anticipated emotions, affect towards means and the type of innovation indicating that the relative strength of these emotional factors is increases with the complexity of innovations. This is consistent with the proposition that the adoption of more complex innovations requires correspondingly greater levels of motivation than less complex innovations. As a consequence, the adoption of more complex innovations such as architectural and radical innovations may be more susceptible to delay because of insufficient motivation. In such instances, the role of extension agents is to increase, if possible, the motivation of producers to consider adopting the innovation. This would require knowledge of the root cause of the lack of motivation.

Second, we found significant positive correlation between the strength of anticipated emotions, anticipatory emotions and affect towards means. This result raises the possibility that one or more of the factors that influence these emotions, such as perceptions of relative advantage, may be common to all. Alternatively, these emotions may interact directly. Strong, positive anticipated emotions may, for example, result in more favourable evaluations of affects towards means than might otherwise be the case. In either case this means that, in the right circumstances, goal setting might be responsive to extension efforts. Consequently, extension may influence the rate of adoption via two routes: by contributing to goal setting and by facilitating goal striving.

Third, we found that there were significant positive correlations between the type of innovation and the need for new skills and decision effort. We also found that complex innovations were evaluated for a significantly longer period than simple innovations prior to adoption. These results were consistent with the literature and highlight that the rate of adoption of complex innovations will be inherently slower, on average, than the rate of adoption of simple innovations. This implies classifying innovations into types; incremental, modular, architectural and radical, is useful in predicting the rate of adoption of an innovation. This knowledge will also be useful for anticipating the information and training needs of producers as previously suggested by Kaine et al. (2008).

Fourth, the qualitative and statistical results indicate that current skills, knowledge and experience were useful in the adoption of complex as well as simple innovations; this result is not consistent with other studies. Significant positive correlations were found between the impact of the innovation on the architecture of the farm system, the usefulness of current skills, knowledge and experience, and decision effort. This suggests that, unlike manufacturing industries, current knowledge and experience is vital in the task of realigning farm sub-systems when integrating more complex innovations into a farm system. This finding highlights the potential for delay in the adoption of architectural and radical innovations because integration of these more complex innovations requires greater effort, both in goal setting and goal striving, than does the integration of incremental innovations.

Overall, the results reported here suggest that the dual-process model (Bagozzi 2006a) suggested by Wright (2011) shows promise as a means for predicting the rate of adoption of agricultural innovations and for providing guidance as to how rates may best be influenced. Further research along a number of lines could be conducted that would build confidence in the findings reported here and establish the merit of the dual-process model.

First, the scales describing anticipated emotions, anticipatory emotions, and affect towards means and the scales describing the different types of innovations need development and validation. Second, the analysis should be repeated with a suitably large sample.

Third, the role of personality predispositions and social identity that influence goal setting could be explored as these factors influence anticipated emotions, anticipatory emotions, and affect towards means directly and the formation of behavioural intentions.

Finally, the predictions of the dual-process model could be validated against actual data on the rate of adoption of agricultural innovations where satisfactory information on the population of potential adopters is available.

7. Conclusion

In this paper we reported on a preliminary investigation into the associations between type of innovation and anticipated emotions, anticipatory emotions, and affect towards the means. Qualitative and quantitative data in relation to these variables were collected from a small sample of grain farmers in the Wimmera and southern Riverina. The results indicated there were significant associations between the complexity of an innovation and measures of the strength of anticipated emotions, anticipatory emotions, and affect towards the means.

The results indicate that goal desire can play an important role in the rate with which agricultural innovations are adopted. They also indicate that the dual-process model shows promise as a method for predicting the rate of adoption of agricultural innovations. Furthermore, unlike other models in the literature, the dual-process model has the potential to provide a rich description of the factors influencing the rate of adoption of innovations and, as a consequence, provide guidance as to how rates may best be influenced.

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