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The psychological factors that influence successful technology adoption in the oil and gas industry.

ROBERTS, R., FLIN, R.

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The psychological factors that influence successful technology adoption in the oil and gas industry.

Ruby Roberts & Rhona Flin
Aberdeen Business School, Robert Gordon University, Aberdeen, Scotland.

To ensure that the full potential of innovative technology is maximised, it is crucial to understand the psychological factors that influence technology adoption in all industrial consumers. The oil and gas (O&G) industry exemplifies industrial consumers' reluctance to adopt new technology. Our critical incident interviews identified the key psychological factors that influence technology adoption in the O&G industry. These were personality (innovativeness and risk aversion), attitudes (trust, motivations, "not invented here" syndrome and "engineering mindset"), social (subjective norms and self-image), cognitive (risk perception, uncertainty and familiarity, expertise, and previous experiences) and organizational level factors (leadership, management, organisational culture, adoption culture, and rewards system). In combination with future case studies, these results can be used to develop interventions that support the successful introduction and acceptance of new technology not only in O&G but in other high-risk sectors.

INTRODUCTION

New technology continues to change the face of the modern workplace. Yet, businesses, organizations and industrial consumers can be reluctant to adopt new technologies, despite the outward benefits (Makkonen, Johnston, & Javalgi, 2016). Psychological barriers to introducing new technology in industry include mangers' resistance to prototypes being trialed on their worksites, their concerns about being an early adopter if there could be productivity risks, as well as end-users' reluctance to change familiar ways of working.

An industry that exemplifies this problem is the oil and gas (O&G) business. O&G utilizes a wide range of technology in its everyday business from complex hardware, remote monitoring and analytics software to drone technology for seismic surveys. Understanding how these psychological factors influence technology adoption in industrial consumers is vital to support the successful introduction and adoption of new products not only in O&G but in the broader market (e.g. automation).

The O&G industry faces many challenges, such as accessing increasingly complex and remote oil reserves (Perrons, 2014), the need to automate high-risk, error-prone tasks, and the future challenges of decommissioning (Hassani et al, 2017). To remain competitive, it needs to embrace technological innovation but has a reputation for being conservative and slow to uptake new inventions (Perrons, 2014). Companies who are slow to uptake technology are commonly referred to as "fast followers" (Daneshy & Donnelly, 2004) as opposed to early adopters.

It has been argued that the O&G sector has a set of special characteristics that can hinder the introduction of technology (Roberts & Flin, under review). These include the extreme risks of failure, combined with the high cost of being a first user, resulting in an uncollaborative culture in which companies race to be second. This can be characterized in the sector's "slow clock speed" in which the uptake of new technology can take up 16 years to have widespread industry adoption (Noke, Perrons, & Hughes, 2008).

These factors have the potential to create a hostile environment for the introduction of new technology. Despite significant efforts to improve the technology adoption process (e.g., government- and industry-backed accelerator/incubator programmes and increased R&D spending (Thuriaux-Aleman, Salisbury & Dutto, 2010)), there is still a need to understand the underlying factors that influence the successful adoption of innovative technology.

Technology adoption in Oil and Gas

Despite its relevance, there is a limited body of work examining the psychological factors that influence technology adoption in upstream O&G. Evidence from O&G industry bodies indicate that psychological factors play a key role in technology adoption, such as risk aversion (Wood Review, 2014), lack of ownership and leadership around technology (OGTC, 2018), with an attitude that is reluctant to change (OGA, 2018).

A recent literature review (Roberts & Flin, under review) provides insight into the psychological barriers that can hinder technology uptake in the upstream O&G sector. Personality (risk aversion, exploration traits), attitudes (trust and 'not invented here' syndrome), social (social norms and self-image), cognitive (risk perception), and organisational issues (leadership and organizational culture) were identified as key influencing factors. It was also suggested that insufficient access to reliable information sources and expertise may result in a poor technical backbone that negatively impacts on subsequent risk perceptions within O&G (Daneshy & Bahorich, 2005).

However, only a handful of psychological factors has been empirically studied within O&G to date. Furthermore, many of the articles reviewed by Roberts and Flin (under review) typically took an organisational perspective, discussing organisational factors and organisational intervention

approaches, rather than addressing the attitudinal, personality or cognitive factors.

STUDY AIM

The aim of this study was to identify the underlying psychological factors that influence the introduction of new technology within the UK upstream oil and gas industry, including both facilitators and barriers.

METHOD

Procedure. The co-authors from the sponsoring organization invited relevant technology innovation personnel to take part and the first author then arranged interviews with those who agreed. Face to face, Skype and phone interviews were conducted (December 2018-February 2019). With the permission of the interviewees, they were audio recorded and transcribed for analysis.

Sample. In total, 30 interviews were conducted. All interviewees had direct experience in technology innovation in the oil and gas industry with a range of 3 to 35 years. The sample consisted of leadership, senior and middle management, technology development, technology adoption consultants, start-up companies and end-users with a broad range of backgrounds and experience in technology adoption. Approximately half of the interviewees had experience working outside of the United Kingdom Continental Shelf (UKCS) and a third had experience working in other industries (e.g. metals, manufacturing, and IT). After 30 interviews, data saturation was reached (Glaser & Strauss, 1967).

The average interview length was 45 minutes with a range of 40 minutes to 70 minutes. The total interview time was 23 hours and 25 minutes.

Interview Schedule. In order to examine key decisions about adoption, Flanagan's (1954) critical incident method was adapted, along with Klein, Calderwood and Macgregor's (1989) Critical Decision Method with reference to the psychological factors discussed above (Roberts & Flin. under review). This approach was selected as the literature review had identified that new technology must pass through several stage gates which typically consist of individuals decision making around the new technology. This method can examine these decision-making strategies and the output may be valuable for developing subsequent intervention tools. The interview schedule was piloted with several technology innovation managers. First interviewees were asked a set of general questions about their roles and experiences in relation to technology adoption in O&G, as well as the psychological factors that can impact on successful introduction of technology. They were then asked to briefly describe a technology that they had been involved in developing, deploying or adopting. The interviewer then asked a set of probing questions about this event, such as what difficulties they faced, how they overcame them, and what they would do differently. Interviewees were encouraged to discuss examples of both successful and unsuccessful introductions of technology.

Data Analysis. The transcribed interviews were analyzed using an adapted version of Braun & Clarke's (2006) Thematic Analysis via the software program Nvivo 11 (QSR International, 2013). This is a structured method for identifying, analyzing and reporting themes within the interview content. This process followed an inductive, content analysis method to identify the underlying psychological factors that impact on technology adoption in the UKCS. An initial coding framework was developed iteratively during the familiarization of the interview data.

Inter-rater reliability (IRR) will be undertaken using Cohen's (1960) kappa coefficient (Fleiss, 1981). A sample of 6 interview transcripts selected from the full set will be cross-coded.

Ongoing examination of the data will uncover further detail and establish the weightings of the themes identified. A more in-depth discussion of the results will be given during the presentation.

PRELIMINARY RESULTS

In total, 17 themes were identified during the interview analysis within five overarching categories: personality, attitudes, social, cognitive and organizational level factors. These were identified as influencing the introduction of new technology into the UKCS oil and gas industry. In the main these themes reflected the themes identified within the previous O&G literature review (Roberts & Flin, under review) and the broader research. However, the results provide enhanced detail of the themes, sub-themes and how they interact within the O&G context. The themes and sub-themes are shown in Table 1, with working definitions and illustrative quotes.

Personality differences were discussed as impacting on the introduction of new technology. Individual differences in innovativeness (i.e. the willingness to try new things) and risk aversion were perceived to influence the introduction of new technology. In particular, leadership and senior managers' characteristics were identified as key influencing factors – those who had backgrounds in technology, were perceived to be innovative and enthusiastic towards innovation, tended to support new technology through resources and more communication, compared to those who were perceived as risk averse and unwilling to try new methods of working.

A positive **attitude** in which technology is perceived to add value to the business unit, company/firm or industry was discussed as a key driver for supporting technology from senior leadership to end-users. This attitude conflicts with the perspective that we have always done it this way and so do not need to change – "we will survive, the old way of working is good enough" (I2). **Motivations** and personal agendas, such

as concerns over job security, career progression and department budgets were also perceived as influencing attitudes towards piloting or introducing new technology. The attitude of "**the fear of failure is one of our worst barriers"** and may be driven by expectations, organizational culture and leadership.

The idea of the **"engineering mindset"** was discussed frequently. It represented an attitude towards technology in which an individual erroneously believes that they know enough information about a technology, so are unwilling to learn about or try out new a technology. Consequences include poor decisions being made around trialing or adopting new technology as based upon attitudes, perceptions of risk and uncertainty (see below). The **"not invented here syndrome"** was also perceived as a possible hinderance to new technology, requiring early engagement and creating a sense of ownership to get over this barrier.

Trust is a key factor in technology adoption. Trust between developers and potential clients is important for the decisions over piloting, partial deployment and full deployment as well as trust between end-users and managers for the final acceptance and use of the product. Building a sense of trust is crucial for collaboration with much of the innovative technology being developed through joint venture and other forms of collaboration. Risk is associated with **collaboration**, particularly around intellectual property rights, making trust between stakeholders fundamental for success – "they were fearful of sharing anything because this was going to be their money maker" (I1).

Social norms around new technology and existing practices were found to influence how individuals responded to new technology. Peer influences, such as not being able to speak out or ask questions about a technology or product that you do not know about were found to hinder technology introduction. **Self-image** and reputation were perceived as influencing attitudes and decisions towards new technology. A fear of losing face or reputation could result in a hostile attitude towards a new technology.

Several cognitive factors were found to influence deployment and adoption decisions. **Risk perception** was frequently discussed throughout the interviews as a key influencing factor. Risks included loss of reputation, financial and safety consequences if the technology fails as well as job security. New technology is often associated with uncertainty (e.g. how it will work, and if it will work, what will the direct and indirect consequences be). Developers discussed how to build credibility and trust through increased **familiarity** to reduce perceptions of uncertainty and risk. **Expertise**, or the lack of, was perceived to be closely linked to risk perceptions and uncertainty – without sufficient expertise, accurate risk perception was hindered. Positive or negative **previous experiences** with new technology would also influence attitudes and decisions around it.

Organizational culture plays a significant role in the whole process of how new technology is introduced and adopted. Developing a **technology adoption culture** that is receptive to technology includes understanding **how technology is valued** and perceiving it to be a part of organizational priorities, strategy and the core business. This includes having a culture in which there is a "the freedom to fail" (I1), making it acceptable for some technologies/projects to fail and for the organization to be able to learn from that. Adoption culture, like safety culture, is an aspect of the overall organizational culture. **Leadership**, including their attitudes towards technology, incentives and priorities drive the adoption culture. This includes having a holistic vision of the future and how technology fits into that – "so what they've done is they created a future vision of what work could look like" (I2). **Rewards and incentives** will likely communicate leaders'/organizations' priorities, forming attitudes and driving behaviors around new technology.

DISCUSSION

To ensure that the full potential of innovative technology is maximised, it is crucial to understand the psychological factors that influence technology adoption in industrial consumers not only in O&G but in the broader high-risk, high-reliability market. Our critical incident interviews identified the key psychological factors that influence technology adoption in the oil and gas industry. These preliminary results support and complement anecdotal discussion found in the previous literature and will be further discussed at the conference.

Whilst an extensive range of variables have been examined relating to consumer behaviour and product usage more generally, very limited research has specifically examined these influencing factors within O&G. Our preliminary results add to this by outlining an initial taxonomy of the psychological factors that influence technology uptake in O&G. This can be used to direct interventions that support technology adoption in not only O&G but other industrial consumers in other high risk, high reliability sectors (e.g. nuclear power control).

Personality factors were identified as influencing technology uptake including innovativeness and risk aversion. Innovativeness - the degree to which an individual is willing to adopt innovations – has previously been identified as influencing technology adoption in O&G as part of an 'exploration' trait in which individuals searching out new products or evaluating a diverse range of new products (Perrons, Burgers & Newton, 2018). The preliminary results also reflect individual and sector level risk aversion as a factor that may act as a barrier to the uptake of new technology in O&G (Oyovwevto, 2014).

Trust was identified as a key attitudinal factor in the introduction of new technology in O&G particularly in uncertain or risky situations, reflecting the wider consumer and human factors literature (Pavlou, 2003; see Endsley, 2017 for a review). Whereas trust had been identified as an influencing factor in the introduction of automated drilling technology on a Norwegian offshore oil and gas production

installation between end-users and management (Saetren & Laumann, 2015), this study also identified the role of trust between developers and clients, particularly for collaboration.

The importance of social factors for technology introduction is not surprising given that the O&G industry has particular social dynamics caused by the remoteness of installations and long rotation schedules (Roberts & Flin, under review). Our results reflect the role of social norms about whether (or not) a new piece of technology was trusted, introduced and accepted (Saetren & Laumann 2015).

Risk was one of the most frequently discussed barriers to technology adoption. Introducing a new technology, particularly one that is radical or has little credibility, was perceived to have considerable financial consequences should it fail. Additional concerns over safety risks and reputational risks were also discussed. Our study identified additional cognitive components not previously discussed within the O&G literature, including uncertainty, familiarity, expertise and previous experience, reflecting the human factors literature (e.g. Klein's (1993) Recognition Primed Decision Making). Further examination of the data will be required to understand the relationships between these components and how they influence responses to new technology in O&G at the individual, organisational and industry level.

The role of leadership in shaping both the overall organisational culture and specific adoption culture is widely recognised within the O&G and wider management literature as crucial for both the development of and adoption of technological innovations (Daneshy & Bahorich, 2005; Radnejad, & Vredenburg, 2017). Previous research from other industries have also identified the powerful impact that managers can have on technology adoption (Makkonen et al.,2016) on supporting or hindering new technology – often referred to the "clay layer" (Rezvani & Hudson, 2016). It is possible that methods utilised in the introduction and safety culture may be harnessed to support technology adoption (National Academy of Sciences, 2016).

The interview study adds to the literature by identifying the key influencing factors that impact on technology adoption in O&G, however there are limitations. Interviews are self-report and can be subject to bias as well as motivational agendas (Rowley, 2012). Furthermore, the interviews were focused on the UKCS which has specific attributes which may influence technology adoption (e.g. mature assets and government regulation) which may limit the generalizability of the results to other O&G sectors (e.g. Gulf of Mexico). To support content validity, a broad sample was selected with participants from a wide range of companies, roles and backgrounds. Future research will aim to further support data triangulation through case studies (interviews and observation) to determine best practices for technology introduction. Experimental work may also be conducted to examine the relative weightings of the psychological factors on technology adoption (e.g. having experts rate innovative technology scenarios).

Furthermore, these preliminary findings have the potential to provide valuable insight for product design and technology deployment. For example, early engagement of end-users in product development may help to foster trust and positive technology attitudes, as well as providing the opportunity to discuss perceived risks (e.g. concerns about job security).

CONCLUSION

Understanding how psychological factors influence technology adoption in industrial consumers is vital to support the successful introduction adoption of new products not only in O&G but in the broader market (e.g. automation). Critical incident interviews identified the key psychological factors that influence technology uptake in the upstream O&G industry. Further examination of the results will need to be conducted to determine the weightings of the influencing factors. In combination with several future case studies, these results can be used to develop interventions that support the successful introduction and acceptance of new technology in O&G.

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Table 1. The themes and sub-themes identified from the interview transcripts with illustrative quotes plus interviewee number.

Theme	Quotes
Personality	
Innovativeness	*There are some groups that are really accepting and want to go live with this, it's really, really cool and those are the more adventurous ones I think that want to try it and see it as a potential solution. (I2)*
Risk Aversion	*Others are just thinking about the chaos it will cause and are trying to stop it. (I3)*
Attitudes	
Trust	*Just run something, get it to work, build some trust. It's a big trust to get someone to run something, where they're producing hundreds of thousands of pounds of product from their oil platform, and the risk of not doing that, is huge financially. (I4)*
Motivations	*I think one of the challenges for people being a manager is self-preservation. (I4)*
"Not invented here" syndrome	*Those things have not been received very well because again that's more like the engineer might want to create their own thing. (I2)*
"Engineering Mindset"	*They have that engineering background they go I know this, and then make a decision, which isn't always based on actual information. (I2)*
Social factors	
Self-image	*The potential risk that you look like an idiot or old hat by taking on a new piece of technology. (I6)*
Social Norms	*They would never go back and say "what's that? No idea." My colleague looked at me like "what are you doing, you idiot?" (I4)*
Cognitive	
Risk Perception	*I don't fully understand this "it's too much of a risk for me to do anything with". (I9)*
Uncertainty & Familiarity	*That's an acceptable risk, a risk that we have become very comfortable with, it's part of our job. We have tools, we have measurement methods, lots of things around that, and I wonder if new technology or innovation is a type of risk that we don't have that familiarity around. (I1)*
Expertise	*But just having those reports or those overviews is not going to be enough. You need to train the engineers to be able to read them. (I2)*
Previous experience	*Those who have had successes tend to get on a bit better because they have experienced and realised how they need to do the project. (I6)*
Organization level	
Leadership	*It's a top-down imperative. (I8)*
Management	*The middle-aged or middle layer of middle management and upwards have the opportunity to be the most powerful players in this, it's just giving them the tools. (I1)*
Organisational Culture	*It's the talent, it's the leadership, it's the ways of working, and underlying the strategy and the belief structure of the organisation… It's the digital DNA that needs to be put in place. (I2)*
Adoption Culture	*Is it how it's valued? Or do I consider it part of my core business? (I9)*
Rewards system	*I was able to reward the individuals who are involved with that for their culture of learning and sharing. (I1)*