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Behavioural science applied to risk-based decision processes: A case study for earthquake prone buildings in New Zealand.

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Behavioural science applied to risk-based decision processes: A case study for earthquake prone buildings in New Zealand.

Policy and technical guidance are only as good as their implementation. Often well-meaning legislation has unintended consequences, as individuals and organisations overlay their own risk perceptions and understanding to an issue.

This paper illustrates how behavioural science can be applied to risk-based engineering decisions to improve decision outcomes. It is framed around an analysis of the management of earthquake prone public buildings in New Zealand. It demonstrates how the individual, social and cultural contexts can influence how risks and impacts are perceived, evaluated, and communicated. The framing of the decision, unconscious biases, cognitive limitations, trust, and other social influences are all critical factors in translation of technical policy to effective outcomes.

Keywords: risk management; earthquake prone buildings; policy implementation; decision making

1. Introduction

Science and engineering are often critical inputs into policy. However, regardless of the quality of the scientific or engineering advice, successful policy relies on people aligning their behaviour and decision making to achieve the desired outcomes. Behavioural science offers numerous insights as to why the scientific advice often does not translate into the behaviours expected. This paper looks at the lessons of behavioural science for decision making and policy implementation in an engineering context.

Behavioural science focuses on the influences that impact perceptions, decisions, and behaviours. It emphasises that human behaviours are not solely based on rational evaluations of facts but are heavily influenced by a complex array of individual and social influences that impact in ways that are sometimes surprising and can make the resulting choices appear irrational (Eiser et al 2012).

The behavioural approach sits in contrast to the rational choice approach, initially developed in classical economics (as reviewed in Eiser et al, 2012). The rational choice approach assumes decision makers compare the costs and benefits of available options, take account of probabilities, and make a logical choice based *solely* on the expected values of the options (Kahneman & Tversky, 1979). It implies decision makers will make optimal decisions based on their preferences and the information available to them (Eiser et al, 2012).

In the rational choice model, an apparently illogical or irrational decision is either the result of an information deficit or the misinterpretation of the relevant information (Tversky & Kahneman, 1981). Thus, the solution is to provide better information or enhance the decision makers understanding of how to interpret it.

This approach has been subject to substantial theoretical and empirical critique, including in the context of natural hazards (Eiser et al. 2012; Slovic et al. 2004; Loewenstein et al. 2001). Behavioural insights have moved modern thinking on risk communication and decision making beyond the rational choice model of decision making. By better understanding these behavioural influences, policy makers and those responsible for implementation can better understand the risk context, the influences on decisions, and how these can support or detract from the intended outcomes.

This paper analyses a recent New Zealand case study to demonstrate how behavioural science can complement engineering advice to enhance risk decision making. The case study focuses on occupancy decisions of publicly owned earthquake prone buildings (EPB). Recent legislation requiring the identification, and gradual upgrade, of earthquake-prone buildings in New Zealand has led to varied and arguably undesirable policy outcomes, including the immediate closure of a number of earthquake prone buildings (C. Brown et al. 2021). Internationally, similar policies exist for identification and management of earthquake vulnerable buildings. However, most of the related research focuses on decisions about whether to retrofit a building or not (Zawacki et al. 2020; Sevieri et al. 2020; Aigwi et al. 2019; Grant et al. 2007) rather than whether a building should be continued to be occupied. Moreover, the authors are not aware of any research that specifically links behavioural science with earthquake prone building decision making. This paper focuses on the behavioural aspects of earthquake prone building occupancy decisions and the more general lessons from behavioural science that can be applied to risk-based decision making..

2. Case study context: earthquake prone buildings in New Zealand

A focus on seismic risk following the 2010 and 2011 Canterbury Earthquake Sequence, and the implementation of the Building (Earthquake-prone Amendment) Act 2016, saw the rapid closure of a number of council owned buildings throughout New Zealand. The Building (Earthquake-prone Amendment) Act 2016 provides between seven and 35 years to remediate buildings that are legally deemed earthquake prone, and there is no requirement to vacate buildings before they are remediated. However, some councils have chosen to immediately vacate anything classified as earthquake prone. This has led to long periods when facilities and services housed in those buildings were unavailable to local communities, resulting in some notable socio-economic impacts.

In New Zealand, councils have a role as both regulators and building owners. The analysis in this paper focuses on the decisions of councils as owners of EPBs. When considering occupation of earthquake prone buildings decision-makers are effectively comparing two sets of risks:

(1) The potential for injury or harm from structural failure in the event of an earthquake.
(2) The disruption to council services and wider community impacts from closure of EPBs.

Both risks contain consequences. Risk 1 has potentially catastrophic consequences, such as loss of life and serious injury. Risk 2 has socio-economic impacts to a community. These include job losses, loss of cultural and recreational activities, and in some instances the loss of facilities for disadvantaged groups. There are secondary effects for surrounding businesses and activities due to the loss of council services in the vicinity. The likelihood associated with each risk is also very different. Risk 1 has a very low likelihood while Risk 2 is almost certain. The trade-off between the two risks is not straightforward and the consequence and likelihood of both risks are usually site specific. This is further compounded by the complexities of the legal context and the assessment of the seismic engineering risks.

2.1 The legal context

There are three key pieces of legislation relevant to decisions on council owned earthquake prone buildings in New Zealand: the Building Act 2004 (and subsequent amendments), the Health and Safety at Work Act 2015, and the Local Government Act 2002.

Amendments to New Zealand's Building Act were introduced following the 2010–2011 Canterbury earthquake sequence. These amendments updated previous provisions related to earthquake prone buildings and created a nationally focused and consistent system through new mechanisms such as the EPB methodology (MBIE 2017), the requirement for engineers to use the seismic assessment guidelines (MBIE, Earthquake Commission, NZSEE, SESOC 2017), the establishment of a national EPB register, and introduced timeframes for the treatment of the seismic risk.

To be legally deemed earthquake prone under s.133 of the Building Act, a building must be assessed as failing a test comprising three elements:

(1) Its ultimate capacity will be exceeded;
(2) during an earthquake of one-third of the strength;
(3) that an equivalent new building constructed on the site concerned would be designed to withstand (New Building Standard or NBS).

This is commonly shortened to defining an EPB as buildings under 34% NBS. This definition is purely legal. Importantly, there is no requirement to vacate an EPB. Instead, being assessed as earthquake prone only requires remediation or demolition within specified timeframes. Although being assessed as an EPB may be indicative of the performance of a building in an earthquake, it is far from definitive, particularly in terms of catastrophic failure. It is only used to define whether an owner must act to resolve seismic issues with a building and, if so, the timeframes that apply for doing so. It does not necessarily define whether a building is in fact vulnerable to earthquakes.

The second piece of relevant legislation is the Health and Safety at Work Act (HSWA). It is the primary legislation governing workplace safety in New Zealand. The HSWA was introduced in 2015 and while it does not specifically apply to earthquake vulnerable buildings, it contains broad legal duties and has potentially significant implications for owners of such buildings and those who operate businesses within them.

Under s.36 of the HSWA, a person conducting a business or undertaking (PCBU) is required to protect people's health and safety and provide a work environment that is without risks to health and safety, to the extent that it is 'reasonably practicable'. Conviction for failing to comply with this duty can result in imprisonment and substantial fines. Importantly, a PCBU can be personally liable (that is, charges can be laid against either an individual or an organisation) and liability can arise irrespective of whether an incident has actually occurred.

The responsibilities of a building owner under the HSWA and the Building Act are separate. An EPB under the Building Act is subject to the seismic work requirements. However, this does not alter the responsibility of a PCBU under the HSWA to minimise seismic risks, so far as is reasonably practicable. This may require a building owner to take additional steps, beyond the Building Act.

The Local Government Act 2002 (LGA) makes up the third piece of legislation for council owned building decision making. The LGA requires councils to consider other factors in their decision-making process, including the social, environmental, economic, and cultural well-being of the communities they represent. As building owners, a council's management of risk in public buildings must be made in this context. When a council determines that a public building poses too great a risk to safety to remain open, the LGA requires that they must also consider the wider impacts of such a closure, and, potentially, mitigate the impacts.

The combination of these three pieces of legislation, creates a complex legal framework surrounding earthquake vulnerable public buildings. The legal designation of earthquake prone under the Building Act applies when a building is assessed as falling under 34% NBS and requires remediation or demolition of the building within prescribed timeframes. However, the EPB definition is purely legal. Other buildings may not fall under the legal EPB definition but pose an equivalent or greater engineering risk (as discussed shortly). A PCBU under the HSWA therefore cannot rely upon the EPB definition as a means of assessing the risk that a building poses or the liability they may face under the HSWA.

Under the LGA, councils making decisions on buildings they own are obligated to consider both life safety and community impact. This creates a difficult tension in relation to council owned EPBs because it compels council decision makers to balance the legal requirement (and personal liability) to manage health and safety risk with their broader requirement to preserve the social, cultural, economic, and environmental wellbeing of present and future communities.

2.2 Risk management processes

The aim of risk management frameworks, such as ISO31000, are to ensure that a robust and comprehensive assessment of the risks and potential treatment options is undertaken before critical risk management decisions, such as closure of buildings, are made.

Risk can be reduced by either altering the likelihood or the consequences of an event. In the case of risk from EPB, the likelihood of an earthquake cannot be controlled, and it is the consequences that we can influence the most, by either altering the performance of the building or reducing people's exposure to the risk of building failure.

From an engineering perspective, the assessment, treatment, and communication of these risks is complex(C. B. Brown and Elms 2013). For example, assessing the likelihood of injury requires an assessment of the building performance risk and the level of exposure people may have to that risk. The %NBS ratings may appear straightforward but are a poor indicator of a building's seismic behaviour. The actual performance of a building in an earthquake depends on many factors. These include the earthquake itself (duration, amplitude, and period of shaking), local and geotechnical features (e.g. soil conditions, presence of liquifiable materials, ground slope, water table), the characteristics of specific buildings (e.g. regularity of the structure, both in plan and throughout its height), and how these factors interact. Accordingly, %NBS does not predict seismic performance from one earthquake to the next (Hare 2019). EPB assessment guidelines recognise that all assessments require a level of engineering judgment (MBIE 2017).

The potential exposure of people to building damage in the event of an earthquake is the second part of determining life safety risk. This is partly reflected in the Importance Level (IL) ratings within the Building Act which impose higher performance criteria on buildings housing large numbers of people. However, IL categorisation focuses on peak occupancy, rather than average occupancy, for example, which is a more accurate determinant of life safety risk.

Finally, there is no common view as to what risk is acceptable for seismic safety of existing buildings. This is partly due to a lack of understanding of the intricacies of seismic design (Hare 2019). Murphy and Gardoni (2007) stress the importance of society setting risk acceptability and tolerability limits. How this can and should be achieved is an ongoing challenge as the engineering community contemplate a move toward risk-based performance building codes (Meacham and van Straalen, 2018). As discussed later, people's appetite for risk is highly variable between individuals and over time, being influenced by personal preferences as well as the duration since, and impact of, past earthquake events.

Assessing the consequences of closure can be equally complex. They include economic and social impacts that are beyond the engineering assessment guidelines. While these impacts would not usually result in loss of life, they can create a real harm and hardship. With the engineering assessment focused on the life safety risk of structural failure, the absence of assessments of the impacts on community wellbeing because of closure (such as loss of services form the building or secondary economic and social impacts in the vicinity), leads to a lop-sided and incomplete risk assessment.

For more details on the decision context please refer to Nuth et al. (2021).

3. Methodology

The case study sought to understand the internal processes for identifying and managing seismic risk and community impacts for EPB owned by councils. Following a review of the legal and technical frameworks, empirical data was obtained qualitatively in late 2020, through a series of structured interviews with eight staff representing five councils across New Zealand. This case study approach was taken to obtain an in-depth understanding of the decision-making processes used, along with areas of commonality and difference (Yin 2009).

The five councils were selected to represent a range of council sizes, locations and different seismic hazard zones[1] as shown in Table 1. Note that we were unable to recruit a small council due to resource pressures at these councils. The interviewees were all individuals who provided advice, either directly or indirectly, on whether to continue occupying council buildings legally deemed as EPBs. They represented the property or asset sections of councils, regulatory sections and one was an executive manager with responsibility for managing seismic risk. The selection of councils and interviewees brought a variety of contexts and perspectives to the case study interviews and provide 5 diverse approaches to decision making around EPBs.

Table 1 Summary of case study interviews

Council ID	Council size	Seismic hazard zone	Interviewees
1	Large	Low	Two separate interviews: • Executive Manager • Engineer
2	Large	High	Combined interview with two council representatives: • Regulatory manager • Asset manager
3	Mid-sized	High	• Building services manager (responsible for both council and non-council owned buildings)
4	Mid-sized	Medium	Combined interview with two council representatives: • Environment and planning group manager • Manager planning and building regulatory side
5	Mid-sized	High	• Property manager

All participants were provided with three hypothetical EPB decision scenarios, covering different building types, uses, levels of occupancy and ratings of seismic risk.

[1] For explanation of seismic risk zones in New Zealand, see: http://www.seismicresilience.org.nz/topics/seismic-science-and-site-influences/faults/earthquake-risk-zones/

For example, one scenario referred to a memorial hall, which is common across New Zealand:

"A memorial hall in an isolated community has been given a seismic rating of 30%NBS. The hall can accommodate up to 80 people but is generally only used once or twice a week for smaller gatherings. It is also used as a Civil Defence welfare centre. The building is a Category 2 Heritage Building. The building and adjacent war memorial were built in the late 1940s.

The building was built from cast in-situ columns and walls, with timber roof trusses. The low rating is due to inadequate connections between the trusses and concrete walls, and the lack of bracing in the roof structure."

Alongside these were a range of semi-structured interview questions about ongoing occupancy of the hypothetical buildings. The scenarios and questions were designed to enable interviewees to talk through their respective decision-making processes while enabling the research team to compare approaches to the same problem across councils. Questions included: What would you do when you first received the engineering report for this building? Who else in Council would be involved in the occupancy decision making? What short-term options would you look at? What factors and information would you consider when comparing options? The interviewers also used prompts to elicit thoughts on issues such as reputational risk, consideration of community impacts on building closure, sensitivity of decision to different %NBS ratings, impact of HSWA on decisions, etc.

The questions developed for each scenario were designed to evaluate:

- how seismic risk information is assessed alongside other risk information (e.g. in relation to liability, reputation, legislative responsibility, insurance, social impact, and public sentiment);

- what information councils required for their decisions;
- how the provision of risk information could be improved to assist in the formation of potentially high-risk asset management decisions.

Each interview was conducted by at least two, sometimes three, of the research team to enhance consistency of approach and understanding. The interviews were recorded with the permission of those being interviewed. For each Council, a flowchart was developed that documented the decision making process. In addition, qualitative thematic analysis was conducted on the interview data. As described by Braun & Clarke (2006) this is a 'method for identifying, analysing and reporting patterns (themes) within data', where the theme captures important aspects of the data and meaning within the data set. These themes are found via a process of familiarisation with the data, identification of interesting features, and collation and refinement of those to develop final themes. In this study this analysis was driven by the need to understand the various decision-making processes, decision drivers, decision makers, and their motivations. For this paper, these themes were then mapped to key behavioural influences identified through the behavioural science literature.

Following the interviews with individual councils, the research team facilitated two cross-council workshops to share the results of the interviews, identify best practice and codevelop materials to support future decision making around occupation of EPBs (see Brown et al. 2021 for more detail on the decision-making process developed in this research). The results of this second stage were informed by, rather than contributed to, the behavioural insights outlined in this paper.

Human ethics approval for the interviews and workshops was granted in June 2020 through the BRANZ ethics approval process, reference ER11645.

4. Case study findings

The interviews identified clear variance in how decisions are made on council owned EPB. This variance is reflected in 1) different processes for rationalising risk-based decisions, 2) who has decision-making authority, 3) whether there is a documented policy guiding decisions, and 4) degree to which councils tolerate potential life safety risk.

4.1 Policies

Of the five councils interviewed, only three had formal policies related to occupancy of council-owned earthquake prone buildings. Generally, it appeared that the policies for managing EQP buildings emerged from each council's property management arm in conjunction with their building regulation team (depending on size of council). Two councils noted that a policy enabled them to put aside the misperception that anything deemed EPB was imminently dangerous and created a consistent platform for decision-making across the building portfolio. One council commented that establishing a robust policy was essential for effectively managing council-owned building risk and reducing variations in approach due to differences in individual opinions or variations in risk understanding and tolerance.

> *"You can have a building assessment, you can know that you've got a building rating [%NBS]. But if you are the owner, occupier, you don't actually know what that means for your staff and their safety…that's a key driver behind the work we've done on the policy" Council 1, Engineer.*

4.2 Driver for building management decisions

The primary driver behind EPB decisions for all five councils was people's safety, rather than cost, disruption to services or wider community impacts. This was a key area of commonality across those interviewed. The legal obligations of HSWA and the BA contributed to this to varying degrees but the need to protect people from harm was often more intrinsic, possibly reflecting personal values and their perception of public expectations. Those interviewed applied their own understanding and judgements to engineering assessments. While the BA required them to address the issue within prescribed timeframes, it was widely seen as inadequate to address the safety risk.

“Safety of the occupants and staff is simply foremost in our minds” Council 5, Property manager

The consideration of the wider impacts of closure on community well-being, as described under the LGA, was secondary and based mainly around the mitigation of impacts and the long-term management of the EPB after a closure decision was made. Impacts beyond services specific to the building being closed (such as impact on, nearby businesses, tenants or vulnerable populations) were not routinely considered by councils.

“The primary focus is on safety. The decision to close or undertake [mitigation efforts] is around safety. Continuation of service is there, but it's not a major factor.” Council 1, Executive Manager.

Across each council there appeared to be little internal discussion around risk tolerance. To some extent risk tolerance was reflected in closure decisions and speed of implementing those decisions, which varied between councils from one hour to several months. They did not appear to use comparative risk estimates in their decisions, e.g., between the health and safety risks of day-to-day council activities, such as motor vehicle use, and the risks from a building being subject to a low probability event.

Much of the decision making of councils appears to rest on the potential consequence of an earthquake, rather than its likelihood. Two councils indicated they had done some work to try and educate their respective executive leadership teams on this issue but explained that it remained a work in progress.

4.3 Decision-makers

For all Councils, there was a clear and conscious delineation between building safety and building function. Property or building managers tended to make the decision about the building before consulting with the corresponding service manager. One council had established a cross functional seismic risk team to make decisions on buildings. It was noted that the group had a diversity of perceptions around risk to achieve a balanced decision. For smaller councils, the building manager typically made a recommendation to the asset manager/service manager.

> *"I do involve [the asset manager] but generally he just says 'you're the expert', you tell me what your decision [on closure of a building] is….in terms of elected officials I inform rather than ask" Council 3, Building services manager.*

Three out of five councils did not require the decision to close to be signed off from elected officials. With safety being the primary driver and council staff being PCBUs under the HSWA, the immediate decisions regarding closure were made by council staff. Elected representatives had a greater role in decision making for the longer-term future of the building, rather than immediate decisions as to whether to continue to occupy or vacate the building.

Two councils did involve elected officials. One indicated they would take a decision about a potential building closure to elected officials because it was of public interest. In another council, elected members would be asked to confirm a decision made by the Chief Executive on recommendation from the property manager.

4.4 Risk Assessment

Four of the five councils indicated they took account of %NBS in building closure decisions, however only one council had a rigid policy of building closure at a certain %NBS (<34%NBS).

Three councils spoke of the importance of conversing with engineers to understand a building's behaviour and to understand the judgement behind the assessment made. This included requiring engineers to be explicit about any critical structural weakness that could lead to catastrophic failure and giving engineers scope to look at wider risks to services, nearby roadways, risk from other buildings, etc.

> *"…engineers [make] judgment calls as well…one engineering firm says 30%NBS, another engineering firm might come in and say it's 45%NBS. And so there's an issue here … they need to explain how this building might perform in a moderate earthquake. … So we're asking them to go a bit further than simply an engineering assessment based on the code. " Council 1, Executive Manager.*

A key observation during the interviews was that there was little discussion about risk likelihood. Councils mainly focused on the potential consequences of a building's seismic failure and less so its probability. Interviewees were cognisant of the community impacts of building closure but gave these much less weight than the potential consequences of a seismic event. In most cases (three out of five councils), occupancy frequency and numbers (which are components of risk exposure) were not deemed relevant.

For the interviewees, the management of EPBs had been a learning process. As time from earthquakes drew longer and risks were better understood, closure decisions were less likely.

4.5 Stakeholder involvement

Tenants and other stakeholders were generally communicated with by council officials after a decision about building safety had been made. Language around engineering assessment and building safety came up with several interviewees. One council noted they decided not to use terminology describing buildings as 'safe' and preferred to use terms such as ‘fit to occupy’. They saw safe as meaning zero risk which was impossible to achieve.

> *“One thing we decided very early on was that we wouldn’t use the word safe; we’d used “fit to occupy”... if we have a big enough earthquake, who is to say what is safe? Safe to me means zero risk” Council 2, Asset Manager.*

One council gave an example of an EPB that housed a playcentre that was initially closed but re-opened after consultation with the playcentre operators and parents. Another spoke of the importance of releasing the engineering report at the same time as the closure decision for transparency. Some had held public meetings to explain decisions.

> *“[The playcentre] community was really happy that we could reopen the building, and it was in a very informed way... [when asked if they were worried about this, they said] “no, we've been informed about this by council and we know the programme of when it's going to be strengthened”. I think that they were our best advocate [for keeping the building open].” Council 2, Asset Manager.*

5. Application of behavioural science

In decision making environments such as EPB, the key message from behavioural science is that the facts are only part of the decision making equation, and often a surprisingly small part (Eiser et al 2012). Solberg et al. (2010) concludes that it is difficult to judge whether material (actual) risk has a consistent effect on risk perceptions. It is therefore not surprising that councils apply such a variety of approaches to EPB decisions, particularly when 1) the legal and engineering frameworks are complex and require judgement, 2) standardised decision-making frameworks are lacking, and 3) there are multiple individuals involved in decision making, each with varying roles, experience, knowledge, attitudes, and beliefs, resulting in varying levels of understanding and information needs.

In this section, these behavioural influences are discussed further, along with suggestions on how decision-making processes may be adjusted to strengthen EPB decision making and reduce unintended bias.

5.1 Decision making framework and context

The behavioural literature emphasises that the perceived context, scope and framing of an issue is a critical first step in risk decision making (Eiser et al. 2012; Solberg et al. 2010; Stewart et al. 2018). These determine what is regarded as relevant to the decision, as well as the way risk information is presented and perceived (Elms and Brown 2012). This is reflected in risk decision-making frameworks such as ISO31000, but this study identified a number of shortcomings in relation to EBP decisions.

All the interviewees emphasised the importance of health and safety, not just in terms of legal obligations, but as a core value that drove their decision making. This context and scope, centred on health and safety, raises several issues.

First, New Zealand has a long history of seismic events and the risks for building performance were known but seldom acted upon until the catastrophic consequences were demonstrated through the Canterbury earthquake sequence and the subsequent amendments to the BA which required councils to address the risk, as regulators and building owners. Given the importance interviewees put on life safety as a core value, and the known risks of seismic activity prior to the Christchurch earthquakes, it highlights issues of problem recognition and situational awareness. The risk was known, life safety was regarded as important, but this was not sufficient to spur significant action to address the risk.

Second, the impetus for identifying and managing EPB came from both the heightened visibility of the risk due to the Canterbury earthquake sequence and the requirements for identifying and managing EPB under the amendment to the BA. In combination with the introduction of the HSWA at a similar time, this framed the issue as one of life safety, rather than a broader assessment of well-being as required under the LGA. It is therefore not surprising that the wider social, cultural, and economic impacts were generally considered after the decision to close had already been made. In some instances, this was exacerbated by the misunderstanding that a building legally deemed as earthquake prone was an imminently dangerous building.

Third, in the case of EPB, even the parameters of health and safety risk were narrowly defined, limiting what may be regarded as rational decision making. The case study interviews highlighted that decision makers often gave little, if any, consideration to risk exposure in terms of occupancy, and certainly there was a primary focus on consequences of potential building failure with far less consideration of the likelihood, sometimes acting solely on the %NBS rating despite the inherent uncertainties in that evaluation. In other words, the decision-making framework and risk assessment criteria were very narrowly defined. It appears likely that this contributed to public buildings being unnecessarily vacated after being deemed EPB.

Even if there is agreement on the issue and relevant information, the way information and choices are presented will impact the decision. For example, a choice presented as avoiding a potential loss is more likely to be accepted than when it is framed as receiving a potential gain, even when the outcomes are identical. Kahneman & Tversky (1979) illustrated this in an epidemic response example where two intervention options with the *same* expected outcomes were presented using a different reference point, thereby framing the decision as a loss or gain. The preferred choices were highly skewed towards avoiding losses. Other framing examples relating to technical risk communication are available (see Doyle et al. 2014; Kahan et al. 2012; Mcclure, White, and Sibley 2009; Vinnell, McClure, and Milfont 2017). In this instance, the literature suggests that the focus on the potential negative impacts of continuing to occupy is more likely to result in a decision to vacate if compared to the benefits of remaining open.

5.2 Bias

Many forms of bias are applicable to risk communication and decision making (Carmichael 2020). For example, if people perceive benefits from a hazard they are more prone to discount its risk (Peters et al. 2006; Slovic et al. 2004). People tend to dismiss information that contradicts existing behaviours, beliefs or past decisions (Festinger 1957; Stewart, Ickert, and Lacassin 2018), avoiding what Festinger described as cognitive dissonance. Solberg et al. (2010) cite various studies that provide evidence of optimism bias in relation to seismic risk, where people perceive themselves as less likely to experience a negative event than probabilities suggest (also see Crawford et al. 2019; Mileti and O'Brien 1992).

Two contextual biases of particular relevance to the seismic risk case study are the consequence bias and recency bias, both of which can lead people to over-estimate the future likelihood of events. The consequence bias is when an event with a severe outcome is perceived as having a higher probability than what is conveyed in a likelihood message (Windschitl and Weber 1999; Bruine De Bruin et al. 2000; Patt and Dessai 2005; Joslyn and Nichols 2009). The recency bias is the natural tendency to focus on risks highlighted by recently past events, rather than future risks (McClure et al. 2016). Given the Canterbury and 2016 Kaikoura earthquakes were relatively recent and high-consequence events, it is likely both of these are applicable.

5.3 Bounded rationality

Simon (1955, 1992) found people to be 'rationally bounded', whereby they rarely analyse all the relevant information, even if it is readily available. Instead, decisions are made on limited information or simplifying heuristics, a process he described as 'satisficing'. Eppler & Mengis (2004) identify that providing too much information may overwhelm the decision maker, reducing the situational awareness needed for effective decisions.

Simplifying decision-making heuristics are a necessary and everyday part of our decision making. For example, most behaviours are based on continuing what we have done in the past until, for some reason, we become dissatisfied with that choice. This may, at least in part, explain why risks may not be proactively addressed prior to events: we simply do not have the cognitive bandwidth or sufficient motivation to address the risk.

For EPB, the decisions are complex, and the analysis is technical, and the interviews highlighted the bounded rationality and cognitive limitations of decision making. Interviewees revealed examples of simplified decision-making heuristics that may be paraphrased as '*any risk to life must be reduced*', or '*if a building is less than 34%NBS, it is unsafe and must be closed*', or '*if it is above 34%NBS it is safe*'.

However, any simplifying heuristics have an inherent and systematic bias, resulting in the downplaying or dismissal of relevant information. When applied to complex and high-consequence decisions, they can have substantial impacts. In the case of EBP, these types of simplifying heuristics can lead to resources being wasted and unnecessary disruption due to premature or unnecessary closure or, conversely a building remaining open when it does in fact pose an unacceptable risk. The limitations of this type of decision making were acknowledged by one interviewee who summarised it as '*it is expected that there will be no harm, but we all know that is* *impossible'*. Eliminating harm is not only unachievable but also inconsistent with other everyday risk decisions made by councils and individuals.

The interviews conducted for this research suggested that as time progressed, the risks have become better understood and the decisions become more nuanced. For example, several interviewees spoke of the need to interrogate engineers to ascertain whether any critical failure mechanisms existed, rather than relying on the relatively crude %NBS. In one example this appears to have continued into the public discussion, resulting in the re-occupancy of an EPB by a playcentre. In that instance, the discussion with users resulted in all parties having a better understanding of the nature and likelihood of the seismic risk, and the impacts of building closure. The users and the Council agreed the seismic risk was tolerable and re-occupied the building.

5.4 Social influences

People's values, group identity and perceived norms can have a stronger influence on their risk judgements than the information communicated (Kahan et al. 2012; Slovic et al. 2004). Social norms (socially defined rules of behaviour) can have a substantial effect on seismic risk attitudes and behaviour (Solberg, Rossetto, and Joffe 2010). The extent to which these impact on risk adjustment behaviours is dependent on the existence of perceived norms, their visibility and the extent of social connection (L. J. Vinnell, Milfont, and McClure 2019; Solberg, Rossetto, and Joffe 2010).

In relation to EPB, this may relate to the perceived norms regarding the acceptability of occupying a building deemed earthquake prone. For example, if members of the public see others occupying a building it may convey a norm that it is safe to occupy. Similarly, in the political context of council decision making, the perceived willingness of the public or staff to occupy a building deemed earthquake prone may influence decision making, regardless of the actual risk.

Social influences extend into organisational cultures and professional backgrounds. For example, Demeritt et al (2007) found meteorologists preferred to issue precautionary warnings even at low likelihoods, or with high uncertainty, to reduce chances of 'unwarned floods', while flood forecasters preferred to decrease the chance of false alarms because of their impact on future public response. For EPB, the engineering focus on life safety risk may be seen as part of a social influence aligned with professional practice, possibly diminishing the weight put on other community impacts.

Stewart, Ickert, and Lacassin (2018) suggest that when information is complex, people make decisions based on their values and beliefs, rather than facts, and that people seek affirmation of their attitudes or beliefs, no matter how strange those views are. Moreover, people generally place greater trust in people whose values mirror their own (Stewart, Ickert, and Lacassin 2018).

In these circumstances, the literature suggests there is a tendency to rely on things they know or are more familiar with. These extend from the initial problem recognition and definition, through to how we assess information and what decisions we make (Kloprogge, van der Sluijs, and Petersen 2011).

In most instances in this case study, the staff advisors and decision makers were from technical or engineering backgrounds, suggesting they are more likely to put weight on engineering assessments looking at building performance and risks to life safety, than the less familiar and often less studied or quantified social or economic impacts.

5.5. Trust

Trust consistently comes through as a key determinant of risk perceptions for both the general public and official decision-makers (Khan et al. 2017; Wachinger et al. 2013;

Solberg, Rossetto, and Joffe 2010). A high degree of trust increases the likelihood that information will be believed and acted upon. The converse is also true: a low degree of trust diminishes the likelihood of action or behaviour changes.

Stewart et al. (2018) suggests that trust is arguably more important than technical understanding because people use trust as a cognitive shortcut when faced with complexity. When the issues are complex or subject to different interpretations, trust acts as a substitute for evaluating information. This reduces their need to make rational evaluations directly (Wachninger et al., 2013).

Trust is a complex social phenomenon with multiple dimensions (Kasperson et al., 1992). It can include trust in both the communicator of technical information, and in the information itself.

The importance of trust came through in the interviews. Although it was widely acknowledged that judgements are required both in the technical assessment of risk and subsequent decision making, having reliable and trustworthy information was seen as critical to ensure good decisions were made and able to be defended, either to the public or potentially in a court of law. One interviewee explicitly referred to the need to know and trust the consulting engineer, while others spoke of the need to discuss the results to fully understand and trust the advice. Some councils sought peer reviews of engineering reports.

This reinforces the importance of robust guidelines, not only for engineering assessments but also for the subsequent decisions which balance life safety against other risks, such as the impacts of building closure on the community. Having widely accepted nationwide guidelines, developed with input from both experts and decision makers, is likely to reduce the ad hoc variance in decision making by councils. As behaviours and decisions are partly driven by socially defined norms, deviation from accepted guidelines may require clear justification to avoid incurring a perceived social penalty. Being able to have trust in such guidelines is particularly important in the context of decision making by public bodies, where the nuances of the decision may not be well-understood by the wider public or the decision may be at odds with public perceptions.

5.6 Socially defined risk tolerance

The interviews highlighted different approaches to determining acceptable levels of risk. In one council, a panel of staff from different parts of council and with different levels of risk tolerance made the recommendations to occupy or vacate a building. In another instance, recommendations were made to the elected Council on specific buildings and in another, the interviewees emphasised the importance of a clear policy direction from their Council. These highlight that risk tolerance among decision makers is in part socially defined. In this context, individuals may have varying understandings and risk tolerances. The language used to describe risk can be particularly important in this social context (Sword-Daniels et al. 2018; Slovic et al. 2004; Eiser et al. 2012) and it is not surprising that use of terms such as ‘earthquake prone’ can lead to misunderstandings regarding whether a building is safe to occupy.

The interviews also indicated that as time moves on from the Canterbury and 2016 Kaikoura earthquakes, public acceptance of the risk is becoming more common. This may be due to the diminishing effect of the recency bias or a growing understanding of the risk. However, it may also be due to other psychological or social influences on risk behaviours, such as observing other people using a building and concluding it must therefore be safe to occupy.

This has implications for setting levels of risk tolerance. In New Zealand, legislation such as the Building (Earthquake-prone buildings) Amendment Act 2016, discussed in this paper, was introduced following a major earthquake event; a time when effects such as recency bias are likely to skew risk tolerances.

5.7 Responsibility and liability.

Perceptions of responsibility have been shown to affect behaviour (Haynes, Barclay, and Pidgeon 2008). In the case of decisions regarding EPB, the HSWA introduced the concept of PCBU and included a potential personal liability for those failing to fulfil the duties required of them. The inclusion of this personal liability was in response to some high-profile cases where negligent behaviours resulted in death at workplaces. While the inclusion of this personal liability provides clarity in relation to Health and Safety responsibilities, the interviews suggest that it may have contributed to the dismissal of other forms of harm resulting from the closure of EBP. Specifically, the desire to avoid a conviction in relation to potential seismic risk may be leading to other unnecessary social harm or economic hardship for which a decision maker will not be held personally liable.

Whether the caveat contained in the HSWA of ‘as far as reasonably practicable’ is being appropriately applied is a question for PCBUs, policy makers, and the courts. However, the fear of liability is clearly contributing to decision outcomes. Guidance for EBP decision making, or other risk-based decisions, may provide society with greater confidence and willingness to tolerate risk when risk mitigation creates other forms of harm. This includes impacts beyond health and safety.

5.8 Participatory processes

In response to the lessons from the behavioural sciences, several papers point to participatory processes that allow for two-way dialogue between experts, policy makers and affected parties (Stewart, Ickert, and Lacassin 2018; Wachinger et al. 2013). The participatory processes recognise that communication is a social process and enables a better understanding of controversy, the path to resolution and, ultimately, better risk adjustment outcomes (Sandman, 1993). Participatory approaches are also an important way to identify the decision-relevant information needs (Hudson-Doyle and Johnston 2018).

For EPB, affected parties were generally notified after the decision to close had been made. In situations of high risk or imminent danger this may be appropriate. However, in some situations, subsequent participatory processes including discussions with users, led to a greater understanding of the risk by users and the building was subsequently re-opened. The playcentre example is a demonstration of how participatory processes can result in greater understanding and acceptance of risk. This reinforces the emphasis in the more recent risk literature of participatory processes in managing risk.

6. Discussion

Engineering risk decisions require robust and scientific input. However, behavioural science highlights that human decision making is subject to a diverse range of individual psychological and social influences, often unconsciously, that detract from balanced risk decision making.

The interviews showed inconsistent practices among councils. Some councils rapidly closed earthquake prone buildings (EPB) while others kept buildings with lower seismic ratings open. They confirmed the common misperception that if a building is declared earthquake-prone then it was imminently dangerous and should be closed immediately, which is seldom the case. It demonstrated the complex and ambiguous legal context, as well as the practical challenges and expert judgements required for engineering risk assessments, all of which are relevant to the behavioural and decision-making context.

It is important to acknowledge that the behavioural insights given in this case study are not criticisms of the individuals involved in managing EPB. These insights come from decades of study on human behaviour, across many activities, locations, and contexts. This is what makes them so important: knowing that they are universal, and we are all subject to these influences and limitations.

A key limitation of these behavioural lessons is that they are often context specific, reflecting the individuals involved along with the organisational, social and economic circumstances of the decision. Frequently, the insight comes with hindsight. A major challenge is that the influences on risk related decision making are so numerous and pervasive that there are no single or simple solutions. The key lesson is how easily, subtly and unconsciously our perceptions and decisions can be influenced. Awareness, reflection and review on how they may apply to individual decisions, both past and present, is perhaps the best safeguard to good decision making.

It is important to recognise that behavioural influences cannot be fully anticipated and addressed during the initial policy design and implementation. Behavioural science demonstrates the complexity of human decision making. This reinforces the need for an agile approach to policy: monitoring implementation, review and initiating follow-up actions when needed. In this context, behavioural science provides insights as to why policy may have resulted in unintended outcomes and suitable remedies, if needed.

Table 2 summarises the generalised findings of this research for each of the behavioural dimensions discussed. These are consistent with processes such as ISO31000, which recognise the contextual importance, but go further to provide additional insights into less obvious and conscious influences on behaviours and decisions that could be applied to a range of different risk decision contexts.

Table 2. Key behavioural science principles applied to technical risk decision making

Behavioural dimension	**Key findings**
Context and decision framework	Ensure the decision-making framework clearly and explicitly defines the full scope of the decision and identifies all the relevant elements as early as possible. Even though a full assessment of all impacts and risk treatment options will not be available at the beginning of the process, providing the overall context and framework can assist in clarifying the full context, scope, and relevant considerations, thereby enhancing the likelihood of balanced and informed decision making.
Bias	Consciously look for and address sources of bias in risk communication and decision making. This applies to the perceptions of the decision makers, as well as the public. In political decision-making contexts, such as elected councils, this can lead to public demands for greater or more rapid action than is warranted. Awareness can reduce the unintentional introduction of potential bias, either through individual self-reflection or enabling others to safely question risk decisions.
Bounded rationality	The lesson from this is that our bounded rationality and the use of simplifying heuristics is something we all use every day but can lead

	to poor decisions. Where risk context is complex, ambiguous, or unfamiliar, more formal guides and decision-making processes can add real value. Having guidance that draws together all the relevant considerations may at least partially address this, particularly for smaller organisations where the relevant managers often have a broad range of responsibilities and little time or resources for detailed evaluation of this issue.
Social influences	Be aware that when information is complex, we increasingly look for social cues based on our values and beliefs, rather than evaluating the facts. This extends to the culture and norms associated with professional practice, which varies between disciplines. This can be advantageous if you can find ways to increase visibility, social interaction and alignment to people's values to spur people to action if risk reducing behaviour change is needed. Risk awareness alone is rarely sufficient to bring about changes in established behaviours.
Trust	It is important that trust is not a substitute for understanding, especially in complex or ambiguous circumstances. Ask questions, critically evaluate responses, and establish that trust is well founded on relevant experience and understanding of the specific context.
Socially defined risk tolerance	Where possible, distance the setting of risk tolerances from immediate events, or at least be aware of increased risk aversity immediately post an event. This can allow a better balance between

	different types of risk and risk treatment options. Similarly, seek a wide range of perspectives to help ensure risk tolerances are set to reflect the attitudes of the wider community.
Responsibility and liability	Liability potential as a decision driver should not be underestimated and can result in unintended outcomes. The risk context and decision parameters need to be clearly defined to avoid a lopsided approach to risk assessment and decision making. This is particularly relevant in situations where personal or organisational liability needs to be balanced with societal interest.
Participatory Processes	Engage in participatory processes where risk trade-offs are required. It is acknowledged that participatory processes can add time and cost to decision making. However, with low likelihood events such as earthquakes, the decision-making timeframes do allow for participatory processes.

A limitation of this research is the number of case study councils and people able to be interviewed. It was appropriate to the purpose and context of the research, and sufficient to demonstrate the application of behavioural theory to the context of EPB. It is acknowledged, however, that a larger sample and more quantitative methods would be required to robustly test the application of a specific hypothesis.

7. Conclusion

This paper applied behavioural insights to the context of decision making on council owned EPB in New Zealand. The case study illustrated how behavioural aspects can influence decisions and suggests ways that may support good decision making. These lessons apply widely to risk decision making across many professional disciplines. Good processes, critical thinking, self-awareness, and reflection are needed to avoid these very human pitfalls.

The intersection between behavioural science, technical risk-based decision-making, and policy is ripe for further research, particularly where risk is being managed in an organisational setting. For example, local authorities are having to navigate a myriad of natural hazard and climate risks within their communities. More research and support are needed to ensure decision making is robust and appropriately balances the many competing pressures and priorities within communities. This could include identifying current decision processes and drivers and applying the behavioural principles in this paper to build more effective risk and decision making processes.

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