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**Gaining a deeper understanding of the psychology underpinning significance judgements in environmental impact assessment (EIA)**

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**Gaining a deeper understanding of the psychology underpinning significance judgements in environmental impact assessment (EIA)**

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**Abstract**

Significance judgements lie at the heart of EIA and provide the basis and justification for overall decision making. Although the subjective nature of significance judgements is widely recognized there has been limited research aimed at gaining a deeper understanding of its implications. This paper builds on the growing tradition of exploring learning from psychology in dealing with challenges in EIA practice, in this case significance judgements. The aim of the research is therefore, to gain a deeper understanding of the psychology underpinning significance judgements. This is achieved by applying 10 concepts from psychology to the four steps in the ‘significance spectrum model’ namely: decide thresholds, make predictions, judge acceptability and consider mitigation. The results suggest that significance judgements should (with underpinning concepts from psychology provided in parentheses) aim for a limited number of key thresholds (paradox of choice); design thresholds with future gains in mind (loss aversion), reconsider probability scoring (possibility and certainty effect); avoid judgements based on limited information (What You See Is All There Is, WHYSIATI); utilise statistical prediction over expert opinion (expert fallacy); communicate carefully (priming, framing and cognitive ease); and consider personal attitudes and biases (affect heuristic).

**Key words**: environmental impact assessment, significance, decision-making, value judgements, psychology

1. **Significance judgements in EIA**

Significance judgements lie at the heart of environmental impact assessment (EIA) and are central to screening, scoping and the eventual authorization decisions (Beanlands and Duinker 1983). Notwithstanding the importance of dealing with significance in EIA it has been a somewhat elusive concept, which is difficult to define, conceptualize and operationalize (Ehrlich and Ross, 2015; Jones and Morrison-Saunders, 2016). However, although there is no universally agreed definition of, and/or methodology to deal with, significance, there is general agreement that significance determination is essentially based on value judgements throughout the EA process at varying degrees of subjectivity, depending on the particular context and decision in question (Beanlands and Duinker, 1983; Sippe, 1999; Lawrence, 2007; Glasson et al, 2012).

The early literature on significance was mainly concerned with impact characterization, by describing the various attributes of significance such as probability, scale, magnitude, duration, etc. and then producing a significance outcome or score (Leopold et al, 1971; Thompson, 1990). However, there has been increasing recognition over time of the role of human values in impact significance judgements, acknowledging that dealing with significance ultimately requires judgements on the meaning of the impact for different stakeholders. The need for clarity in these judgments has been highlighted since the 1980s. Furthermore, the role of values in decision making is considered central to the complexities and difficulties in dealing with significance determinations (Wood et al, 2007). In this regard, Haug et al (1984, p18) make a clear distinction between the ‘fact’ of an impact and ‘value’ or ‘meaning’ of an impact, *“The fact of an environmental impact is the change itself, its magnitude, direction, units, and estimated probability that it will occur. The meaning of an environmental impact is the value placed on the change by different affected interests.”* Thompson (1990, p241) states in relation to significance judgements that it *“is the impact of a particular set of findings or predictions upon the minds of men, not the impact of the pollutant on the environment per se that is our key unknown.”*

The difficulty characterizing significance is important because it underpins a number of problems with EIA. Ehrlich and Ross (2015, p88) outlined key issues with significance determinations extracted from the literature as lack of: objectivity; uniformity; guidance; clarity over characteristics of significance; agreed evaluation methods, understanding of the role of significance determinations in broader EIA processes and poor communication.

In this paper we engage with these key issues and argue that there has been little reflection and/or progress in gaining a deeper understanding of significance judgements. However, the field of psychology has produced much research on explaining subjective value judgments and the role of facts and values in decision making and therefore invites further investigation. This paper builds on the growing tradition of exploring learning from psychology in dealing with questions around EIA. For example, Lyhne and Kørnøv (2013) introduced socio-psychological thinking and the theory of ‘sense-making’ to construct meanings of significance judgements, specifically within the screening and scoping stages of EIA. Retief et al. (2013) and Retief et al. (2015) drew on the field of psychology to better understand the practice of EIA in dealing with trade-offs and the practice of sustainability assessment respectively. Therefore, the overall aim of the paper is to gain a deeper understanding of the psychology underpinning significance judgements in EIA with a view to inform future significance evaluation practice.

The rest of the paper is structured to meet this aim with the next section describing the research methodology, which involves a two-phase literature review to first develop an analytical framework (phase 1). The framework is applied in the subsequent section, in the light of learning from the psychology literature (phase 2), to better conceptualize significance determinations in EIA. Finally, conclusions are drawn based on the implications of the findings for the future consideration of significance in EIA practice.

1. **Methodology**

The approach taken to this research is based on the development and application of an analytical framework which is used to structure analysis of psychology literature relevant to significance determination in EIA. This involves a two-phase literature search, with the first phase identifying the key literature to develop the analytical framework, and the second phase using the same literature to systematically characterize significance determinations structured by the analytical framework. Theliterature review first identified the key literature related to EIA, significance, and psychology. Identification of this literature followed a standard approach for a structured literature review. Searches were made of Scopus and Google Scholar, using the following search terms individually and in combination: ‘environmental impact assessment’ AND ‘significance’ AND ‘value judgement’ AND ‘psychology’. All literature up to October 2022 was included. For all the identified literature, duplicates were removed, abstracts were initially read to identify the papers of potential relevance, with the reduced list of literature then being read in detail. Additional sources were identified by following citations back and forward from the papers, where not already identified in the literature search. The first phase identified two key papers as the basis for constructing the analytical framework: the significance spectrum model proposed by Ehrlich and Ross (2015) and the 10 different concepts in psychology relevant to environmental and sustainability assessment as identified by Retief et al (2015).

The significance spectrum model provides the main understanding of significance for this paper. The model was developed by Ehrlich and Ross et al (2015) in response to the need for clarity and a better generic understanding of the actual process of significance determination for individual impacts on environmental components towards an overall significance outcome (Ehrlich, 2021). The paper was voted as best annual paper for 2015 by the editorial board of the Impact Assessment and Project Appraisal (IAPA) Journal. This was taken as an endorsement of the quality of the article, and associated credibility of the conceptualisation by the impact assessment community. The significance spectrum framework recommends the following four steps in the significance determination process, as illustrated in Figure 1:

* *Step 1: Decide thresholds*: Decide where on the spectrum of potential impacts to place the threshold of significance for that particular environmental component. This threshold can be placed anywhere along the spectrum between zero impact and catastrophic impact, depending on the informed subjective judgement of significance determiners. This threshold should distinguish acceptability from unacceptability. It should be based on evidence in the EIA, but also societal values.
* *Step 2: Make predictions*: Weigh the evidence and make predictions about possible impacts. In weighing the evidence (the impact predictions) the arguments of all parties participating in the EIA must be considered. This may include carefully judging between the conflicting predictions of different participants, who may have (deliberately or otherwise) introduced their own values into predictions and who also may have competing views of where the threshold of significance should be for a given impact. The public participation process outcomes typically feature strongly during this phase.
* *Step 3: Judge acceptability*: Decide which side of the threshold the predicted adverse impact falls on. It can either be on the side of the acceptable (and therefore is not a significant impact) or on the side of the unacceptable (and is therefore a significant impact). Level of acceptability is based on scientific as well as value judgements.
* *Step 4: Consider mitigation*: If the impact falls on the unacceptable side, and is therefore significant, the significance determiner must consider whether mitigation measures are sufficient to shift it across the threshold of significance, so that the residual impact is not significant. The significance determination should not be arbitrary and should be informed by a reasonable weighing of the evidence, and by the values of society. The reasoning for the judgements that led to the significance determination, should be clear and communicated in a language understandable to all stakeholders.

Graphical user interface

Description automatically generated

**Figure 1:** *Significance spectrum model (adapted from Ehrlich and Ross, 2015). The significance determiner decides where on the spectrum a predicted impact (shown as the yellow dot) falls and weighs the effect of mitigation measures (shown as the arrow) on impact significance.*

The literature dealing with EIA and psychology is much more limited. However, research by Retief et al (2015) identified 10 concepts in psychology potentially relevant to environmental and sustainability assessment practice. Therefore, in order to address our research aim, an analytical framework was constructed which relates the four step ‘significance spectrum model’ by Ehrlich and Ross (2015) to the 10 different concepts in psychology as identified by Retief et al (2015). The psychology literature is vast, and it is well recognized that this paper represents the tip of the iceberg in terms of learning from psychology for EIA. However, the 10 concepts included in this paper were chosen because they have already been identified as having relevance to impact assessment generally and significance specifically. This analytical framework presented in Table 1 serves as a template for characterizing significance determinations in EIA practice in the next section, using phase 2 of the literature review.

**Table 1:** *Analytical framework* - *Concepts in psychology and their relation to steps in the significance spectrum model*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Concepts in Psychology**  (Retief et al., 2015) | | **Significance Spectrum Model**  (Ehrlich and Ross, 2015) | | | |
| **Step 1:**  Decide thresholds | **Step 2:**  Make prediction | **Step 3:**  Judge acceptability | **Step 4:**  Consider  mitigation |
| 1 | Loss aversion | X |  |  |  |
| 2 | Possibility and certainty effect | X |  |  |  |
| 3 | Expert fallacy |  | X |  |  |
| 4 | Clinical versus statistical prediction |  | X |  |  |
| 5 | Expert intuition |  | X |  |  |
| 6 | WYSIATI (‘what you see is all there is’) |  | X | X |  |
| 7 | Paradox of choice |  |  | X |  |
| 8 | Priming and framing |  |  | X | X |
| 9 | Effect heuristic |  |  | X | X |
| 10 | Cognitive ease |  |  | X | X |

The relation of the different concepts in psychology to the steps in the significance spectrum is discussed in more detail in the following sections, and this discussion explains what each of the 10 concepts means. Although the structure of the following discussion tries to stick to the four steps, reference is also made in the discussion of each step to the implications for following steps, so the discussion also bridges across steps to explain the implications.

1. **The psychology of significance judgements in EIA**

The significance spectrum model provides a good conceptual approach to significance judgements, however, from a psychology perspective it masks a great deal of complexity. In the following text, learning from the psychology literature is associated with the significance spectrum steps in turn, with steps 3 and 4 being combined given they associate with the same concepts drawn from the psychology literature. To illustrate the discussion, Figure 2 presents a refined two-dimensional version of the ‘significance spectrum model’ that incorporates learning from psychology. The x-axis represents impact ‘change’ (made up of, for example, magnitude, scale, severity, etc.) and the y-axis represents ‘probability’. The dots represent the ‘fact of an impact’ (according to probability and change) and the ‘meaning of an impact’ (as influenced by values and psychological factors, which is the focus of this paper). The fact and the meaning of impacts are plotted relative to a predetermined significance threshold shown as a dotted line. In some instances, the fact and meaning of an impact align and in other instances the perceived meaning of an impact will be of lesser significance or greater significance than the fact of the impact.



**Figure 2:** *The psychology of significance judgements in EIA (also compare Table 1)*

**3.1 Decide thresholds - Step 1**

Deciding on thresholds to guide significance determination is potentially a very complex process, especially for large developments in sensitive environments. Such EIAs typically produce a long and convoluted list of potential impacts and significance thresholds, that are difficult to deal with. There are two concepts in psychology with particular relevance to the process of deciding on thresholds namely, ‘loss aversion’ and ‘possibility and certainty effect’.

3.1.1 Relevant concepts from psychology – Step 1

One of the most significant contributions from psychology, applied to behavioural economics, is the concept of ‘loss aversion’, which shows that in decision making, losses are given more prominence or weight than gains (Rozin and Royzman 2001). For example, golfers tend to concentrate more when putting to save par (i.e., avoiding loss) than putting for birdie (i.e., achieving a gain) (Kahneman 2012, p303). Carstensen et al (2004) found that success in long term relationships depends much more on avoiding the negative than on seeking the positive, at a ratio of 5 to 1. Research exploring behaviour during negotiations shows that it is much more difficult to negotiate about shrinking profits because it involves assigning losses, than negotiate about and expanding profits which assigns gains. The message is that negativity dominates thinking. Significance judgement and thresholds are steeped in loss aversion thinking, as opposed to focusing on benefits or gains. How can thresholds for gains be developed, for example? In other words, at what point do we stop minimizing impacts and starts achieving net gain? This insight is profound for EIA in general and significance judgements in particular. Decades ago, Brown and McDonald (1995) argued that the focus of EA on ‘impacts’ is too negative and places undue attention on losses rather than on achieving gains. Others have even suggested new terms such as ‘benefits assessment’ in an attempt to move away from ‘impact minimization’ (King 2009; João et al 2011), but with seemingly little success, which could at least in part be explained by the ‘loss aversion’ literature.

Decisions and choices of significance thresholds are based in part on the need to consider the severity of a particular effect versus its probability of occurring. However, what psychologists have shown is that utility and probability experience varies (Loewenstein et al 2001). For example, consider the following possibilities of winning $1 million:

1. From 0 to 5%
2. From 5% to 10%
3. From 60% to 65%
4. From 95% to 100%

Although the above example shows that the utility to win $1 million increases by a constant 5%, the experience of each option varies significantly. The 0 to 5% option has been described as the ‘possibility effect’ with high psychological value. The next option from 5% to 10% does not present an equivalent increase in value. On the other hand, the 95% to 100% also has a significant psychological impact and is referred to as the ‘certainty effect’. Therefore, percentage change in psychological value is not constant which suggests a different psychological spectrum around probability. The two ends of the spectrum show the largest psychological effect, either by introducing the possibility of winning or providing extreme certainty of winning in the case of gambling. The notion that there is a psychological value to probability of occurrence that is not constant across the probability spectrum (i.e., 0 – 100%) presents much food for thought. It implies that in cases of low probability (0-5%) the mere fact that there is a possibility has a disproportionate psychological effect, i.e., ‘possibility effect’. To shift the probability from 5% to 10% or even 20% will not lessen the psychological effect to the same extent. We do not think along constant percentage scales. For example, the siting of nuclear power stations raises serious probability issues around nuclear disasters. Although the probability is very low, the fact that it is at all possible triggers the ‘possibility effect’. The understanding that the psychological value of probability is inconsistent, has serious implications for thinking about mitigation (step 4) and the application of for example the precautionary principle. Scruton (2012) makes the case that the utility of the precautionary principle in decision making is limited due to a lack of agreement on when, and how, it should be applied.

The psychological effect at the extremes of the probability spectrum is therefore also disproportionate to the actual risk. Psychology specifically explores the way people deal with rare, unlikely or new events that shows people overestimate the probabilities of such events as well as assigning undue weight to such events in decisions (Fox 1999, p325). The possibility and certainty effect also suggest that where probability is not quantified perceptions might tilt the scale to either of the extremes. For example, entrepreneurs and investors in new ideas are known to overestimate their chances of success (Kahneman 2012, p326). Similarly, people tend to overestimate their chances of being affected by a terrorist or shark attack. It is also important to note that the psychological value of possibility will differ for different stakeholders. For example, local communities and conservationists are known to have a much lower appetite for risk than developers, while government is driven by political agendas, so their appetite fluctuates depending on the political climate (Morrison‐Saunders and Bailey 2009). In short, thinking about probability is exceedingly value driven and not rational.

3.1.2 Implications for applying the significance spectrum model – Step 1

The two concepts discussed above have direct implications for the determination of a significance threshold as the first step in the significance judgement process that aims to guide decision making as to the relative acceptability of predicted impacts – see Figure 2. In certain instances, these significance thresholds result from quantitative objective science incorporated into regulation, for example minimum standards relating to water quality, air quality or noise. Even though such thresholds are easy to deal with and seem clear, they are also ultimately based on subjective judgements related to human health tolerances and agreement that poisoning people is undesirable. However, in areas such as visual, heritage and biodiversity impacts where significance thresholds are highly subjective and where law and policy are silent, the subjective nature of these determinations means that psychological factors are even more relevant. To place the threshold of significance in such instances is cognitively difficult. Moreover, from a psychology perspective decision making losses are given more prominence or weight than gains (loss aversion) which explains the obsession with minimising impacts and the resistance to thinking about gains. We could therefore expect thresholds to fail in their attempt to improve the status quo, rather based on our psychological inclination we should expect thresholds to avoid losses and thereby merely slow inevitable regression. Furthermore, the percentage change in psychological probability value is not constant across the significance spectrum with the two ends of the spectrum showing the largest psychological effect (possibility and certainty effect). This means that we are wired to over, or underestimate impact significance when considering and designing significance thresholds.

**3.2 Make predictions - Step 2**

There are three concepts in psychology identified as having potential relevance to prediction, namely ‘expert fallacy’, ‘clinical versus statistical prediction’ and ‘expert intuition’, and another which has relevance to both prediction and the judgement of acceptability, ‘WYSIATI’.

3.2.1 Relevant concepts from psychology – Step 2

The psychology literature shows that we tend to jump to conclusions even in the face of very limited information (Kahneman 2012, p85). This understanding has led to the ‘WYSIATI’ acronym that stands for, ‘what you see is all there is’. Research by Brenner et al (1996) showed that people construct opinions based on the information that is presented, even if they are aware that the information is biased or one-sided. Moreover, seeing only the biased one-sided information led to participants being even more confident about their conclusions than those who were given the balanced information. So, humans are happy to draw conclusions based on limited and even obviously biased information. As Kahneman (2012, p87) states, *“As the WYSIATI rule implies, neither the quantity nor the quality of the evidence counts for much in subjective confidence. The confidence that individuals have in their beliefs depend mostly on the quality of the story they can tell about what they see, even if they see little. We often fail to allow for the possibility that evidence that should be critical to our judgement is missing – what we see is all there is.”* and *“It is the consistency of information that matters for a good story, not its completeness. Indeed, you will often find that knowing little makes it easier to fit everything you know into a coherent pattern.”*

The WYSIATI idea talks to the way humans make predictions in impact assessment. Generally, EIA is described as a decision aiding tool which provides decision makers with information about the consequences of actions. What the psychologists say, is that what is put on the table, is what is considered. Normally what is put on the table starts with the proponent’s ideas. Practitioners and government are then mostly guided and influenced by the initial thinking of the proponent. Much has been said about the need for objectivity in EA and the role of science in achieving the perceived objectivity (Bartlett and Kurian 1999; Owens et al 2004; Cashmore 2004), but if it is agreed that all the possible information is never available and that EA functions on the best available information it leads to the WYSIATI effect. This might typically mean that the predictions made do not reflect or consider the most relevant data, but are rather based on what could be gather as secondary data, or collected as primary data cheaply. Moreover, recent psychology research shows that personality traits also influence the extent to which we are attentional specialists and attentional generalists, in other words how and where we focus our attention (Swift et al 2020), that further emphasize the subjective nature of of how we deal with information and data.

Related to the discussion about WYSIATI is the question around whose opinion to trust? Trust is a very important ingredient in significance determination. The level of trust in the significance information provided during the EA process will have a direct influence on the meaning assigned to significance by different affected interests. For example, if there is a high level of trust in the significance judgement and the outcome of the significance judgement is ‘low significance’ then it is reasonable to expect affected parties to generally support such an outcome, and vice versa. However, the ‘expert fallacy’ concept suggests that when it comes to trust we are exceedingly lazy thinkers, and our brains take a surprising number of shortcuts. The psychology literature suggest that we trust people without really knowing much about them, giving undue weight in our judgement to appearance (how they look) and occupation (what they do) (Morewedge and Kahneman 2010; Nauts et al 2014). Furthermore, a person in authority is generally given more trust, whether that authority is due to position (for example policemen, fire fighter, etc.), qualification (doctor, accountant, lawyer, etc.), or financial status (for example rich businessman or entrepreneur). We therefore make decisions on competence and trustworthiness based on seemingly trivial/unrelated factors such as appearance and occupation. According to the ‘expert fallacy’ factors that could influence the meaning of significance include g*eneral overconfidence in specialists*: Trusting experts at face value could leave room for manipulation of the credibility of outcomes, especially in cases where there is a high level of uncertainty around significance judgements anyway. Cashmore et al (2008) show the influential role that experts play by demonstrating that power, agency, and agenda operated to dictate what knowledge was influential, and hence important, rather than what counted as knowledge *per se*; that is, they determined which rationalities and realities environmental assessment procedures needed to engage with and, in part, how. The point made is that the developers controlled which stakeholders participated in the process, and therefore controlled the expertise that was brought to bear. The only way to counter specialist opinion is to appoint additional similar specialists. Due to the confusion this creates the distrust of specialists is one of the most difficult challenges to resolve, because it raises the question ‐ which specialist is correct and which specialist should be trusted? Our natural tendency is to trust specialists, so it is important to avoid the creation of mistrust which is very difficult or even impossible to fully resolve.

One of the main areas of psychology research which has particular relevance for significance determination is the work done on ‘clinical versus statistical prediction’. The question asked is whether clinical prediction based on subjective opinions by trained professionals is more accurate than statistical prediction based on scores assigned according to a particular rule? An important early publication on this topic was by psychologist Paul Meehl entitled, *‘Clinical vs Statistical Prediction: A theoretical Analysis and a Review of Evidence’* (Meehl 1954). In it Meehl pulled together the results of 20 research studies which went on to show that statistical prediction was far superior to clinical prediction. According to Kahneman (2012, p223) the outcome of the research *“ … provoked shock and disbelief among clinical psychologists, …”* and provided the basis for a stream of research which still endures 50 years after the publication with more than 200 studies having been conducted on the comparison between clinical and statistical prediction covering a vast spectrum of everyday life such as prediction of university performance, parole violations, pilot training, criminal recidivism, prospect of success for new businesses, longevity of cancer patients, etc.. These contexts are described as ‘low-validity environments’ because they represent a high degree of uncertainty and unpredictability. The outcome remains constant with around 60% showing significantly better accuracy for statistics (typically in the form of algorithms). The remaining 40% of studies show a tie. Meehl (as quoted by Kahneman 2012, p223) concludes that *“ … there is no controversy in social science which shows such a large body of qualitatively diverse studies coming out so uniformly in the same direction”*.

There are three reasons put forward to explain why experts fare worse than statistics. Firstly, experts overcomplicate the prediction by introducing too many variables and possible explanations. They try to be too clever. Secondly, people are generally inconsistent in making judgements of complex information. When presented with the same set of complex scenarios people frequently give different answers. For example, a particular study of radiologists found a 20% inconsistency when shown the same X-ray picture on different occasions (Hoffman et al 1968). This general trend has been confirmed in 41 other studies in the diverse fields such as business management and medicine (Schanteau 1988). The third factor is that statistics, formulas and algorithms do not suffer from contextual interference. This means that significance thresholds that can reasonably be used quantitatively, produce easier and more accurate outcomes than reliance on subjective expert value judgements.

Although expert judgement should be considered with caution accurate ‘expert intuition’ is, according to Klein and Bloom (1995) a skill that can be developed. Extensive work done on the expert intuition of fire fighters has shown remarkable accuracy based on skill and experience. The explanation is that intuition is nothing other than recognition and that with enough experience in a particular field of expertise intuition or recognition of scenarios and possible solutions are almost second nature. So, when can an intuitive judgment be trusted? There are two conditions namely, that the environment is sufficiently regular to be predictable and that there is an opportunity to learn the regularities through prolonged practice (Kahneman and Klein 2009). When these conditions are present the skill of more accurate intuition can be achieved, while in low validity noisy environments intuition should not be trusted and one is better off using algorithms. The lack of long-term monitoring or longitudinal research on impact prediction in EIA means limited statistical evidence to work from. Because significance judgments and prediction functions in a highly unpredictable context, accurate expert intuition would be exceedingly difficult to achieve, except maybe in cases where it relates to historically well-established scientific fields dealing with generic impacts. In the words of Kahneman (2012, p220), *“The first lesson is that errors of prediction are inevitable because the world is unpredictable. The second is that high subjective confidence is not to be trusted as an indicator of accuracy (low confidence could be more informative)”*. Therefore, what is required for more accurate prediction is continual critical reflection and testing of our intuition, combined with a general recognition of the limitations and assumptions that underpin our thinking (as suggested by Bond et al 2011). Moreover, it is also suggested that better decisions are made when there is wide consultation (Gibson 2005; Sinclair et al 2008). So, introspection is recommended and especially being critical of intuition, but others should also be involved in decision making. The ‘wisdom of the crowd’ concept clearly enforces this notion that independent views could, if correctly harnessed, provide innovative new solutions to difficult problems which is beyond the wisdom of individuals (Surowiecki 2005).

3.2.2 Implications for applying the significance spectrum model – Step 2

Ultimately predictions can be based on what is considered objective facts such as water discharge quality (fact of water quality impact) or the line of visibility of a particular development (visual impact) as well as the meanings through subjective value judgements - see Figure 2. What we have gained from psychology is more insight into how these meanings are derived. For example, we are willing to make judgements with limited information even if we know the information to be biased (WYSIATI). Moreover, this effect could be exacerbated by high levels of trust in those making the judgements based on factors such as appearance and occupation (expert fallacy). We therefore tend to be overconfident in specialist opinions. This is risky because psychology research shows that statistical prediction is much more accurate than specialist opinion (clinical vs statistical prediction). Expert opinion should only be trusted in cases where the environment is sufficiently regular to be predictable and there has been sufficient opportunity to learn the regularities (expert intuition). Considering the fast-changing environment and high level of uncertainty within many specialist fields within the environmental assessment context, expert intuition could reasonably be expected to in many cases produce unreliable results.

**3.3 Judge acceptability before and after mitigation - Steps 3 and 4**

There is one psychology concept relevant to step 3 only, namely ‘paradox of choice’, with another three psychology concepts identified as being relevant to both steps 3 and 4 namely ‘priming and framing’, ‘effect heuristic’ and ‘cognitive ease’. These concepts mainly deal with how we communicate and present information to influence judgements. In this case judgements about acceptability or significance of impacts pre and post mitigation.

3.3.1 Relevant concepts from psychology – Steps 3 and 4

Barry Schwarts in his book entitled ‘The paradox of choice’ explains how too many choices causes paralysis and regret and leave individuals less satisfied. More choice also leads to higher expectations which opens the door to regret. Humans tend to avoid pain just as much as they seek pleasure. When more and more options are available for a decision humans try to avoid the feeling that they are missing out. For example, having to choose between three types of ice cream is less stressful than having to choose between 20 types of ice cream. To choose between only three options also allows humans to operate with little cognitive strain. Even if humans have managed to choose between 20 types, a level of regret and uncertainty over whether the correct decision has been made is till retained. Moreover, research shows that the cognitive abilities of humans to choose between options are limited to around seven variables. This ‘magic number’ was first introduced by Miller (1956) and has since been confirmed by numerous other studies (e.g., Kahneman and Tversky 1984; Beike and Sherman 1998). Significance rating methods have been criticised for introducing too many impacts and thresholds in an attempt to be risk averse and avoid excluding impacts (Morrison-Saunders et al., 2014; Retief et al., 2014). This creates a snowball effect throughout the significance determination process as each impact needs to be considered against a particular threshold. The learning from psychology suggests that decision makers are sensitive to having too many impacts and thresholds to consider and ideally overall significance judgements should deal with around seven key impacts at any one time. Cognitive limitations in dealing with excessive information should be kept in mind when deciding on the number of thresholds (which is linked to the number of impacts) and also the comparability of the types of thresholds. For example, quantitative thresholds based on water and air quality standards are very different from cultural or heritage impacts thresholds and standards, yet they all need to be considered in an integrated manner when making decisions. However, the number of impacts to consider is ultimately based on the outcomes of the scoping process, which tends to deliver broad scopes to avoid the potential for legal action. So, whilst in dealing with thresholds, we have to recognize our limits in dealing with complex information, delivering a scope conducive to the cognitive limitations of decision makers is not a trivial matter.

Psychology has a long history of investigating the mechanisms influencing how we gain understandings and communicate by exploring our ability to make associations. Initial research in the 1980s showed that we make associations when we hear certain words (Kahneman, 2012). For example, if you have recently heard the word ‘EAT’ you are more like to complete the word fragment SO\_P as SOUP rather than SOAP. This effect is referred to as ‘priming’, the word EAT primes the idea of SOUP. For example, reference to money has different conscious and unconscious psychological effects including social distress and physical pain (Xinyue et al 2009). Moreover, research found that money‐primed individuals become more independent and exhibit increased self‐reliance and selfishness (Vohs et al 2006). In short money primes individualism. Therefore, being continually reminded of money may subconsciously shape behaviour and attitudes. The theme of money is central to many impact assessments typically with reference to the contribution of the development to the regional economy and the value of the employment to be created. The use of cost benefit analysis is a well‐known attempt to convert environmental and social decisions to monetary value to make choice easier for decision makers (Hardisty 2010). However, psychology research shows that the conversion of certain non‐commodities (defined as objects that cannot be traded in markets for example objects with intrinsic and aesthetical value) to monetary value violates strongly held value systems and is considered morally offensive or even taboo (Fiske and Tetlock 1997). For a more detailed discussion on how these value systems relate to dealing with trade‐off decision making in impact assessment, see Retief et al (2013).

The applicability of priming for acceptability judgements lies in the associations made with key concepts and terminology. For example, the use of the word ‘impact’ primes negativity while the word ‘conservation’ might in some contexts, prime images of privilege and exclusion. There have been calls, especially from experience with state of the environment reporting, to move away from words such as ‘impact’, ‘green’, ‘ecosystem’ and ‘conservation’ and to rather use words such as ‘quality of life’, ‘sustainable services’ and ‘human well-being’ which could cover similar ground but is bound to have more traction with decision makers (Retief et al., 2011). Research by O’Neill and Nicholson‐Cole (2009) on the role of visual, and iconic, representations of climate change illustrate how the way information is presented affects people’s attention and level of engagement with the issue. They found for example, that nonthreatening imagery and icons that link to individuals' everyday emotions and concerns in the context of climate change tend to be more engaging than threatening messages. It would be interesting to better understand the associations that decision makers have to some of the complicated and poorly defined concepts typically used in sustainability assessment, such as ‘intra‐generational equity’, ‘social capital’, ‘ecosystem services’, etc. It is therefore important that we consider priming against the terminology and concepts typically used when judging acceptability. It would be interesting to better understand the associations decision makers have to some of the complicated and poorly defined thresholds on which acceptability is based such as ‘irreplaceable’, ‘vulnerable’ and ‘least threatened’.

The concept of priming also considers the order of things or how they are framed. Typically, the first information you hear stands out and your brain uses that to colour all later information. Therefore, in an interview it would be more advantageous to start with positive information about yourself than negative. Order of information / words makes all the difference – you want to start with your best foot forward. Your brain takes shortcuts to avoid cognitive fatigue and starts to ignore later information. The order of things matters, for example, a study of German students asked two questions to test correlation (Kahneman 2012, p101):

How happy are you these days?

How many dates did you have last month?

The aim was to test the correlation of happiness and the number of dates. Surprisingly the correlation between the two answers were zero, because dating was not the first thing that came to mind when thinking about their happiness. However, when the questions were reversed, and the interviewer asked about the number of dates first, the correlation was significant. The explanation is that the emotions triggered by thinking about your romantic life (be it positive or negative) influenced the follow-up question on happiness. Kahneman (2012, p88) states with reference to ‘framing’, *“Different ways of presenting the same information evoke different emotions. The statement that “the odds of survival one month after surgery is 90%” is more reassuring than the equivalent statement that “mortality within one month of surgery is 10%”. Similarly, cold cuts described as 90% fat free is more attractive than when they are described as 10% fat.”*

In acceptability judgements it is also apparent that the order and the way in which results are presented and/or the message might significantly influence the ultimate outcome. This holds true for the communication between the developer and the assessment practitioner, because the general expectation would be that the developer emphasizes the opportunities and downplays the impacts of what is being proposed. Moreover, when the practitioners interact with the community it is possible to unintentionally manipulate the audience and therefore the outcome. For example, the order of the information influences the correlation made between different information. Similar to the happiness experiment above, correlation could be tested by the following two questions:

How acceptable is the proposal?

How many new roads will be built?

According to the psychology literature it is reasonable to expect the correlation between the two questions will be lower if the question about roads is posed second. If the question about roads were to be asked first the association between transport infrastructure and acceptability will be made and the correlations can be expected to be higher. It is perhaps not a surprise that developers tend to start the description of their particular development with the socioeconomic benefits.

Work done by Slovic et al (2002) also shows that likes and dislikes colour beliefs about the world. For example, if someone likes a particular project, one would, also expect them to believe its costs are low and its benefits are high. Slovic et al (2002) calls this the ‘affect heuristic’. Kahneman (2012, p103) states in relation to this effect that, *“Your emotional attitude to such things as irradiated* *food, red meat, nuclear power, tattoos, and motorcycles drives your belief about their benefits and risks. If you dislike any of these things, you probably believe that its risks are high and its benefits negligible.”* What the ‘affect heuristic’ means for judging acceptability is that stakeholders involved in the EIA process have preconceived biases towards certain outcomes, which are very difficult to change or influence. This also means stakeholders’ reactions to certain proposals can be anticipated. For example, those of us who enjoy golf might be more convinced of the value of golf estates than non‐golfers. It is therefore maybe no surprise that golf courses were excluded from the list of projects subject to EIA when the EU EIA Directive was first adopted (Bond 1997). This means that when communicating benefits and risks of key controversial issues it is advisable to have some understanding of the potential biases of the audience, be it the public or government. The aim is not to radically change people’s convictions but rather to anticipate the potential effect emotional attitudes might have for acceptability judgements.

Because we avoid the cognitive strain the way to communicate a persuasive and believable message is to evoke ‘cognitive ease’. Research suggests that the way a message is presented will influence cognitive ease, for example by maximising contrast between characters and the background, or the use of colours such as blue or red rather than green and yellow. Moreover, Oppenheimer (2006) found that couching familiar ideas in pretentious language is taken as a sign of poor intelligence and low credibility. Kahneman (2012, p63) agrees when he states, *“If you care about being thought credible and intelligent, do not use complex language where simpler language will do.”* and, *“If possible, the recipients of your message want to stay away from anything that reminds them of effort, including a source with a complicated name.”* Simple, versed language increases memorability and is more likely to be accepted as the truth. The message therefore is that, to communicate the outcome of the significance judgement effectively keep the message simple and memorable. This is not an entirely new insight for impact assessment, which has always understood that decision makers do not read long scientific reports. However, addressing this weakness seems to be easier said than done, as research on impact assessment report quality has shown (Sandham et al 2013). Therefore, much thinking still needs to be done around the effective communication of significance determination outcomes.

3.3.2 Implications for applying the significance spectrum model – Steps 3 and 4

In view of the above the placement of impacts in relation to an identified significance threshold in order to determine significance acceptability before and after mitigation during steps 3 and 4 is potentially extremely challenging. The psychology literature suggests that the meaning of an impact relative to the significance threshold is potentially influenced and even manipulated by various factors. This includes the way we communicate and even the order in which we present impacts to decision makers (priming and framing). The clarity and simplicity of our language affects the believability of what is being communicated (cognitive ease). Furthermore, our attitudes and personal dislikes also potentially determines the meaning we assign to significance judgements (affect heuristic). These psychological effects could lead to increasing misalignment between the factual impact and the meaning of the impact with potential implications for EIA practice. For example, should the occurrence of an impact be considered unacceptable because it is predicted to be above the significance threshold for water quality, the meaning of the impact would also be unacceptable - see Figure 2. This is where thresholds are clear and represent a generally unacceptable impact to communities. However, it could also reasonably happen that community attitudes and personal value assigned to, for example, biodiversity loss be below what might be thresholds in the form of protection status of species. In such cases the meaning of an impact would lower the acceptability threshold below the fact of an impact, i.e., number of species impacted - see Figure 2. It could also happen that the fact of an impact, in the case of nuclear radiation, falls below the acceptable significance threshold, however, surrounding communities might experience the psychological meaning as above the significance threshold - see Figure 2.

It is also anticipated that integrating multiple significance judgements across different thresholds is problematic for decision makers (paradox of choice). This is explained by the psychology literature that shows we struggle cognitively to deal with multiple variables, with more than seven suggested as the magic number. Scoping typically inflates the number of variables to be considered by decision makers, and therefore this has implications for the judgements subsequently made.

These examples shows that psychological factors could result in various permutations of impact meaning that needs to be acknowledged and ideally anticipated in EIA practice.

**4. Learning from psychology to inform future EIA practice**

The aim of the research was to gain a deeper understanding of the psychology underpinning significance judgements in EIA with a view to inform future significance evaluation practice. This was achieved by drawing on the psychology underpinning significance judgements in EIA. We however recognize that the learning from psychology presented in this paper serves merely as the proverbial ‘tip of the iceberg’ or ‘the ears of the hippo’. In many instances the discussion is illustrative of the kinds of learning the field of psychology could contribute. As a field of science psychology is hundreds of years old with a well-established and vast research tradition. Therefore, this paper is probing in its intention to explore the interface between EIA and psychology. In an attempt to inform future EIA practice, the following seven main learning point are highlighted:

* *Decide on limited number of key thresholds*: The psychology literature suggest that when it comes to thresholds, less is more. Thresholds should ideally serve to produce cognitive ease by limiting the complexity and number of thresholds to consider in significance judgements. Applying the significance spectrum model to a single valued component or impact seems relatively straight forward. However, what the significance spectrum model fails to address is the consideration of multiple significance judgements across different thresholds which is cognitively exceedingly challenging (paradox of choice). In practice therefore this means that effective screening and scoping is important to ensure we limit the number of thresholds to only those dealing with key impacts or valued components.
* *Design thresholds with future gains in mind*. This paper shows that losses are given more prominence than gains (loss aversion) so ways should be found to ensure that the thresholds we use represents, or results in, improvement over time and not mere minimization. For example, having water quality standards that leads to improvement in water quality or biodiversity loss thresholds that increase species abundance not merely avoiding further loss.
* *Reconsider probability scoring*: Learning from psychology suggest that the percentage change in psychological probability value is not constant across the significance spectrum, with the two ends of the spectrum showing the largest psychological effect (possibility and certainty effect). This means that a typical ‘low’ probability score for a particular impact is not psychologically considered or experienced as ‘low’ by those affected. In practice this might suggest that in certain cases even ‘low’ probability should still be considered ‘high’ significance in view of the psychological value placed on probability. For example, the probability of a catastrophic impact related to a nuclear power plant might score ‘low’ (fact of the impact), but still be experienced as ‘high’ (meaning of the impact) by those potentially affected.
* *Avoid significance judgements based on limited information*: The research suggest that we are willing to make judgements and decisions with limited information even in cases where we know the information to be biased (WYSIATI). In practice we are readily confronted with limited and biased information. However, practitioners should constantly strive towards rational and transparent science-based decisions and guard against the temptation to make snap judgements. In cases where information is limited and biased, practitioners should rather apply the precautionary principle.
* *Prefer statistical prediction over expert opinion*: We tend to be overconfident in specialist opinions based on appearance and occupation (expert fallacy). This paper found that according to psychology research statistical prediction is more accurate than specialist opinion (clinical vs statistical prediction). The EIA decision making context is too unpredictable and fast-changing to over rely on expert intuition and opinion. The use of expert opinion should maybe be limited to the screening and scoping phases and not as the sole basis for significance judgement.
* *Communicate carefully*: The meaning of a significance judgement can be influenced and even manipulated by the way we communicate. This is achieved by the specific words we use, the order in which we present words and information and the clarity and simplicity of our language (priming and framing; cognitive ease). This effects the understanding and believability of the significance judgement being communicated. Because communication is such a multifaceted and complex topic, we recommend a communication guideline be considered that can deal with these issues in depth. This is especially relevant in a time when rapidly changing information technology affects the way society communicates (Retief et al, 2016). The influence of information technology on EIA is also a growing area of research (Wardekker et al, 2008; Wood, 2008; Ross, 2018; Duarte and Sánchez, 2020).
* *Consider personal attitudes and biases*: Our personal attitudes, biases and dislikes potentially influence the meaning we assign to significance judgements (affect heuristic) which means that practitioners could (even subconsciously) influence outcomes. Although the personal values of practitioners can never be fully divorced from their role in significance judgements, it is the relevant stakeholder values that matters most in decision making, and which should be reflected in the EIA outcomes.

As an ‘art’ and a ‘science’ EIA is expected to produce significance judgements that give meaning (Beanlands and Duinker, 1983; Sippe, 1999; Wood, 2003; Owens et al, 2004; Lawrence, 2007) and the subjective meaning of impacts (or its importance) outweighs its characterization (Sadler and McCabe, 2002). It is precisely because of this, that the EIA community should embrace and mine fields such as psychology to further inform our understanding of how to deal better with significance judgements. We hope that this paper provides a step in this direction.

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