

Behavioural Estimating - Observations on the Psychology of Cost Estimating

by Dr Mark Gilmour and Mr Dale Shermon, QinetiQ,

mwgilmour@QinetiQ.com dshermon@QinetiQ.com

Can psychology and sociology teach us to be better estimators?

Abstract - *It is well known that a credible and justifiable cost estimate or forecast cannot be created in a vacuum. When compiling a cost estimate a cost estimator will typically have to interact with a wide range of stakeholders and subject-matter experts. When people interact with an estimate there is inevitably an opportunity to influence it. This paper will consider some of the human characteristics observed during estimating, their potential impact on our estimates and what psychology and sociology can teach us about why they occur. The paper constitutes step one in a two step process, with the second step being to understand what mitigations we can put in place to protect our estimates from any potential negative, people-based, influences in the future.*

1 Introduction

In these austere times where financial resources are becoming increasingly tight and the demands for budgets is becoming ever more competitive, the need for credible and justifiable costs estimates is as great as it can be. Cost estimating has a strong 'People' element and as a consequence individuals often have the ability to influence, either implicitly or explicitly, the estimates that they are involved in generating. This ability to influence can lead to corruption of the estimates. This paper is the first step in an exploration by QinetiQ [1] of some of the human characteristics observed during estimating, their potential impact on our estimates and what psychology and sociology can teach us about why they occur. The ultimate aim of this piece of work is to understand what mitigations we can put in place to protect our estimates from any potential negative, people-based, influences in the future. The work stems from an understanding of a similar approach that has been used within the field of economics, where psychology and sociology has been used to explain and understand divergence of observed economics from that which traditional economic theory would suggest should happen.

This paper begins by setting this piece of work within the framework of QinetiQ's Knowledge Based Estimating philosophy (KBE) and introduces the idea of the ideal cost estimator. It presents an idealised view of the behaviours of this individual, and the individuals with whom they engage when compiling an estimate. This view is then contrasted with some real-life observations of actual estimator behaviours, which naturally leads on to a consideration of the psychological and sociological concepts that can help explain these behaviours (see Figure 1). The second phase of the work, which has yet to be conducted, is the design and running of experiments to demonstrate and measure the likelihood and impact of such positive or negative behaviours within the estimating process, such that strategies can be put in place to identify and mitigate against them and to ensure that our estimates are not corrupted by them.

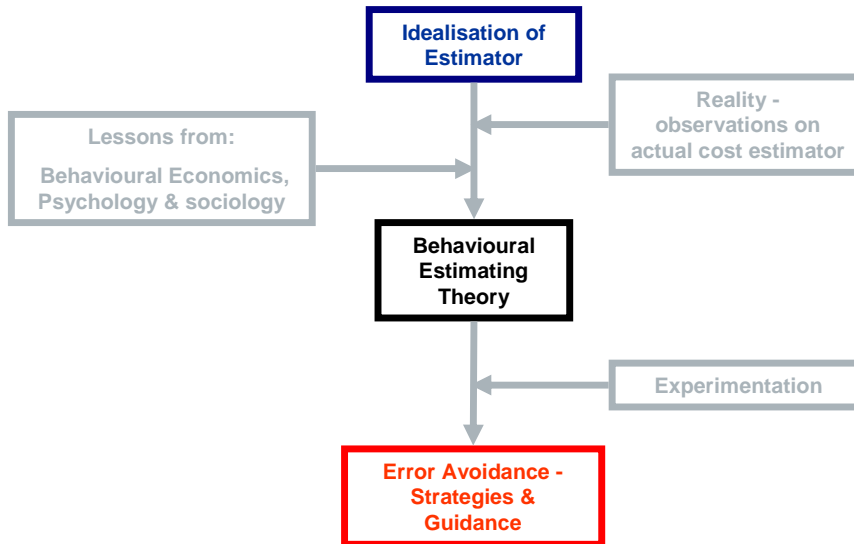


Figure 1: QinetiQ’s Behavioural Estimating Study Process

2 Knowledge Based Estimating (KBE)

QinetiQ cost forecasts and estimates are underpinned by its philosophy of Knowledge Based Estimating (KBE) (see Figure 2). This values the importance of knowledge and skills for generating credible and justifiable cost estimates. The building blocks that form the foundation of Knowledge and Skills are Data, Tools, People and Processes.

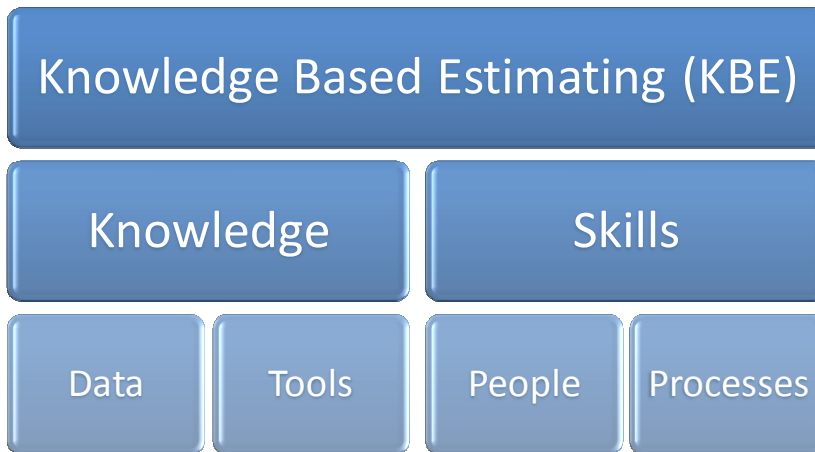


Figure 2: KBE

Within the context of QinetiQ’s KBE philosophy ‘Data’ is defined as any information, both cost and technical, concerning historical projects that will be used as the basis for future estimates, whilst also extending out to information about the technical or programme characteristics of future projects or services. ‘Tools’ are defined as the software systems that help cost estimators to interpret historical data, such as statistical tools, that can be used to create cost estimating relationships (CER), or other tools that allow the application of such relationships to generate estimates.

‘People’ within KBE are recognised as being needed to interpret historical data and predict the concepts for the new projects and services that will satisfy the perceived

capability or requirements. Cost estimators need the formal qualifications to justify their professionalism and the effective interpersonal communication skills to elicit the data from finance, project staff and customers. Finally, 'Processes' are necessary so that people conduct an estimate in a rational, repeatable way, ensuring that the outputs are traceable to source data and assumptions.

The remainder of this paper focuses on the 'People' element of cost estimating. Whether it is in relation to the cost estimator or the subject matters experts with whom the cost estimator must engage in order to elicit costing assumptions; where individuals interact with the cost estimating process, they have the opportunity to influence the ultimate estimate, and that influence may act to compromise the estimates validity. It is important to understand and recognise where such interactions could impact the estimate and understand what measures could be put in place to protect against them, to avoid the estimate being corrupted.

3 KBE and the Ideal Cost Estimator

In this paper we identify a number of different actors within the cost estimating process:

- **Cost Estimator** - this is the individual responsible for conducting cost estimates on the behalf of their organisation. These estimates could be to support proposal developments, inform studies or requests for funding.
- **Subject Matter Expert** – often an engineer – this is a technical subject matter expert within the organisation, or the domain or perhaps even from outside the immediate domain but who's knowledge will have value within the context of creating an estimate. They are typically consulted by the estimator for their technical understanding of the problem when an estimate is being compiled.
- **Organisation** - this is the organisation in which the cost estimator resides. In the example of the UK defence industry, this could represent a supplier organisation, or could represent the Ministry of Defence (MOD) Defence Equipment and Support (DE&S).
- **Market/ Domain/ Customer** - This is the market or domain in which the estimator and organisation reside, and is often highly influenced by the needs of a specific customer, or type of customer. In the example of the UK defence industry this could be considered the UK defence market as a whole, or perhaps a user of defence equipment such as the Royal Navy or Royal Air Force.

Expanding upon the 'People' pillar of KBE, we focus on the 'Cost Estimator' as being the principal actor within the cost estimating process. In an ideal world we expect this individual to:

- Understand costing requirements and understand the importance of cost estimates for supporting decision making, and to be able to communicate these to decision makers;
- Be able to communicate effectively with a diverse range of stakeholders and individuals from government, industry and the user community (in the defence domain - the armed forces);
- Understand technical and programmatic characteristics of new concepts;
- Have the ability to source data in relation to historic systems and to draw analogies with them and current concepts;

- Objectively interpret historical data, define cost drivers and identify logical Cost Estimating Relationships (CERs);
- Apply CERs and develop rational estimates;
- Be the first line of scrutiny for their own estimates;
- Confidently present (sell) results to peers and decision makers;
- Defend results under external scrutiny.

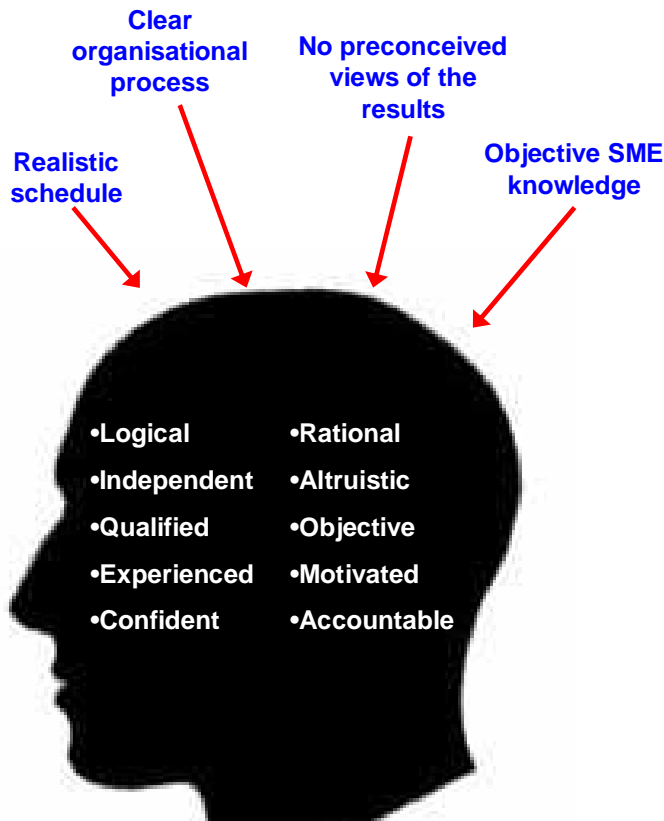


Figure 3: The Ideal Cost Estimator – “Homo Estimatus”

In doing these things, as is observed in Figure 3, we expect these individuals to act logically, to remain independent and objective, to be appropriately qualified and experienced, to work confidently and rationally, all whilst putting the needs of the organisation within which they sit before their own needs. In addition we also hope that they have a genuine interest in the systems for which they are generating the estimates. Ultimately we ask that that our estimators are willing to be held accountable for the estimates that they generate.

In addition to this we expect the organisations (and their management) within which estimators sit not to impose any unrealistic constraints upon them when carrying out their estimates (i.e. tight timescales), to be explicit concerning the expectations of any organisational estimating and assurance processes that they must follow, not to have any preconceived expectations as to what value the estimate will have, and to be able to provide them with objective knowledge, data and assumptions with which to generate their estimates.

So if all these things were to happen in practice, combined with the right data, tools and processes, why do we so often get our estimates wrong?

Economics realised a similar phenomenon. Traditionally based on the idea of '*Homo economicus*', economics postulated that humans are rational and narrowly self-interested individuals who have the ability to make judgments toward subjectively defined ends and who maximise utility as a consumer and economic profit as a producer[16]. This model of humans was used as the backbone of traditional economic theory. The application of such a model however often generated outcomes that were at odds with what was being experienced in practice. Consider for example that individuals in reality have bounded rationality, they make emotional decisions, and there are many instances in which they act altruistically, and it becomes evident why in certain circumstances such a model would fail. To overcome some of these shortfalls, the field of Behavioural economics was borne, which looked to the fields of psychology and sociology to create a more credible model of the human, and which could help explain some of the real life observations within the field of economics[12]. Can something similar be done within the field of cost estimating, to explain why cost estimators, and those involved in the cost estimating process, often behave in a manner that differs from how we would expect them to behave?

4 The Real Cost Estimator

The behaviours that we observe in our estimators and their organisations, and the people with whom they engage, vary somewhat from the ideal case. Our cost estimators engage with - and run the risk of having their estimates influenced by - their peers and SMEs, by their organisations, and by the market or domain in which they sit (see Figure 4).

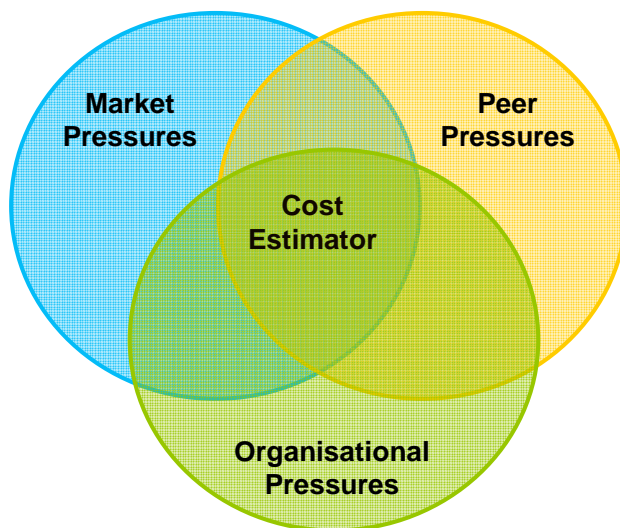


Figure 4: Cost estimator influences

As is portrayed in Figure 5 people are, by virtue of being human, illogical and emotional, they often allow themselves to be influenced by others, they don't always have the necessary experience or qualifications that we would like them to have to undertake the cost estimating activity, they act in their own self-interest which can work against that of the organisation, and they are often uninspired by the domain they work in or the systems for which they are generating estimates. Ultimately very few of our estimators are held to account for the estimates that they generate. In addition they are bombarded with surplus, irrelevant information and biased subject matter expert opinion - as opposed to fact. They are given insufficient time to conduct their estimates, and the organisation and their managers or decision makers already

have some expectation as to what they think the 'correct' estimate should be. As a consequence, estimates are generated that are inherently flawed, not by the data, tools or processes used, but by the people involved in their production.

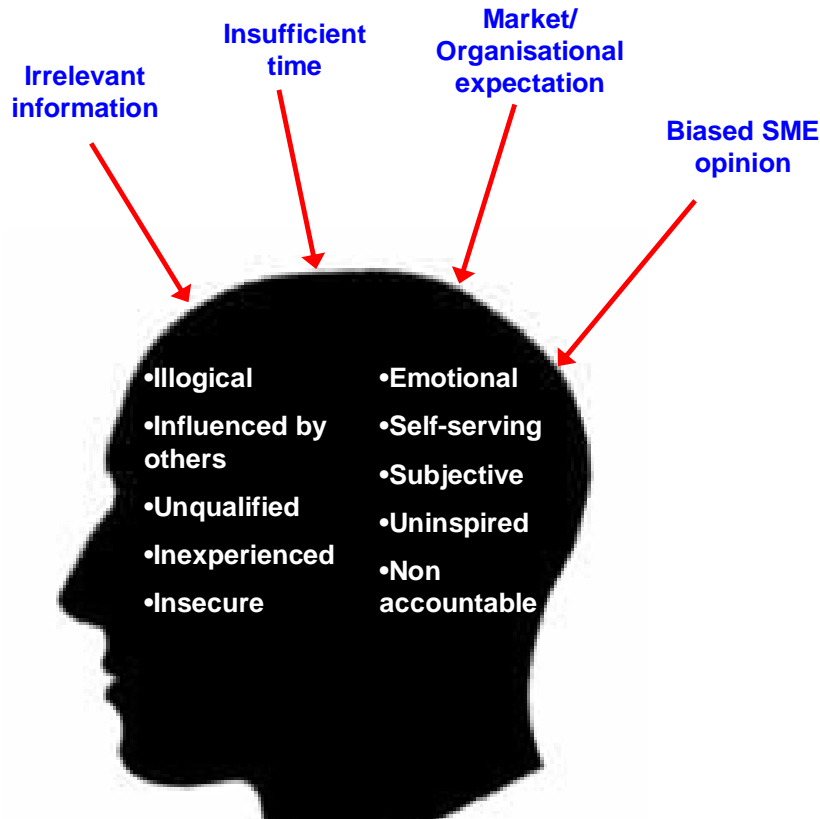


Figure 5: The real cost estimator

5 Observations

On the basis that cost estimators and those involved in the estimating process do not always behave in a manner in keeping with how we would expect them to behave, this section highlights four observations concerning some common estimating behaviours and relates these to commonly understood behaviours in psychology and sociology. Accepting that these behaviours exist and trying to understand what gives rise to their existence is the first step along the process to putting in place mechanisms to prevent them from impacting upon our estimates in the future. The list of observations is not exhaustive, nor is the psychology or sociology principles linked to each.

5.1 Technical Bias

Observation: SMEs (often engineers) are biased by nature and this often leads to biased cost estimates.

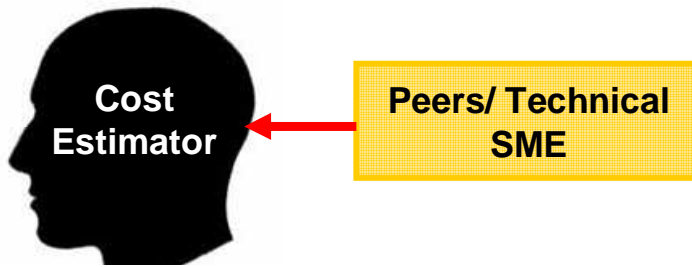


Figure 6: Technical / SME Bias

The understanding of technical subject matter experts regarding the solution or system to be estimated is a valuable and necessary part of the cost estimating process. Whether it is to help understand the required performance characteristics of the solution, or their expectations concerning how much design effort would be needed to arrive at the solution, cost estimators are critically dependent upon their input. The downside to this is that often, as cost estimators, we are limited as to the SMEs that we can get access to, and we often have limited scope for validating their input. Consequently such individuals have the ability to influence an estimate, either knowingly or unknowingly, in a manner that could ultimately impact its credibility. In considering this observation some commonly held and observed psychological and sociological phenomena are:

- *Selective Recall* - Even if an SME has interpreted evidence in a neutral manner, they may still remember it selectively to reinforce their expectations. It has been demonstrated with psychology and sociology that individuals act in their own self interest to satisfy their own goals or to reinforce the opinions they hold of themselves [2].
- *Illusory correlation* - Humans have a natural tendency to seek relationships between variables but this can lead to seeing non-existent correlations [6]. This can be problematic when working with SMEs in identifying analogous systems upon which to base estimates. It can also lead to anecdotal rules of thumb – such as “for a stack of paper documentation, every foot costs one million dollars” – but is there any evidence for such statements?
- *Optimism bias* - It has been demonstrated that under normal conditions the human tendency is towards optimism where they believe they are less at risk of experiencing a negative event compared to others [7]. Indeed this is an issue that the Her Majesty’s Treasury in the UK is acutely aware of, and as a consequence they now mandate that all their projects approaching Initial Gate (IG) and Main Gate (MG) decisions undertake a cost and schedule optimism assessment [8].
- *Pessimism bias* - Certain individuals, especially those within depressed states of mind have been demonstrated to exaggerate the likelihood of negative things occurring. Whilst a lot of attention has been focused upon optimism bias, due to the potential impact of under-estimating costs, pessimism bias receives less attention. However it is QinetiQ’s view that this principle should be considered as equally valid as optimism bias. When comparing the costs of existent capability options, with those of new options, the problems experienced on existent assets may act to negatively impact upon the future projection of their costs, casting them in a less favourable light relative to their potential replacements [9]. Optimism bias has an assessment and avoidance strategy (see above) but pessimism bias currently does not and as a consequence there is a real danger of imbalance in the outcome of an investment appraisal.

- *Serial Position Effect (Recency and primacy effect)* - When recalling a list of items in any order (free recall), people tend to begin recall with the end of the list, recalling those items best [10]. Among earlier list items, the first few items are recalled more frequently than the middle items. This is important within the context of estimating, in that subject matter experts are likely to recall those events or projects that they have recently experienced, or those projects with which they had exposure at the start of their careers, with less importance being placed upon those middle-career projects. The effect may link to, and be a cause of, pessimism bias, especially if recent or primary experience was particularly negative for a cost estimator.

5.2 Social Influence

Observation: Estimation is conducted within the context of an organisational (and Market) setting, and the expectations of that organisation (and Market) will impact on the quality of the estimate generated.

Cost estimators sit within an organisation, and typically generate estimates on it's behalf. That organisation has the ability to reward (or punish) their cost estimators for their performance. Similarly cost estimators sit within a particular market, and the pressures exerted by that market may place certain pressures on estimators concerning the numbers that they generate (see Figure 7). There are a number of well-known factors [11] that potentially impact upon the ability of an organisation or a market to influence an estimator, which without clearly understanding and planning around could result in organisations and markets acting to diminish the credibility of an estimate:

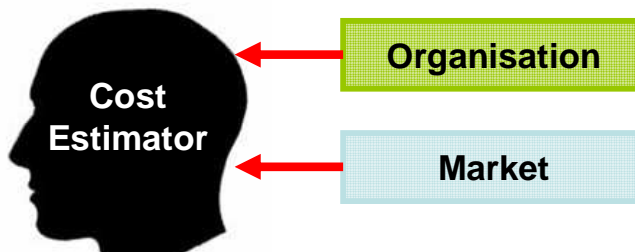


Figure 7: Social Influence

- *Group strength and social identity* - it has been demonstrated within the Stanford Prison Experiment [17] that a group with perceived social norms can invoke within an individual the need to comply with its social influence. If a cost estimator recognises his/her peers as being proficient in what they are doing, or if the peers have commonly accepted norms, then that estimator is likely to adopt their behaviours and seek assurance from individuals within the peer group that what they are doing is correct.
- *Group proximity* – In the Asch Experiment [20] it was demonstrated that proximity of the group makes an individual more likely to conform and comply with the group's commonly held consensus. This is interesting within the context of cost estimating as there is always the trade-off between the advantage that a cost estimator will have when embedded within a project team (in terms of the ready access to the necessary project data that they need), with the need to maintain a degree of professional independence from the project (such that the estimates generated remain independent). It is important for those responsible for

structuring project teams and estimating functions to be aware of the potential pressures they can be exposing their estimators to.

- *Relationship to group* - Pressures are strongest when the group contains authority figures, with this having been demonstrated in the Milgram Experiment [18] and in Hofling's Hospital Experiment [19]. This is important, consider the situation in which a cost estimator is answerable to a particular manager, say a cost estimating team manager, or a project manager, and that these individuals have control over the potential success of the cost estimators career. In such a situation, should these individuals have any specific views as to what an estimate 'should be', then it may be likely that an estimator would act to comply with such views so as to maximise their potential career progression.
- *Group Size* – In the Asch Experiment [20] it has been shown that compliance of an individual increases as the number of people in the group increases but once the size exceeds 4 or 5 compliance is less likely to occur. After this point, each additional person has less of an effect. Adding more members to a small group (i.e. 3 to 4 people) has a greater effect than adding more members to a larger group. The point is important when reviewing the organisational structure of a project team or an estimating department and attempting to mitigate against potentially negative dynamics within the group.

5.3 Information Exchange

Observation: Estimation is facilitated by a complex set of social information exchanges, all of which impact the quality of the generated estimate.

An estimator can, both implicitly and explicitly, influence the individuals with whom they engage when collating data in support of an estimate. An estimator needs to be emotionally aware of how their behaviours can influence the stakeholders with whom they engage so as to maximise the value of such engagements and to avoid introducing any of their own personnel biases. The following are a few areas that psychology and sociology teaches that could have an impact upon the ability of a cost estimator to elicit high-quality information from those people with whom they engage:

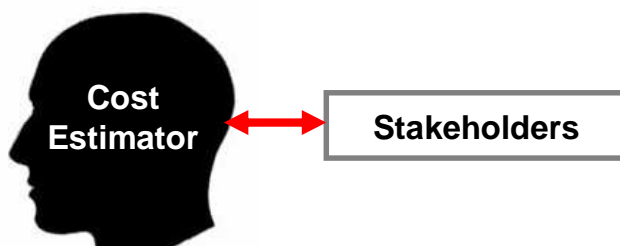


Figure 8: Information Exchange

- *Reciprocity effect* - When approached for information, stakeholders (such as SMEs, project managers, finance managers, and end users) are more likely to provide it if they believe that they will get something worthwhile in return. It is useful for a cost estimator to remember that if they can reward the individuals with something in return for their contribution of knowledge then they are more likely to get credible information in return and are also more likely to retain support when additional data may be required in the future. Something as simple as giving the SMEs feedback on the resultant estimate, or feedback on how their data was used, or whether the decision that the estimate informed was

successful, can go along way to building a stronger, more productive, and enduring relationship.

- *Anchoring effect* - Individuals have been shown to rely too heavily on the first piece of information offered when making decisions, and then make insufficient adjustments away from this number when arriving at their estimates [14]. A cost estimator's bias can result in questions being asked in a leading or loaded manner which will result in information being provided that is biased. This is important and a commonly accepted principle when establishing three point estimates (3PE) in that asking for a 'minimum' value prior to a 'maximum' or 'most likely' will skew the latter two towards the minimum, resulting in lower estimates and potentially a narrower spread than is perhaps appropriate.
- *Framing effect* - People react differently to a particular choice depending on whether it is presented as a loss or as a gain [2]. The principle is linked closely with Prospect theory [12], where it has been proven, through use of the loss function, that a loss is more devastating than the equivalent gain is gratifying [5]. Thus, people tend to avoid risk when a positive frame is presented but seek risks when a negative frame is presented. Similarly, different answers can be derived based upon open or closed questioning: compare "What resources do you require for this work package?" with "Can this work package be completed for 500 man-hours?"
- *Halo effect* - Individuals place greater confidence in an individual's evidence (or data or opinion) if they can find attributes of the individual that they like, regardless of whether that evidence (or data or opinion) is correct, or whether the quality that they like is something which is relevant to the estimating activity at hand [15]. Estimators need to be aware of their own perceptions of the people with which they engage, and those individual's perceptions of the estimator, such that all evidence or data received is treated with an appropriate degree of scepticism.

5.4 Estimator Experience & Qualification

Observation: The generation of justified and credible estimates needs to be produced by suitably qualified and experienced cost estimators.

Estimators are ultimately responsible for collating data, structuring it, and analysing it in a manner that enables them to generate estimates. However estimators need to be aware of their own personal biases that can impact on their own ability to draw conclusions on the evidence they have been presented with. A good estimator will be able to display the appropriate levels of emotional intelligence around their own thought process such that their own negative cognitive biases are minimised and not allowed to influence the cost estimate. Some of the thinking from psychology and sociology that is relevant to this observation is:

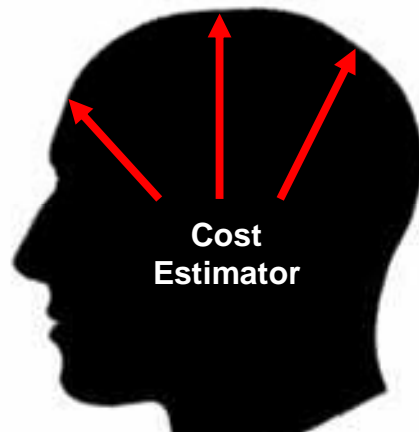


Figure 9: Estimator Experience & Qualification

- *Over-confidence effect* - It has been consistently demonstrated that an individual's subjective confidence in their judgments is reliably greater than their objective accuracy, especially when confidence is relatively high [2] [21] [22]. If a cost estimator with more than 30 years of experience and a PhD gives you an estimate then it must be correct! The impact of experience and qualification upon this within cost estimation would be worthy of further exploration.
- *Classical or operant conditioning* - The experience of a cost estimator may act to diminish their objectivity which may be disadvantageous or advantageous depending upon the circumstance. For instance, perhaps a cost estimator always uses certain rules of thumb - if they believe that management review consistently reduce their estimates by 20%, they learn to add 20% to all their estimates. They exercise such heuristics because they always have, without ever having had them appropriately validated [3][4].
- *Attentional biases* - Individuals who lack experience may focus on limited information within their immediate environment (localised dominant stimuli) but fail to understand the wider context of their tasking [13]. The result is 'not seeing the wood for the trees', with perhaps a lot of effort being expended in generating estimates for what eventually end up being relatively small costs, and failing to spend an appropriate amount of time on the significant cost drivers.
- *Small probabilities* - it has been shown that people tend to under-react to low-probability events resulting in them being willing to make super-risky choices [12]. An experienced estimator will instinctively know not to ignore low probability events, regardless of how unlikely they are to occur.

6 Conclusions

This paper is the first step in an exploration by QinetiQ of some of the human characteristics observed during cost estimating, their potential impact on our estimates and what psychology and sociology can teach us about why they occur. The proposition that this paper puts forward is that there are lessons that we as cost estimators can take from the field of psychology and sociology that can help us improve the quality of the estimates that we generate.

The material presented is by no means complete, and further work is required to arrive at a complete set of robust observations and related psychology and sociology principles that help us make sense of the observations. Step two in this study is

designing and running experiments to demonstrate and measure the impact and probability of negative behaviours within the estimating process, such that strategies can be put in place to identify and mitigate them, and to ensure that our estimates are not corrupted by them in the future.

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