



Competence

In this article, Dr Benoît Jones, Tunnelling and Underground Space MSc Course Manager at the University of Warwick, UK, discusses competence

THERE ARE JOBS where individuals may reasonably expect to have to make quick decisions; for instance a surgeon having to deal with unexpected complications during surgery. There are also jobs where individuals make decisions that may affect the health or safety of large numbers of people, but not under time pressure and usually with the backup of extensive design, testing, trials and review; for instance in developing a new drug.

So where does tunnelling fit on the spectrum? I think usually in the latter situation. Engineers spend many hours on the design of underground structures ensuring it is robust. During construction we try to plan for every eventuality and have pre-prepared mitigation measures or emergency plans ready to avoid the need to improvise or make decisions on the hoof. We try to ensure that there is time available for discussion, consultation or redesign, so that quick decisions by individuals at the tunnel face are minimised. We do this by regular review of monitoring data to spot problems early and by designing tunnel linings that will fail in a ductile manner without sudden loss of load-carrying ability.

Philosophy, competence and risk aversion

I'm going to digress here, but bear with me, we'll get back to competence shortly. Recently in the tunnelling press, we have seen a rehashing of wearisome arguments about what the 'New Austrian Tunnelling Method' actually is. Although one might be forgiven for thinking that this debate is crucial to the future of tunnelling, it is actually just about definitions – Wittgenstein would call it a perfect example of an apparent difference in philosophical opinion really coming down to imprecise language (see e.g. Grayling, 2001). The trouble with calling it a 'method' is that you then have to define what series of actions constitute that method. For example, some have attempted to define it as the use of rockbolts, shotcrete and sequential excavation. But sometimes you don't have to divide the face, sometimes you don't use rockbolts, sometimes you use rockbolts but not shotcrete and vice versa. All of these could still be called the NATM. You can see the problem: if it is defined too specifically, then there will be too many exceptions, and if it is defined too vaguely, then every tunnel could be a NATM tunnel and it becomes a useless definition.

What is immutable and very successful about the NATM is its design philosophy (Brown, 1981), for instance as defined in the series of papers published in *Water Power* by Rabcewicz (1964a, 1964b, 1965) and then Rabcewicz & Golser (1973). If Rabcewicz had called it the 'NATP', the 'New Austrian Tunnelling Philosophy', then all this grief would have been avoided. Though of course he wouldn't have been able to patent it.

For a quiet life and to just get on with, well, tunnelling, what I and many others have done is to use the term 'NATM' only when referring to the NATM philosophy, and to use 'SCL' purely as an acronym for 'sprayed concrete lining', avoiding all connotations of method or philosophy. Hence an 'SCL tunnel' is just a 'tunnel lined with sprayed concrete'. Simple.

But, it appears those days are now over. It was too tempting to some to leave a poor, simple acronym so unburdened with baggage. Now it appears the term 'SCL' is being used to mean some kind of method. To paraphrase the hubbub of people saying, "well but I think it means this...", it seems that the 'SCL method' is a bit like 'NATM' but a little more risk-averse because it is in soft ground in urban areas. Designs are more robust, management procedures are set in stone and there is little or no optimisation of support during the construction phase. Once again, that can't usefully be called a method; at best it is a design philosophy.

There are other objections to using the phrase 'SCL method'. One could argue that it is just the application of the NATM philosophy to soft ground in an urban area. One could equally argue, as Kovári did about the NATM, that the SCL method doesn't add anything to existing good tunnelling practice (Kovári, 2003), so why does it need a label? Is this really all about marketing? Is it just that the UK has TMAE? (Tunnelling Method Acronym Envy)

Does it matter? Not really, but now any use of the phrase 'sprayed concrete lining' or the acronym 'SCL' will be tainted with unintended connotations and I have to shop around for a new term to describe a sprayed concrete lined tunnel. Perhaps 'Tunnel Lined with Shotcrete' could be a new unambiguous way of saying 'a tunnel lined with shotcrete'. But in due course someone will probably wheel up with baggage to unload on that too and render it just as ambiguous and meaningless.

So what has this to do with competence?

If you are still with me, we have established that there exist slightly blurry and overlapping philosophies (not methods) of tunnelling using sprayed concrete, one of which is 'the NATM philosophy' and one is 'the SCL philosophy'. We are now going to use these terms as useful caricatures (in exactly the vague and confusing way I've just been objecting to) to discuss competence. Please remember that these caricatures are completely facile and are not necessarily representative of all such projects or their management.

Nowadays, on 'SCL' projects, risk management and quality assurance requirements are met by specifying strict levels of competence for each role, for the contractor's staff, the independent expert inspectors and engineers, the client's representatives and the permanent and temporary works designers. These may be academic qualifications, 'tickets' (competence cards such as CSCS or CPCs), or experience measured in years or in the number of similar projects worked on. These requirements are not new, but the bureaucracy and procedures now prevalent are. Was the term 'competence management' even used 5 years ago?

'SCL' projects also have several layers of round the clock supervision; it is not unusual for the contractor to be required to employ an independent consultant in an oversight role, the client has a site team, and the permanent works designer also has a team on site 24/7. This means that at least half the people in the tunnel are not there to do any work at all. As well as being expensive, this exacerbates the skills shortage. There are also strict quality management procedures, roles and responsibilities, as well as the Daily Review Meeting to ensure the monitoring data is looked at and mitigation measures implemented if necessary. This kind of project management is therefore near the 'aeroplane design' end of the spectrum. At the other end of the scale, on a 'NATM' project in a rural, mountainous environment, quite low staffing levels are traditionally used. The level of certainty as to what ground conditions will be encountered is usually lower, regularly resulting in the need for engineers to make decisions about support requirements at the tunnel face. This explains why proponents of the NATM rightly insist that it requires highly qualified and

trained personnel with the willingness and experience to make quick decisions, as well as a good organisational and communication structure (Brandl, 2010). This seems more like the surgeon's role, making many predefined routine decisions but occasionally an unexpected event requires a quick decision based on experience.

Daniel Kahneman, a Nobel Laureate in Economics, argues convincingly that while quick decisions by experienced people such as lead firefighters or chess grand masters may seem like the magic of intuition, it is important to understand that they are in fact a kind of hard-won recognition (Kahneman, 2011). Through direct experience of decision-making, and through discussions or mental rehearsals of possible scenarios, we can learn to read situations and respond in an effective manner. The two basic conditions for acquiring this kind of ability are:

- an environment that is sufficiently regular to be predictable
- an opportunity to learn these regularities through prolonged practice

When both these conditions are satisfied, skilled intuitions are likely to develop. In our fictitious 'NATM' mountain tunnel, stability is about controlling deformations and adjusting the time of installation and stiffness of the support. Constant feedback is provided by the tunnel convergence monitoring and other data. This lends itself well to this kind of learning and is known as a 'high validity environment'. Our soft ground, urban 'SCL' tunnel, however, does not lend itself well to this kind of learning, due to the need to minimise ground movements, the shallow cover and the potential for a more sudden failure. This is known as a 'low validity environment', since there are few decisions made and there is very little feedback on those decisions. Therefore a 'NATM' engineer will slowly develop this kind of skilful experience, but an 'SCL' engineer will not.

So it seems that on 'SCL' projects, the aim is to avoid the need for individuals to make quick decisions, by having a robust design and layers of management and supervision. On 'NATM' projects, individuals need to be willing and able to make quick decisions, but if they are ever unsure of what to do, a good organisational and communication structure lets them seek specialist advice when necessary. A 'NATM' project is more reliant on individual competence while the organisational structure and culture of an 'SCL' project dissuades individuals from making decisions, and gives them far less practice in doing so. So although it is more unlikely that something unexpected will occur, when it does, individuals may not have the skill or confidence to deal with it.

What level of competence do we want?

Obviously not everyone who is, for example, a professionally-qualified engineer with more

than 10 years experience on at least 5 tunnelling projects, will be competent. So what is the answer? One recent proposal is to create a register of tunnel engineering professionals. But how could this be a better assessment of competence than the CV already offers? By fulfilling the requirements of professional qualification, chartered engineers should be competent enough to know the limits of their competence, and humble and professional enough to consult others when necessary.

In a serious but unexpectedly funny paper titled "Unskilled and unaware of it: how difficulties in recognising one's own incompetence lead to inflated self-assessments", Kruger and Dunning of Cornell University described a series of psychological experiments designed to measure the

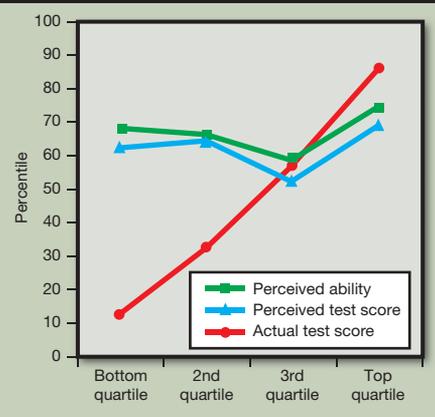
correlation between a person's self-assessment of competence and their actual competence in tasks involving humour, logical reasoning and grammar. Only the results for logical reasoning are presented in Figure 1, but the results for the other tests followed a similar pattern. The work shows that the less competent people are at a particular task, the greater the miscalibration of their self-assessment. It also shows that the most competent people tend to underestimate their competence – perhaps because they are aware of what they still do not know. There appears to be a tipping point, where at a certain level of competence people become adept at assessing their own and others' competence. To quote from Kruger & Dunning (1999), "It seems that the skills that engender competence in a particular domain are often the very same skills necessary to evaluate competence in that domain – one's own or anyone else's".

What this tells us is that as long as people have sufficient competence to assess the limits of their own and others' competence, they are safe to employ. Any decision they do not feel competent enough to make themselves they will refer to others, and the decisions they do make themselves should be sound.

In summary

Competence is not as simple as a CV or a name on a register. The organisation of a project, as well as the type of work being undertaken, will affect the nature of the decision-making. The writing of Kruger & Dunning, and of Daniel Kahneman, are far more nuanced, witty and intelligent than it was possible to convey in this article, so I hope many readers will seek out their work and read it for themselves.

Figure 1: Perceived logical reasoning ability and test performance as a function of actual test performance (redrawn from Kruger & Dunning, 1999)



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