Military work threatens science

In an uncertain world, more governments are asking universities to help develop weapons. That's a threat to the culture and conscience of researchers.

South Korea is understandably nervous. To the north, a bellicose, belligerent and unpredictable leader has nuclear weapons, increasingly powerful missiles and many troops. South Korea is trying to counter that with technological superiority offered by its robust scientific infrastructure. But the nation's efforts to enhance the technological superiority by using academics to pursue military goals have raised a furore. And South Korea is not the only country to court such controversy.

In February, South Korea opened a centre at its premier research facility, the Korea Advanced Institute of Science and Technology (KAIST) in Daejeon, in collaboration with the country's leading arms manufacturer, Hanwha Systems. Media reports said that the centre, known as the Research Centre for the Convergence of National Defence and Artificial Intelligence, would develop technologies that could be useful for more-advanced weapons, such as missiles that use artificial intelligence (AI) to control their speed and altitude and detect enemy radar in real time.

There was an immediate backlash. Almost 60 AI and robotics researchers from around the world signed an open letter opposing KAIST's participation in an autonomous-weapons race. They threatened to cut all ties with KAIST. But this episode had a happy ending: KAIST's president vowed that the centre wouldn't develop lethal weapons. The boycott was abandoned. This week, the letter's author accepted an invitation to visit KAIST.

But similar fault lines have been exposed elsewhere. Australian scientists continue to debate the government's 2014 defence–science partnerships programme, which has so far enrolled researchers from 32 universities. And a 2016 decision by the European Commission to start funding defence research prompted 400 researchers to sign a petition attacking the move.

In Japan, universities are split over whether they should take funds from the defence ministry's Acquisition, Technology and Logistics Agency. Last year, the advisory board to the nation's cabinet — the Science Council of Japan — called for researchers to boycott the work, and for institutions to set up special committees to evaluate the ethics and propriety of military-related research projects. According to survey results released by the council earlier this month, 46 of the 135 universities polled have such a system in place. But 30 institutions have already allowed researchers to apply, and 41 have no intention of creating such a system. And according to results of a poll at the Astronomical Society of Japan's meeting last March, some young astronomers would accept such funding if it falls within Japan's policy of maintaining self defence. However, other members of the society oppose it, and the society itself has not taken a position.

In the United States, university-based military research has long been a fixture, but the push in less-militarized countries points to rising geopolitical uncertainty and instability around the world. Trying to improve defence capabilities in such circumstances is understandable — the issue is where and how it should be done.

More fundamentally, such research threatens core principles that are the bedrock of universities everywhere. A greater reliance on funding for militarized projects threatens the remit of independent and curiosity-driven research. It breaks down the bonds of trust that connect scientists around the world and undermines the spirit of academic research. The sharing of data and techniques through publications and collaborations has been the basis of peaceful collaborations even between researchers from countries that are at war with each other. If researchers need to question whether their contributions are going to feed development of a weapon, they might — understandably — keep their ideas to themselves.

> **"The work should align with a fundamental commitment to humane and life-saving applications."**

Government initiatives around the world seem to show that military funds will continue to permeate universities. So be it. But the researchers involved carry a heavy responsibility. The work should align with a fundamental commitment to humane and life-saving applications — drones that can deliver medical supplies to war-torn areas, or robots that can clear minefields, for example. The line is likely to be fuzzy. An AI navigation system seems relatively innocuous for an autonomous surveillance submarine, but in a nuclear submarine, it becomes the kind of application that the global research community protested against in South Korea. Still, as the South Korea example demonstrates, scientists have a crucial role in alerting the world to the potential dangers of emerging technologies, and redirecting the trajectory of the research. Those researchers and institutions that pursue the technologies despite the risks need to remain transparent, so that their peers can not only judge the rigour of their science, but also ensure they steer clear of inhumane applications. ■

Checklist checked

Nature *authors say a checklist has improved reproducibility, but more needs to be done.*

Five years ago, after extended discussions with the scientific community, *Nature* announced that authors submitting manuscripts to Nature journals would need to complete a checklist addressing key factors underlying irreproducibility for reviewers and editors to assess during peer review. The original checklist focused on the life sciences. More recently we have included criteria relevant to other disciplines.

To learn authors' thoughts about reproducibility and the role of checklists, *Nature* sent surveys to 5,375 researchers who had published in a Nature journal between July 2016 and March 2017 (see Supplementary information at go.nature.com/2vm2fxw and https://doi.org/10.6084/m9.figshare.6139937 for the raw data).

Of the 480 who responded, 49% thought that the checklist had improved the quality of research published in *Nature* (15% disagreed); 37% thought the checklist had improved quality in their field overall (20% disagreed).

Respondents overwhelmingly thought that poor reproducibility is a problem: 86% acknowledged it as a crisis in their field, a rate similar to that found in an earlier survey (*Nature* **533**, 452–454; 2016). Two-thirds of respondents cited selective reporting of results as a contributing factor.

Nature's checklist was designed, in part, to make selective reporting more transparent. Authors are asked to state whether experimental findings have been replicated in the laboratory, whether and how they calculated appropriate sample size, when animals or samples were excluded from studies and whether these were randomized into experimental groups and assessed by 'blinded' researchers (that is, researchers who did not know which experimental group they were assessing). Of those survey respondents who thought the checklist had improved the quality of research at Nature journals, 83% put this down to better reporting of statistics as a result of the checklist.

Is the checklist addressing the core problems that can lead to poor reproducibility? Only partly. Taken as a whole, the responses indicate that we need more nuanced discussions, and more attention on the interconnected issues that result in irreproducibility: training, transparency, publishing pressures and what the report *Fostering Integrity in Research* by the US National Academies of Sciences, Engineering, and Medicine deems "detrimental research practices".

Journals cannot solve this alone. Indeed, 58% of survey respondents felt that researchers have the greatest capacity to improve the reproducibility of published work, followed by laboratory heads (24%), funders (9%) and publishers (7%).

What role, then, should publishers take? Reproducibility cannot be assessed without transparency, and this is what journals must demand. Readers and reviewers must know how experiments were designed and how measurements were taken and deemed acceptable for analysis; they need to be told about all of the statistical tests and replications. As such, the checklist (or 'reporting summary') provides a convenient tool for revealing the key variables that underlie irreproducibility in an accessible manner for authors, reviewers, editors and readers.

Two studies have compared the quality of reporting in Nature journals before and after the checklist was implemented, and with journals that had not implemented checklists. Authors of papers in Nature journals are now several times more likely to state explicitly whether they have carried out blinding, randomization and sample-size calculations (S. Han *et al. PLoS ONE* **12**, e0183591; 2017 and M. R. Macleod *et al.* Preprint at BioRxiv https://doi.org/10.1101/187245; 2017). Journals without checklists showed no or minimal improvement over the same time period. Even after implementation of the checklist, however, only 16% of papers reported the status of all of the crucial 'Landis 4' criteria (blinding, randomization, sample-size calculation and exclusion) for *in vivo* studies — although reporting on individual criteria was significantly higher. Preliminary data suggest that publishing the reporting summaries, as we have done since last year, has resulted in further improvements.

"Respondents overwhelmingly thought that poor reproducibility is a problem."

Fortunately, the trend indicated by the survey is positive. Most respondents had submitted more than one paper using the checklist. Nearly half of respondents said they had not considered the checklist until after they had written their first submission; that fell to 31% for subsequent papers, with authors more likely to consider the checklist while planning or performing experiments. Encouragingly, 78% said that they had continued to implement the checklist to some extent, irrespective of their plans to submit to a Nature journal in the future.

Progress is slow, but a commitment to enforcement is crucial. That is why we make the checklist and the reporting of specific items mandatory, and monitor compliance. The road to full reproducibility is long and will require perseverance, but we hope that the checklist approach will gain wider uptake in the community. ■

Aid from Africa

Africa's genomics research will benefit from a new set of ethics principles.

Helicopter science. Sample safaris. Parachute research. These are all pejorative terms used to describe the practice of collecting biological samples, artefacts or data from developing countries and analysing them elsewhere, with little input from — or credit given to — local scientists. Such practices are almost universally denounced by research funders and institutions in the global north. Yet the language still crops up, especially in disciplines such as genomics, for which the technology required to decode DNA at high volumes remains concentrated in wealthy countries.

In human genomics, there has been a push to ensure that research on samples collected in developing countries — particularly in Africa — is anchored in local science and community engagement. One example of this is the Human Heredity and Health in Africa (H3Africa) initiative, which is funded by the US National Institutes of Health and the London-based Wellcome Trust. Since 2012, it has funded genomics projects whose principal investigators are African, with several of the projects being managed locally from Kenya's capital, Nairobi.

As we report this week, the H3Africa group has now published a guide for the ethical handling of genomic research and biobanking in Africa (see https://doi.org/10.1038/d41586-018-04685-1). It sets out to empower African researchers and communities, and to educate them on their rights in asking for greater control over how samples are collected, stored and used. It also contains rules of engagement for non-African institutions that are partnering with, or funding research in, Africa. It's a useful guide, and draws on existing ethics policy documents. Many of its recommendations — such as avoiding tokenistic participation by African researchers, and ensuring that research results are fed back to the communities that donated the samples — have been regarded as good practice in the field for some time. But, in reality, such practices are all too often still lacking.

The fact that the document is derived from in-depth conversations with African researchers and ethics review boards gives it added legitimacy. Perceptions can vary about whether partnerships are equitable or not, and it is not uncommon for northern partners to hold up projects as exemplary in terms of their equitability, with African participants in the same projects complaining of limited input. This framework should help, by allowing negotiating partners to sing from the same hymn sheet.

Because it is voluntary, the framework's impact will depend on its use by its target audiences. African research-ethics committees that preside over applications to carry out genetic research can use it to ensure that their decisions have the interests of Africans at heart. African researchers can draw on it to negotiate more-advantageous terms in partnerships. Research funders can encourage applicants to consider the framework when submitting proposals. African governments can use it to inform their rules guiding genomics research. And, perhaps most importantly, African communities can look to the framework for information about what to expect, or even demand, from their participation in research.

Ultimately, the foremost priority of researchers, funders, regulators and ethicists should be to respect the rights and interests of the populations studied. In the scramble for African genomes, such rights can easily be overlooked — especially in countries with weak governance, where research-ethics rules are outdated or where patient-rights groups are lacking. There is therefore a need for greater involvement by African governments and civil society, to ensure that genomic research is in the public's interest, not just in the interests of the participating scientists — regardless of where they come from. ■