Introducing IMPACT; Design and Development of a Military Orientated Cognitive Task Battery

Graham Sabine & David J Thompson

Defence Science and Technology Laboratory, UK MoD

SUMMARY

The Interactive Measures of Performance and Assessment of Cognitive Tasks (IMPACT) tool; developed to provide defence with a reconfigurable, repeatable, and scalable battery of military orientated tasks. The design, development, validation, early exploitation, and future use are discussed briefly in this paper.

KEYWORDS

Workload, Human Performance, Military Tasks

Introduction

Dstl has undertaken a substantial programme of work to identify, develop and test innovative concepts, approaches and technologies to support the design and development of future defence systems and platforms. This includes considering the current human sciences practitioners' methods and tools and adding to it with new methods and tools to help deliver future workforce superiority over competitors within Defence and Security.

A gap was identified for a new tool to capture, through easy and accessible means, human performance data for computer based military themed cognitively orientated tasks. Such a tool would capture fine objective user task performance data in a variety of settings including simulations, lab, and field situations (such as military exercises on training areas). Military themed tasks were selected to give the battery context validity to military users. Feedback from previous research with military populations is that they do not often engage well with abstract cognitive tests.

To fill this gap, Dstl undertook a programme of work to develop an innovative generic military cognitive task battery tool titled the Interactive Measures of Performance and Assessment of Cognitive Tasks (IMPACT) tool for collecting user task performance data in various military scenarios, to enable determination of the level of cognitive performance and task demand on users. This would also improve engagement from military populations as the tasks would have greater context validity to them. **Concept**

The concept for IMPACT is to develop a reconfigurable battery of generic military tasks each stimulating multiple cognitive areas. This tool may then be employed to support defence work, through the provision of a platform able to capture computer-based task performance in a range of different settings. There are very few tools such as this. The most widely recognised and commonly used across defence is the National Aeronautics & Space Administration's (NASA) Multi-Attribute Test Battery-II (MATB-II) which is aircrew focused. IMPACT captures useful performance data, whilst providing an intuitive and simple 'back end' for the experimenter to configure the tool.

To date, the Development of IMPACT has undergone three phases. Phase 0 has been scoping and defining the concept, Phase 1 has been the design and software production, Phase 2 has been earlyadopter testing and validation. A Future Phase 3 will focus on wider release and sharing of the tool, as well as the consideration of enhancements.

In Phase 0 (Concept); 17 military tasks were identified through discussion with Military Advisors (MA), these can be seen in Table 1. These tasks were at level that anyone who has completed basic military training would be able to see their military utility even if they do not form part of their day to day military role.

Six tasks were selected from this list by the Dstl project team. Selection was made through considering the anticipated cognitive properties each task encompasses, as well as the overall balance of tasks, and the nature of the tasks themselves (for example continuous versus discreet tasks).

Table 1: Generic Cognitively Orientated Tasks identified in early concept development.

Candidate IMPACT Tasks:	Selected for development:
Driving	
UAVs:	
- Piloting	
- Target Acquisition	
- Battery/health monitoring	
Communications:	
- Audio	
- Chat room	✓
Resource management:	✓
- Ammunition	
- Fuel	
- Drugs	
Completing log books/reports	
Formation Maintenance	✓
Navigation	
Identification friend or foe	✓
Fire mission	
Weapon stoppage drill	
Immediate action drill	✓
Target acquisition	✓

The consideration of cognitive properties for each task is shown in Table 2 and were based upon the work of Tatlock et al (2015). For each task, multiple cognitive processes were considered likely to be challenged.

Table 2: The six Candidate IMPACT Tasks mapped against broad areas of Cognition.

Candidate IMPACT Tasks	Cognitive areas:										
	Attention	Memory	Perception	Language	verbal comms	Intelligence	Decision Making	Estimation	Learning	Motivation	Cognitive Style
Communications	✓	✓		✓						✓	n/a
Immediate action	✓		✓	✓		✓	✓	✓		✓	
Identification Friend or Foe (IFF)	✓	✓	✓	✓		✓	✓		✓	✓	
Resource management	✓		✓			✓	✓	✓	✓	✓	
Formation maintenance	✓	✓	✓			✓	✓	✓	✓	✓	
Target acquisition	✓	✓	✓			✓	✓	✓	✓	✓	

Software Design

For Phase 1, Frazer-Nash Consultancy were selected through open competition to undertake the design and development work. An Agile development methodology, based on Scrum, was used to build upon the initial concept and wire framing undertaken by Dstl. Table 3 details what was developed at each sprint:

Table 3: IMPACT Software Development Sprints

Sprint	Functionality developed
1	- Underlying software architecture - Log in and Home page - Task set up - Immediate action task
2	- Communications task - Participant ID on log in - Multiple task configuration - Multiple task display arrangement
3	- Target acquisition task - Multiple task display arrangement refinement - UX improvements addressing user feedback
4	- Formation maintenance task - UX improvements addressing user feedback
5	- Immediate action task further development. - Identify Friend or Foe (IFF) task - Bug fixes, UX improvements addressing user feedback
6	- Resource management task - Bug fixes and UX improvements addressing user feedback
7	- Bug fixes, UX improvements addressing user feedback

IMPACT Tasks Overview

The result of the phase 1 software design phase was a set of six tasks, as described in the following section, and a supporting user interface.

The **communications task** (Figure 1), is representative of a chat window. The participant is given visual and auditory messages about convoys and their locations. They have to monitor for the convoy of interest and keep track of its location with the buttons at the bottom of the task. Response time and response accuracy may be measured from the task interaction data recorded.

The **immediate action task** (Figure 2), is a simple task where the participant is presented with a visual and optional audible alert that they have to respond to with the button on the right hand side. There are six pre-set alerts and the option of entering an alert more suitable for the researchers' experiment. Response time and response accuracy may be measured from the task interaction data recorded.

The **IFF task** (Figure 3), presents the participant with visual tracks and an auditory message telling them what to classify the track. The user will then select the track on screen and use the buttons at the bottom of the page to correctly classify the track. Response time and response accuracy may be measured from the task interaction data recorded.

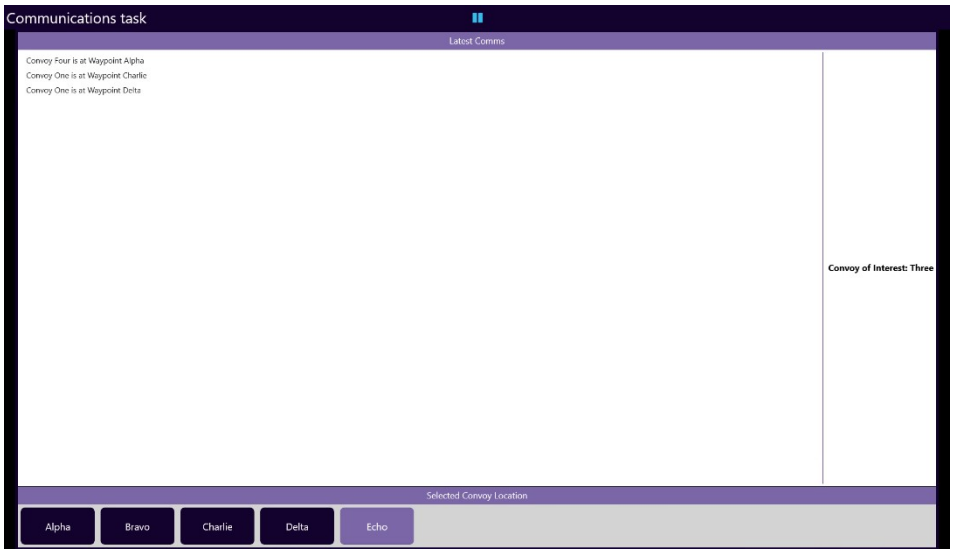

Figure 1: Communications Task

Figure 2: Immediate Action Task

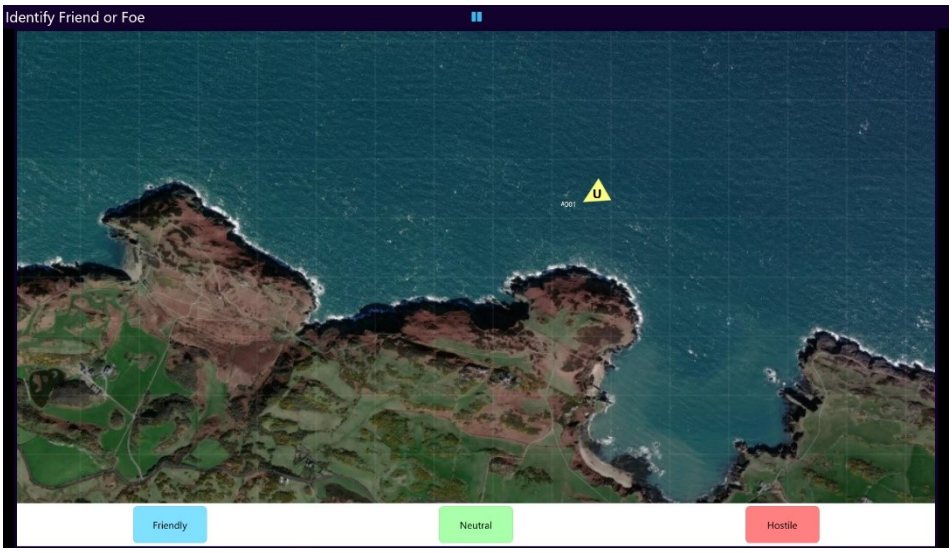

Figure 3: Identification Friend or Foe (IFF) Task

The **resource management task** (Figure 4), presents the participant with three units consuming three different resources. They then have to use the matrix and buttons at the bottom of the task to select the quantity of the three resources to supply and which unit to send it to. A range of resource performance scores may be measured from the task interaction data recorded.

Figure 4: Resource Management Task

The **formation maintenance task** (Figure 5), gives the participant control over a unit of four unmanned vehicles. The participant then needs to neutralise the mines whilst avoiding the sand bars as they advance down the screen. They have control over the formation adopted and movement side to side. The number of mines intercepted and unmanned vehicles remaining may be obtained from the task interaction data recorded.

The **target acquisition task** (Figure 6), presents the participant with a side scrolling image with targets overlaid on top. These targets need to be selected, assessed against the images at the bottom of the screen and then classified with the appropriate button. The number of targets selected, and identified (correctly or incorrectly) may be obtained from the task interaction data recorded.

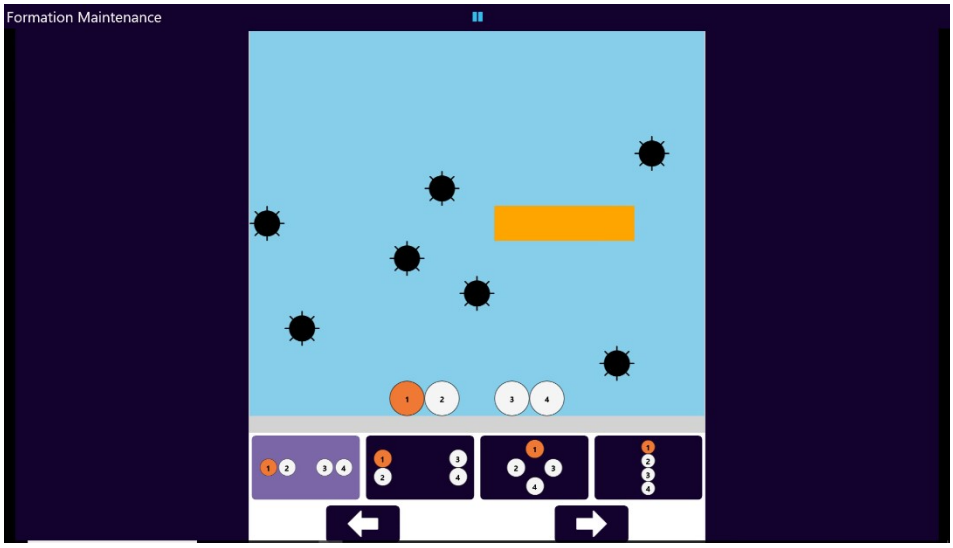

Figure 5: Formation Maintenance Task

Figure 6: Target Acquisition Task

Using IMPACT

IMPACT has the ability to present any of the six tasks on-screen (tablet or desktop device) at one time, and the experimenter can resize and reposition each task accordingly. In certain instances the experimenter may choose to present just a single task on screen or as many tasks as the selected device can accommodate. Each task may be finely adjusted for complexity and intensity; thereby calibrating a test setup to suit the precise environment, situation, and participant group in question. Once a configuration has been designed, this can be exported and loaded into other devices with the IMPACT software, allowing for the experiment to be shared. For the participant, all six tasks require no advanced knowledge or training; whilst task instructions and 'dummy runs' are available to build familiarisation before data capture.

One of the key requirements of IMPACT from a usability perspective was the development of a user interface for the experimenter that did not require them to have any knowledge of how to edit code; as this has been a necessity for similar products like the NASA MAT-B II. Coupled with this, is that the outputs should be easy to download and analyse; in order to quickly derive useful insights.

For the experimenter, an intuitive form-based configuration interface provides a simple 'back-end' without the need to edit code. The data outputs are also easy to download and analyse. Task output is automatically written to a .csv file that can be imported into popular analysis software such as Microsoft Excel. This data is time-stamped from the system clock to enable mapping against external temporal events. No participant performance data is saved in IMPACT, it is saved externally in a user definable location on the host device.

Researcher End User Engagement

At the beginning of Phase 1 (Development) a workshop was held with the prospective community of end users within Dstl. This included participants from across the human sciences group and other interested groups and divisions, such as Platform Systems Division. Following the workshop the participants provided feedback to the development team via a questionnaire. The results of this were analysed to inform the development of user requirements.

Following sprint 3 the project team reengaged with a Dstl MA for initial feedback on how the software was developing. They provided some useful feedback that was fed back to the development team to address in future sprints.

Prior to sprint 7 there was a re-engagement event (17/02/2022) with the Dstl user community, where the in development IMPACT tool was demonstrated and future plans were articulated. The participants provided some useful feedback and some potential opportunities for collaboration and testing.

Towards the end of the first phase there was some limited end user testing within a Dstl internal project. This enabled some very early feedback to be given in time for it to inform the initial tool development.

Validation and Development

For Phase 2 (Early Use & Validation); Thales UK were selected by Dstl through open competition to undertake an independent validation and ensure that IMPACT elicited the expected experiment participant cognitive responses identified during the concept phase.

Thales developed a comprehensive and novel experimental protocol using a multi-modal approach, utilising subjective assessment techniques and psychophysiological monitoring. This received ethical approval via the established Ministry of Defence JSP 536 process. Representative military end users (N=35) took part in the study in June 2023. The results of this broadly met or exceeded the expected cognitive attributes proposed by Sabine (2022) in phase 1. For further detail on this study, see the Thales paper Validating IMPACT: A new cognitive test battery for defence (Sturgess et al, 2024) published within these proceedings.

Concurrent to the validation activity a number of projects have utilised IMPACT in its un-validated state to support their research. This provided useful feedback on the usability of the tool in a research-based context.

As a result of the validation experimental work up and the early experimental use a number of bugs and issues were identified. These were collected by the Dstl project team and passed to Frazer-Nash Consultancy for fixing. Following these updates no significant errors or failures were encountered by Thales during the validation experiment.

Conclusion

Early exploiters of IMPACT have provided positive feedback and the validation activity has found a strong correlation between the intended capabilities of the tool, to elicit different cognitive abilities, and the experimental results. This gives us confidence that IMPACT is performing as intended and can be used to support future defence trials and experiments. There is also ample scope for future development of the tool with many stakeholders already interested in adopting and developing IMPACT. Dstl are currently exploring the release pathways for IMPACT into the wider defence community.

Dstl would like to thank wider colleagues in Frazer-Nash Consultancy, Thales UK and early adopters within Dstl and Industry for their contributions to the design, development, and assessment of IMPACT to-date.

References

MATB-II: Revised Multi-Attribute Task Battery, NASA, https://matb.larc.nasa.gov/

Tatlock, K., Delaney, S., Leahy, D., Croft, D., Brennen, S., Doherty, V., Fisher, N., McNamara, H., & Bowyer, S. (2015). “TIN 2.035 – Challenge 1: Specifying the Cognitive Requirements of

People in Systems". Reference: UH-DHCSTC_I2_H_T2_035_1/003, Defence Human Capability Science and Technology Centre

Sabine, G. (2022). Design and Development: Interactive Measures of Performance and Assessment of Cognitive Tasks (IMPACT) Software Tool. Reference: *DSTL/TR139745*, Defence Science Technology Laboratories.

Sturgess, E., Steane, V., & Chattington, M. (2024). Validating IMPACT: A new cognitive test battery for defence. Ergonomics and Human Factors 2024. Kenilworth. 24/04/2024