

# EVALUATION OF PRE-INTERVENTION DATA: DIVERGENT THINKING AND BRAIN PLASTICITY

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## SUMMARY

The 'new normal' includes larger, more complex incidents. This suggests that leaders will need to think outside the box and use of higher cognitive skills such as creativity that includes divergent thinking, to respond and recover from these incidents. Processes in creativity include thinking skills that are conducive to taking new perspectives on problems, pivoting among different ideas, thinking broadly, and making unusual associations.

This document identifies the empirical results from a series of workshops conducted with end-users to identify if a method for developing creative skills and specifically divergent thinking, led to teams being more creative in the development of options analyses.

Results indicate that teams scored significantly higher on a creativity scale after being taught the methods to enhance their creativity.

The improvement can be traced to improvements in the criteria of fluency (the number of options) and elaboration (embellishment of the information provided). Teams did not demonstrate evidence of the other two criteria for creativity (flexibility in the use of the intelligence provided and originality). Consideration of how to build flexibility and originality into the existing method will drive the next iteration, which will be translated into research utilisation products over the remaining time of the project.



## INTRODUCTION

### DEVELOPING DIVERGENT THINKING AND CREATIVITY IN EMERGENCY MANAGEMENT

In recent times one of the most significant changes in capability has been for emergency services to embrace human factors. Contributing to this, our previous research agenda has explored cognition in the context of decision making, developing training and aide memoires to support personnel in areas such as the management of cognitive biases and maintenance of situational awareness. The research supporting this work identified other problems around developing options analysis and predicting consequences for out-of-scale events. This has led our end users to ask how we can prepare our future leaders for the new norm? For human factors to adapt and remain relevant in this changing environment, the simple answer is we need to build new human capabilities.

The future will demand leaders to think outside the box and use of higher cognitive skills such as creativity and divergent thinking. Processes in creativity include thinking skills that are conducive to taking new perspectives on problems, pivoting among different ideas, thinking broadly, and making unusual associations.

### CREATIVITY

Research on creativity has its origins in psychology where a need for empirical work on this topic was initially identified (Guilford, 1950). Subsequent research focused on identifying the traits of creativity and understanding the creative process (Hennessey, 2010). However, this early research concentrated specifically on the individual and assessing their creativity (Torrance, 1966). Later, empirical research expanded from exclusively investigating individuals and started exploring why some groups are more effective than others. This research focussed on creativity as an outcome of teamwork (Hackman & Morris, 1975). Researchers that referred to creativity as an outcome product or a service invariably conducted research on teams within an organisational environment (Amabile, Conti, Coon, Lazenby, & Herron, 1996). In organisational contexts, creative solutions may be expressed in both tangible and intangible forms such as strategies and ideas (Oldham & Cummings, 1996; Woodman, Sawyer, & Griffin, 1993). This marks a shift in creativity research that was historically confined to psychology and then branched into management and organisational studies. In the latter disciplines, creativity can be defined as the development of novel and useful ideas in any domain (Amabile et al., 1996).

### DIVERGENT THINKING

Much of what we understand about creativity, particularly in how we measure it, has come from studying divergent thinking. "Divergent thinking is clearly the backbone of creativity assessment and has held this position for many decades" (Kaufman, Plucker, & Baer, 2008).



Divergent thinking can be defined as cognitive thought that leads in various directions which is to suggest that it does not intend to converge on one correct answer but diverges to a range of possible answers. Four aspects of divergent thinking are frequently measured, which is therefore a more complex phenomenon than Sommer and Pearson's (2007) articulation of creativity in decision making. Given divergent thinking is a sub-set of creativity this tends to suggest Sommer and Pearson's definition of a creative decision is too simplistic.

1. *Fluency* – The number of responses to a particular stimulus.
2. *Originality* – The uniqueness of the responses.
3. *Flexibility* – The number and uniqueness of the categories of response, adapting and changing the meaning, use or interpretation of something.
4. *Elaboration* – Extending or adding detail to the responses.

The dominant test of divergent thinking is the Torrance Tests of Creative Thinking (TTCT) that is "by far the most commonly used test of divergent thinking and continues to enjoy widespread international use" (Kaufman et al., 2008) (p.25).

## LINKING CREATIVITY AND DECISION-MAKING

A creative decision can be defined as "a decision that is both a novel contribution and of value to a decision context. A novel decision is unusual, uncommon, unconventional or unique from past decisions and reflects responses to new or unique choices for solving a problem in a crisis. In regard to crisis management, a valuable or effective decision occurs when potential crises are averted or when key stakeholders believe that the short- and long-term successes of crisis management efforts have outweighed the failures" (Sommer & Pearson, 2007) p.1236.

Sommer and Pearson (2007) argue that novelty and value are complementary but separate characteristics, and both must be present for creativity to occur in a crisis context. This is borne out by a logical examination of those characteristics individually. Training pigeons to carry water balloons is a novel option which is nonetheless of little value to fighting a wildfire. Solutions that are of high-value but not novel have presumably already been evaluated and either implemented or discarded – and is how an individual or team came to the need for a creative solution.

This project seeks to improve creativity in decision making in the context of emergency management. The aim is to identify when and how this type of thinking or decision-making "style" might be appropriate and therefore what knowledge, skills and processes might be necessary to develop in a cohort of decision makers. As particular 'styles' are appropriate in different situations, the effective emergency management decision-maker is one who knows when and where to use a particular style. Psychologists refer to the skill of being able to identify the appropriate decision style 'meta-cognition' – or thinking about their 'thinking'. It is also likely that meta-cognitive thinking requires a degree of neural plasticity on the part of the individual. In the table below we link the focus area of this document (creative thinking and divergent thinking skills) with key aspects of brain plasticity.

Possible training approach	Aspect of Brain Plasticity	Associated Cognitive Effect	Application in EM
Teaching creativity and divergent thinking skills.	Greater cerebral blood flow, functional connections and structural plasticity associated with regions of the brain that deal with reasoning and memory.	Divergent thinking facilitated; various types of reasoning (associated with causes, effects, elaboration and novel use of objects/assets). Improved capacity for meta-cognitive awareness.	Being more creative in novel situations; improved ability to reason in difficult contexts.

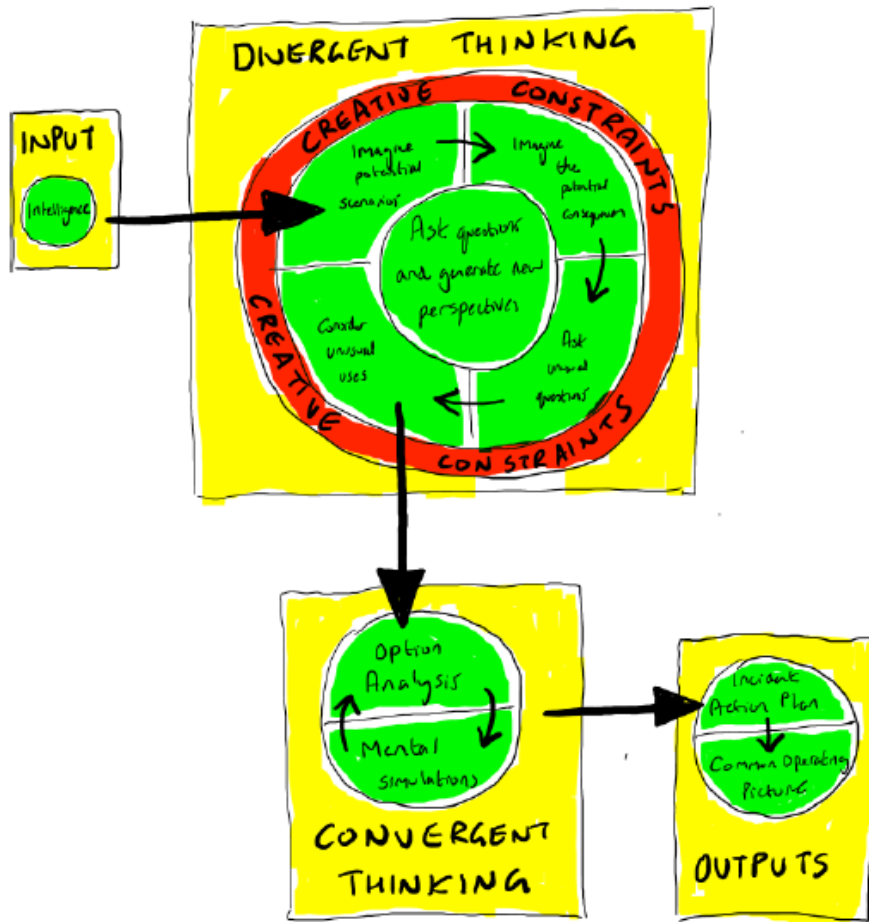


Figure 1: Linking Divergent and Convergent Thinking in Emergency Management

## OPTIONS ANALYSIS

The development of options in response to an emergency or crisis has been targeted as one of the most significant opportunities for personnel to use creative thinking strategies. When options are narrowly articulated this has the subsequent effect of attention tunnelling – focusing the team around that individual or set of options. Often a single option (applying the heuristics of ‘take the first’ or ‘take the best’) is articulated. This can see teams compromised when the situation changes, and the option chosen becomes non-viable.



Figure 1 is a summary of our thinking about how these concepts connect and describes the process taught in the second educational session of the workshop/intervention. There must be some initial information or intelligence to work with, and this serves as an input into the divergent thinking process. That process is driven by the key constructs described earlier, but also occurs within a set of constraints that relate to the assets at the disposal of the team and the context in which they must be deployed. After thinking divergently about possibilities the results need to be refined through mental simulation to converge on a series of options. These options become embedded in the Incident Action Plan and integrated within the Common Operating Picture.



## METHOD

### PRELIMINARY WORKSHOPS

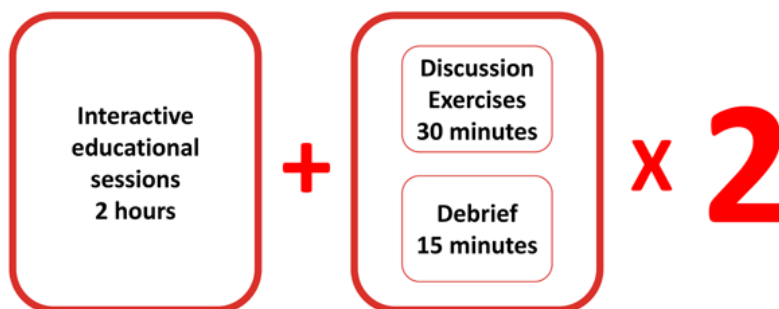
A total of four workshops were conducted with our end users. The first workshop was the pilot and conducted with Tasmanian Fire Service, Tasmanian State Emergency Service and Tasmania Police in Hobart. The second workshop was conducted with the Australian Red Cross in Melbourne and was used to further develop and improve the training intervention and improve the method for assessing the creativity of the options analysis. Improvements were also made to the content, the timing, discussion exercise descriptions and instructions were standardised. Following this development phase, the third and fourth workshops were conducted over 2-days with personnel from NSW Fire and Rescue, NSW Rural Fire Service, NSW State Emergency Service and NSW Police Force.

The exercises were also taken out of the standard operational realm of the participants in order to minimise the likelihood that the participants would 'go tactical' and respond intuitively or following the rule-based logic of their organisation.

### OUTLINE OF TRAINING INTERVENTION

The aim of the training intervention was to identify whether it was possible to increase the level of creative output in an options analysis by teaching participants to use a methods that promote creativity. The structure of the day included:

- An introductory presentation on decision-making,
- A 2 hour educational session that explored key decision-making concepts including cognitive bias, situational awareness, psychological safety and the use of the Individual and Team Coping Concept (The Coping Ugly Framework).
- A 30-minute discussion exercise (DISCEX #1) and 15-minute debrief.
- A 2 hour educational session that explored the nature of creativity and the links between divergent and convergent thinking in emergency management, using the concepts identified above.
- A subsequent 30-minute discussion exercise (DISCEX #2) and 15-minute debrief.





## SUMMARY OF DISCEX #1

A group of 27 personnel for your organisation are in the Kimberley region of Western Australia (WA) on a 4-wheel drive bus travelling between Fitzroy Crossing and Kununurra as part of a goodwill ambassador tour that your organisation is leading. Ten minutes ago, your organisation was informed by the local emergency services that there were reports that a bus had crashed on National Highway One in the Kimberley's. According to the information received by the 000 operator a member of the party from your organisation dialled 000 but only managed to state her organisations name and then say that a bus has crashed in the Kimberley's before the line went dead. The time is 1800 Australian Eastern Standard Time (AEST) on a Wednesday in mid-January.

The executive team at your organisation have requested that you provide them with an analysis of the options based on the existing intelligence, so they can provide a briefing to the board at 1830 local time.

## SUMMARY OF DISCEX #2

A delegation of 30 personnel for your organisation are attending a conference in Hikkaduwa, a seaside resort town in southwestern Sri Lanka. You have just been informed by your respective organisation that an undersea earthquake has occurred approximately 2 hours ago with an epicentre off the southern coast of Sri Lanka with initial reports of a magnitude of approximately 8.5 on the Richter scale (the 2004 Indian Ocean tsunami measured 9.1). The tsunami buoys located in the region of southern Sri Lanka had failed and therefore no warning was provided to the population. The Department of Foreign Affairs and Trade (DFAT) are overwhelmed with requests for information due to the large number of Australian citizens currently in Sri Lanka at the commonwealth games in the capital Colombo. Your respective executive management teams have requested that you assemble a group to explore potential scenarios regarding the wellbeing of your personnel. The time is 1735 on Friday afternoon, 11 hours ahead of Coordinated Universal Time (UTC).

The executive team at your organisation have requested that you provide them with an analysis of the options based on the existing intelligence, so they can provide a briefing to the board at 1820 local time.

## PARTICIPANTS AND MEASUREMENT

The measurement of creativity was evaluated in the final two workshops that was conducted with 40 participants from our NSW end users. These participants were divided into 7 groups (4 on day one and 3 on day two) of approximately 6 persons (no group was larger than six or smaller than 5) and were later identified as groups 1 to 7.

The approach mimics key aspects of the Torrance Test, using four measures of creativity – fluency, originality, elaboration and flexibility. These measures are defined further below. For each of the groups a photograph was taken of the output from each discussion exercise at the end of the 30 minute time allocation. Each result was scored, and the raw scores are shown in Table One.

## NORM REFERENCED MEASURES

### 1. Options Fluency

Fluency is simply a count of pertinent responses, scored by reading each response and making a judgement as to whether the response is in fact relevant to the situation. Each relevant response is given 1 point.

### 2. Options Originality

Originality is the ability to produce ideas that are generally not produced, or ideas that are totally new or unique. The following table gives the common responses. If responses are found on this list then they score zero, all other responses are given one point each.

DISCEX	Common responses
1	All employees were involved in the bus crash and are dead as a worst-case scenario.
	There was a minor bus crash that did not involve any of our employees as best-case scenario.
2	All employees were trapped by the tidal wave and subsequently drowned, and their bodies have been or are able to be recovered.
	No employees were within the impact zone of the tidal wave at the time.
	There was no tidal wave, so the event is a false alarm.

### 3. Options Elaboration

Elaboration is the ability to embellish ideas with details. Two assumptions underlie the scoring on elaboration. The first is that the minimum and primary response is the basic 'option' developed. The second is that the imagination and exposition of detail is a function of the creative ability and is appropriately labelled 'elaboration'. 1 point is given for each elaboration of the options. Elaboration could include – use of assets, identification of outcomes or simulated sequences of events.

### 4. Options Flexibility

Flexibility is the ability to process information or objects in different ways, given the same stimulus. For this test flexibility relates to the evidence of consideration of adjusting the options depending on a range of dynamic variables that influence the hazard/incident in question. This could be wind changes for wild fires, influence of building-to-building ignition in urban fires; rainfall intensity in flood response or after-shocks in earthquakes. 1 point is given for each example of flexibility in the options



## RESULTS

**Table One: Divergent Thinking Component Scores DISCEX #1**

	DISCEX 1				TOTAL SCORE
	Fluency	Originality	Elaboration	Flexibility	
Group 1	0	0	5	0	5
Group 2	4	0	2	0	6
Group 3	1	0	4	0	5
Group 4	1	0	4	0	5
Group 5	2	0	4	0	6
Group 6	2	0	4	0	6
Group 7	6	0	8	0	14

**Table Two: Divergent Thinking Component Scores DISCEX #2**

	DISCEX 1				TOTAL SCORE
	Fluency	Originality	Elaboration	Flexibility	
Group 1	3	0	8	0	11
Group 2	4	0	5	0	9
Group 3	2	0	7	0	9
Group 4	3	0	10	0	13
Group 5	4	0	9	0	13
Group 6	4	0	6	0	10
Group 7	2	0	25	0	27

**Table Three: Summary Scores**

	DISCEX 1	DISCEX 2	Difference
Group 1	5	11	+6
Group 2	6	9	+3
Group 3	5	9	+4
Group 4	5	12	+7
Group 5	6	13	+7
Group 6	6	10	+4
Group 7	14	27	+13

The two-tailed P value = 0.0025 for a paired t-test (t statistic = 4.9897; df = 6) The results indicate a significant difference between the scores in the two different DISCEX's.

The results also indicate that teams failed to demonstrate any degree of originality or flexibility as identified by the definitions of these criteria. They were able to create more options and elaborate to a greater degree on the intelligence provided to them in DISCEX 2 following the creativity training session.



## DISCUSSION AND CONCLUSIONS

The results identified a significant difference between the overall Creativity Scores for the groups in the two DISCEX's. This suggests that the training session had some influence, improving the scores around fluency and elaboration. Teams showed no indications of originality or flexibility – and these results are discussed further below. Throughout the discussion we also identify the key limitations in the current method and identify opportunities for further improvement.

As indicated earlier, fluency is simply a count of pertinent responses, scored by reading each response and making a judgement as to whether the response is in fact relevant to the situation. This translates into the raw number of options a team considers. In the first DISCEX the majority of teams had 1-2 options. This may well be influenced by the nature of emergency management decision-making which sometimes focuses on the 'best' or most likely option or takes a dualistic approach of considering the best and worst case options. In the second DISCEX more teams used the concept that there was some type of 'spectrum' of options between the best and worst case and by exploring the spectrum they could elaborate more options, using different outcomes to articulate what those options were.

The other significant criteria that saw improvement between the two DISCEX's was elaboration. This was earlier defined as the ability to embellish ideas with details. Elaboration could include – use of assets, identification of outcomes or simulated sequences of events. In the current context, elaboration included identification of the complexity of impacts (e.g., a bus crash that included a significant proportion of the organisation's senior personnel may influence certain aspects of business continuity). The scenarios were specifically designed such that participants needed to 'step outside' their familiar emergency responders role to imagine being part of a private organisation that has different drivers and challenges. There may have been a learning effect associated with this between DISCEX 1 and DISCEX 2 that improved the results around elaboration.

None of the groups score on originality or flexibility during either of the DISCEX's. Originality is the ability to produce ideas that are generally not produced, or ideas that are totally new or unique. For example, the bus in DISCEX 1 might have found its way to a remote 5 Star resort after the air conditioner broke down, with personnel now enjoying cocktails by the pool. The scenario is fanciful, but the structures and processes of emergency services seem to restrict people from thinking too originally about these sorts of scenarios. There are also cultural impediments that require people to be 'realistic' and we suggest this factor also influences the originality of options outputs.

Flexibility is the ability to process information or objects in different ways, given the same stimulus. It is possible that we limited the flexibility through the types of information we provided. This information was written, and the written information included spatio-temporal intelligence. The typical way this information was processed included timelines and simple maps. Flexible approaches would have included the extension of the timelines into the future, the creation of more elaborate mapping, or some way of expressing who was



absent/accounted for (such as an organisational chart). These tools could have been modified as dynamic influences like heat (in DISCEX 1) or aftershocks, further tidal waves (in DISCEX 2) were simulated to impact the situation.

This suggests we have more work to do to improve creativity on at least two of the four divergent thinking constructs. These results will be used to develop the utilisation products that flow from the research.



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