Group Versus Individual Use of Power-Only EPMcreate as a Creativity Enhancement Technique for Requirements Elicitation

by

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Introduction

Creativity is often needed in requirements elicitation, e.g., in generating ideas for requirements.

Techniques to enhance creativity are believed to be useful.

In our research, we have been investigating EPMcreate (EPM Creative Requirements Engineering [A] TEchnique), which is based on the Elementary Pragmatic Model (EPM) of the pragmatics of communication.

Acronyms to Save Space in Slides

RElic = requirements elicitation

RA = requirements analyst or engineer

BS = brainstorming ☺

CET = creativity enhancement technique

EPMcreate

EPMcreate supports idea generation in RElic by focusing the RA's search for ideas on only one logical combination of two stakeholders' viewpoints at a time.

16 combinations are possible, corresponding to the 16 basic boolean functions, *fi* for $0 \leq i \leq 15$, of two variables.

16 Boolean Functions of 2 Variables

*V*1	*V*2	*f*0	*f*1	*f*2	*f*3	*f*4	*f*5	*f*6	*f*7
0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	1	1	1	1
1	0	0	0	1	1	0	0	1	1
1	1	0	1	0	1	0	1	0	1

*V*1	*V*2	*f*8	*f*9	*f*10	*f*11	*f*12	*f*13	*f*14	*f*15
0	0	1	1	1	1	1	1	1	1
0	1	0	0	0	0	1	1	1	1
1	0	0	0	1	1	0	0	1	1
1	1	0	1	0	1	0	1	0	1

EPMcreate in Practice

EPMcreate can be used whenever idea generation is needed during RElic.

When a lead RA determines that EPMcreate should be applied during RElic for the system being built, …

EPMcreate in Practice, Cont'd

she chooses 2 kinds of stakeholders, *SH*1 and *SH*2, usually users of the system with different roles.

E.g., the selected stakeholder types could be

- **students and lecturers for an e-learning application, and**
- **employees of the selling and buying companies for a system supporting a company's B2B activities.**

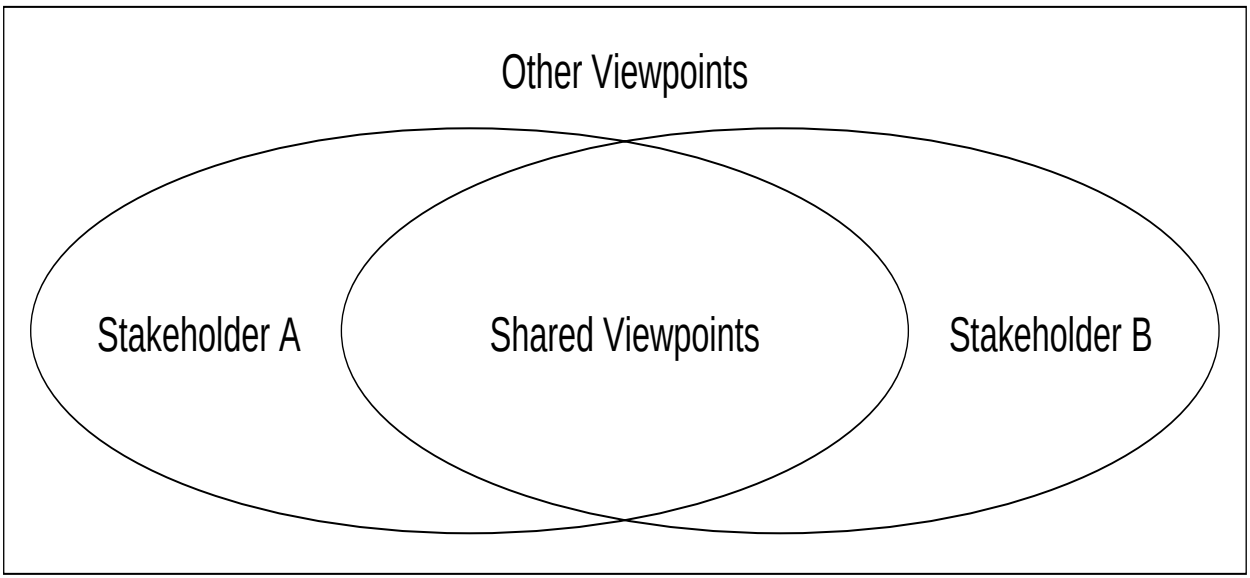
EPMcreate in Practice, Cont'd

Normally, not all pairs of stakeholder types are used.

The lead RA chooses pairs she believes to be informative.

She then convenes a group of RAs and shows them the Venn Diagram on the next slide.

Venn Diagram of Viewpoints



The two ellipses represent 2 stakeholders' viewpoints.

Instructions given to RAs

The lead RA tells all convened RAs:

“Today, we are going to generate requirement ideas for the system *S* in 16 idea generation steps. In all the steps, you will be pretending to think from the viewpoints of two particular stakeholders of *S*, *SH*1 and *SH*2.

Step 0, for $f0 = \mathbf{0}$

In Step 0, you will blank out your minds.

Step 1, for $f1 = \boldsymbol{SH1} \wedge \boldsymbol{SH2}$

In Step 1, you will try to come up with ideas for problem solutions that are needed by both *SH*1 and *SH*2.

Step 2, for $f2 = SH1 \wedge \neg SH2$

In Step 2, you will try to come up with ideas for problem solutions that are needed by *SH*1 but not by *SH*2.

Step 3, for $f3 = SH1$

In Step 3, you will try to come up with ideas for problem solutions that are needed by *SH*1 without concern as to whether they are needed by *SH*2.

Step 4, for $f4 = \neg SH1 \wedge SH2$

In Step 4, you will try to come up with ideas for problem solutions that are needed by *SH2* but not by *SH1*.

Step 5, for $f5 = SH2$

In Step 5, you will try to come up with ideas for problem solutions that are needed by *SH2* without concern as to whether they are needed by *SH1*.

…

Step 8, for $f8 = \neg SH1 \wedge \neg SH2$

In Step 8, you will try to come up with ideas for problem solutions that are needed neither by *SH*1 nor by *SH*2, but are needed by other stakeholders.

…

Step 10, for $f10 = \neg$ ***SH2***

In Step 10, you will try to come up with ideas for problem solutions that are not needed by *SH2* without concern as to whether they are needed by *SH*1.

…

Step 15, for $f15 = 1$

In Step 15, you will try to come up with ideas for problem solutions without concern as to whether they are needed by either *SH*1 or *SH*2.”

Optimization, POEPMcreate

We demonstrated in experiments that one optimization of EPMcreate, the Power-Only EPMcreate (POEPMcreate), is more efficient in supporting idea generation for RElic.

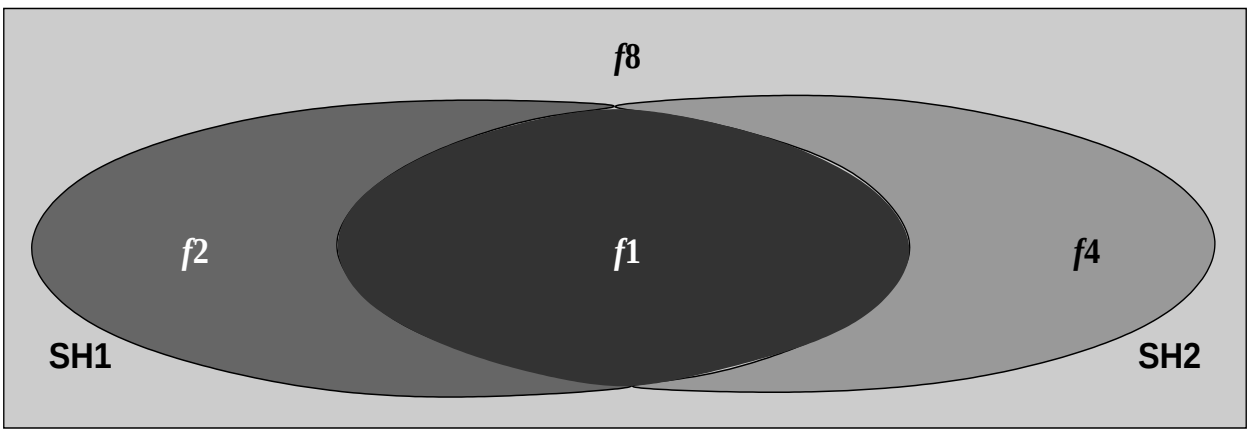
POEPMcreate does only the 4 steps whose names include the powers of 2, namely Steps 1, 2, 4, and 8.

“more efficient” means that more and better ideas are generated in a smaller amount of time (with *no* space–time tradeoff)!

Why More Efficient?

As shown below,

$f1 = SH1 \wedge SH2$ $f2 = SH1 \wedge \neg SH2$ $f4 = \neg SH1 \wedge SH2$ $f8 = \neg SH1 \wedge \neg SH2$



Why, Cont'd

the Boolean function of each of the power-of-2 steps corresponds to exactly one of the four regions of the Venn Diagram shown before.

Thus, the 4 power-of-2 steps suffice to cover the entire space of potential ideas, …

and the other 12 steps just repeat the coverage.

EPMcreate's Effectiveness

We have conducted controlled experiments which used an online course system, an e-government system, the Website of a jazz festival, and the Website of a Canadian high school as the systems about which to elicit requirement ideas.

Notation in the Results

In the following, "*A* ≥ *B*" ≡ "*A* is more effective than *B* in helping to generate requirement ideas, measured by numbers of both raw (quantity) ideas and new (quality) ideas".

Here, "new" is taken relative to the existing system.

Controlled Experiment Results

These controlled experiments concluded with statistically significant results that

EPMcreate ≥ BS

and

POEPMcreate ≥ EPMcreate.

Focus on POEPMcreate

Because POEPMcreate ≥ EPMcreate in both space and time,

and thus we will be using only POEPMcreate,

we focus our experiments on POEPMcreate,

to conserve the very valuable subject resource.

New Research Question

Does the number of members of an elicitation group using EPMcreate or POEPMcreate as a CET affect the number of requirement ideas generated by the group and by each member?

When we started, we really had no idea about the answer.

So we started with null hypotheses.

Hypotheses

H1 **In POEPMcreate, the number of members of an elicitation group has no effect on the quantity and quality of the requirement ideas generated *by the group*.**

H2 **In POEPMcreate, the number of members of an elicitation group has no effect on the quantity and quality of the requirement ideas generated *on average by each member of the group*.**

Method

We combined the data of 3 identically structured experiments in which individuals and groups of size 2 and 4 used POEPMcreate to generate ideas for requirements for enhancing one Canadian high school's Website.

Method, Cont'd

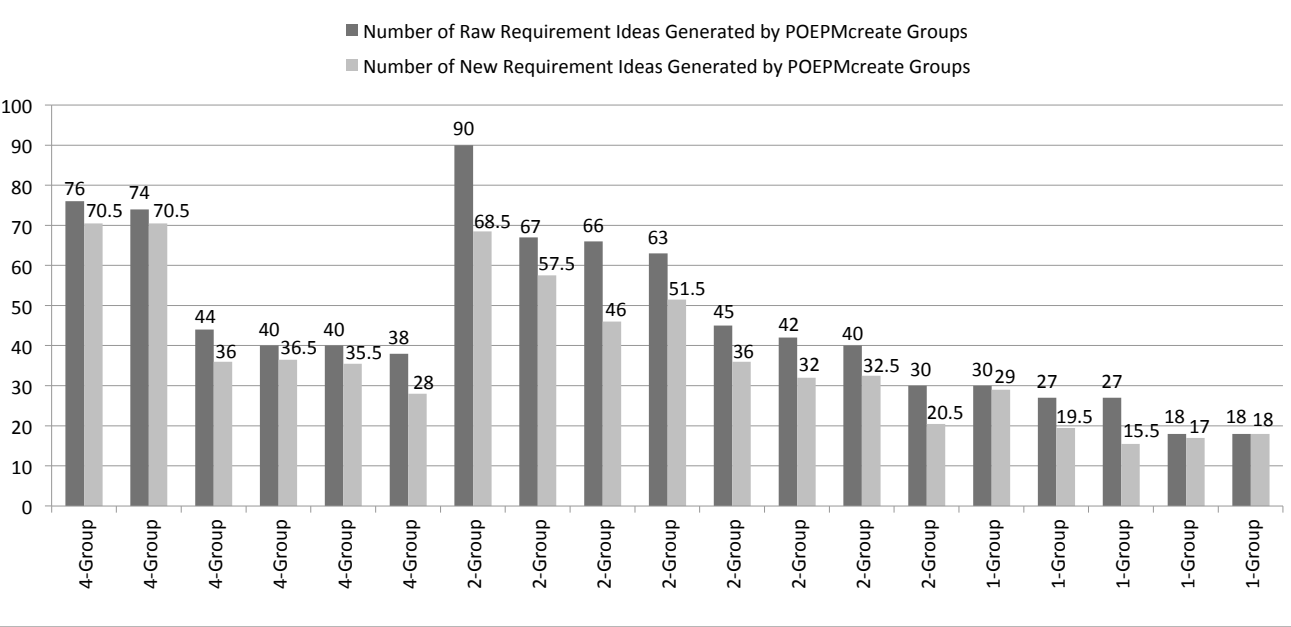
Later, for triangulation, we conducted a survey to determine software development practitioners' attitudes on the comparison of the effectiveness of individuals and groups in requirements elicitation for real projects.

Results of the Experiments

The next two slides show graphs of the data of the combined experiments:

1. **the number of raw and new requirements ideas generated by entire groups, and**

2. **the number of raw and new requirements ideas generated *on average* by each member of groups.**


Number of Raw Requirement Ideas Generated by POEPMcreate Groups
Number of New Requirement Ideas Generated by POEPMcreate Groups
100
90
80
70
60
50
40
30
20
10
0
76
70.5
74
70.5
44
36
40
36.5
40
35.5
38
28
90
68.5
67
57.5
66
46
63
51.5
45
36
42
32
40
32.5
30
20.5
30
29
27
19.5
27
15.5
18
17
18
18
4-Group
4-Group
4-Group
4-Group
4-Group
4-Group
2-Group
2-Group
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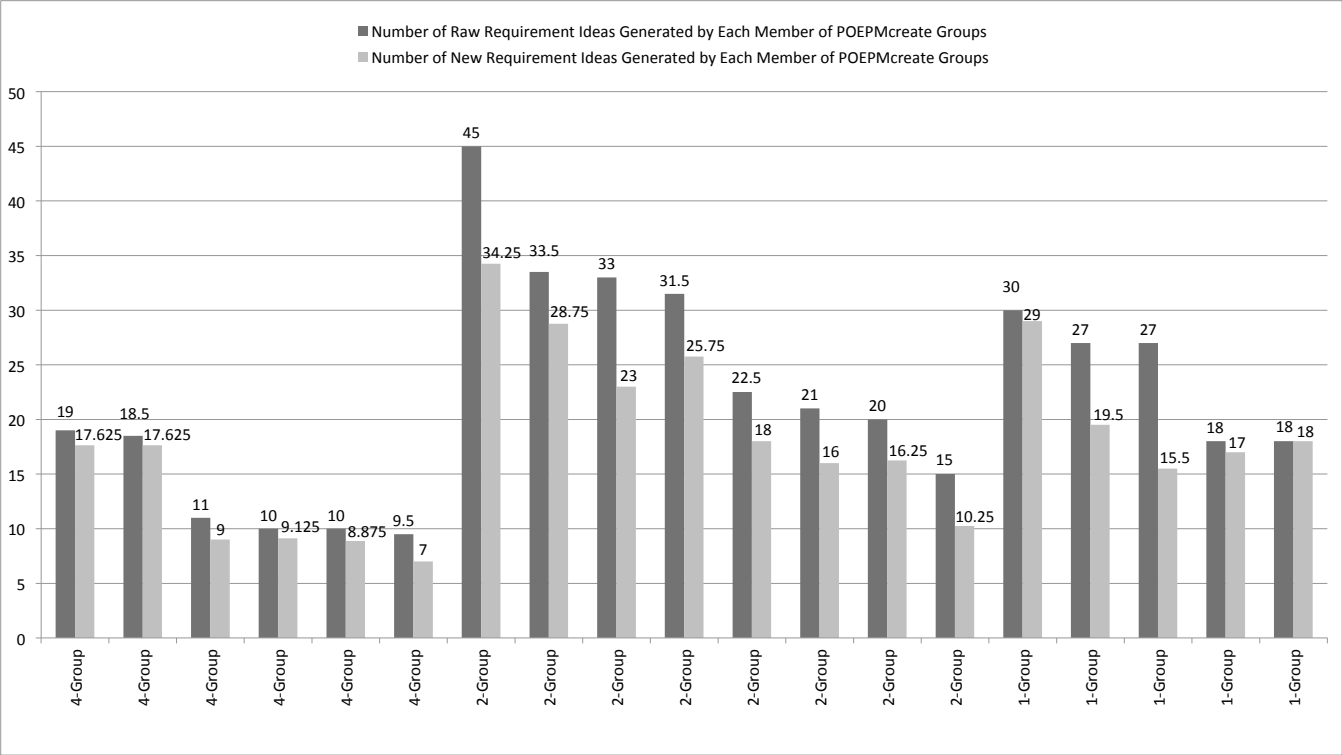

Number of Raw Requirement Ideas Generated by Each Member of POEPMcreate Groups
Number of New Requirement Ideas Generated by Each Member of POEPMcreate Groups
50
45
40
35
30
25
20
15
10
5
0
19
17.625
18.5
17.625
11
9
10
9.125
10
8.875
9.5
7
45
34.25
33.5
28.75
33
23
31.5
25.75
22.5
18
21
16
20
16.25
15
10.25
30
29
27
19.5
27
15.5
18
17
18
18
4-Group
4-Group
4-Group
4-Group
4-Group
4-Group
2-Group
2-Group
2-Group
2-Group
2-Group
2-Group
2-Group
2-Group
1-Group
1-Group
1-Group
1-Group
1-Group

Pre-Tests

We did some several tests, some data adjustment, and some more tests to ensure that it was legitimate to combine the data of 3 identically-run experiments into one analysis as if they were 1 experiment.

Refined Hypotheses

H1 and H2 are refined into 4 subhypotheses, HPTR, HPTN, HPAR, and HPAN:

The number of members of an elicitation group using { ***E*: EPMcreate** ; ***P*: POEPMcreate** } **has no effect on the** { ***T*: total number of ideas per group** ; ***A*: average number of ideas per group member** } **of** { ***R*: raw** ; ***N*: new** } **requirement ideas generated.**

Summary of Conclusions

The table on the next slide summarizes the conclusions about the subhypotheses that are drawn from the data, …

giving in for each subhypothesis,

- **whether**
- **how strongly, and**
- **why**

it is rejected.

Summary of the Effects of Changes in Group Size on the Subhypothesis Dependent Variables

Compared Group Sizes (s)	Subhypotheses			
	H1		H2	
	# Raw Requirement Ideas Generated by	# New Requirement Ideas Generated by	# Raw Requirement Ideas Generated by	# New Requirement Ideas Generated by
	Whole Group		Group Member	
	PTR	PTN	PAR	PAN
$s1 \rightarrow s2$	*** ↑ 39.24 (*** ↑ 39.24)	** ↑ 28.32 (** ↑ 28.32)	↑ 7.62 (↑ 7.62)	↑ 4.26 (↑ 4.32)
$s2 \rightarrow s4$	* ↓ 22.64 (* ↓ 22.60)	↓ 14.06 (↓ 14.02)	*** ↓ 21.44 (** ↓ 21.44)	** ↓ 15.51 (** ↓ 15.49)
$s1 \rightarrow s4$	↑ 16.60 (↑ 16.64)	↑ 14.26 (↑ 14.30)	* ↓ 13.82 (* ↓ 13.80)	* ↓ 11.25 (* ↓ 11.24)

In Other Words

It appears that the size of a group using POEPMcreate *does* affect the number of raw and new requirement ideas generated by the group and by each member of the group.

In Other Words, Cont'd

For whole groups and for average members of groups, group size 2 is the peak.

A 4-person whole group generates more ideas than a 1-person whole group (i.e., an individual).

The average group member in a 4-person group generates *fewer* ideas than in a 1-person group.

Hmmmmm! Individuals & BS

There is empirical evidence that in BS for requirement ideas, individuals are more effective than groups.

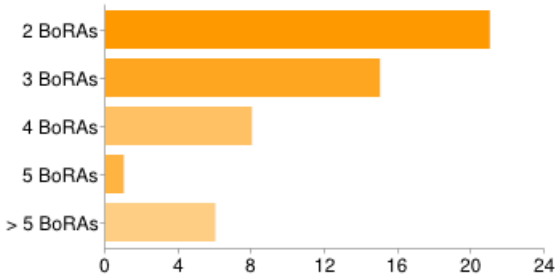
Maybe synergy is not what it's cracked up to be!?!?

Triangulation

The survey results, shown on the next slide, indicate that experienced software development practitioners have observed the same and seem to act accordingly.

First, they use groups more than they use individuals for idea generation.

Size of the groups - Groups usually consist of



2 BoRAs	**21**	40%
3 BoRAs	**15**	28%
4 BoRAs	**8**	15%
5 BoRAs	**1**	2%
> 5 BoRAs	**6**	11%

Speculation

We observed that for POEPMcreate,

- **a 4-person group generates on average 75 raw requirement ideas, 18.75 per member, but**

- **a 2-person group generates on average 55.38 raw requirement ideas, 27.69 per member.**

Best Use of a Set of Analysts

So, if you have 4 analysts, …

maybe it's better to have

two independent 2-person groups generating 110.76 ideas

than

one 4-person group generating 75 ideas.

Duplicated Ideas?

What about the duplicated ideas between the two independent 2-person groups?

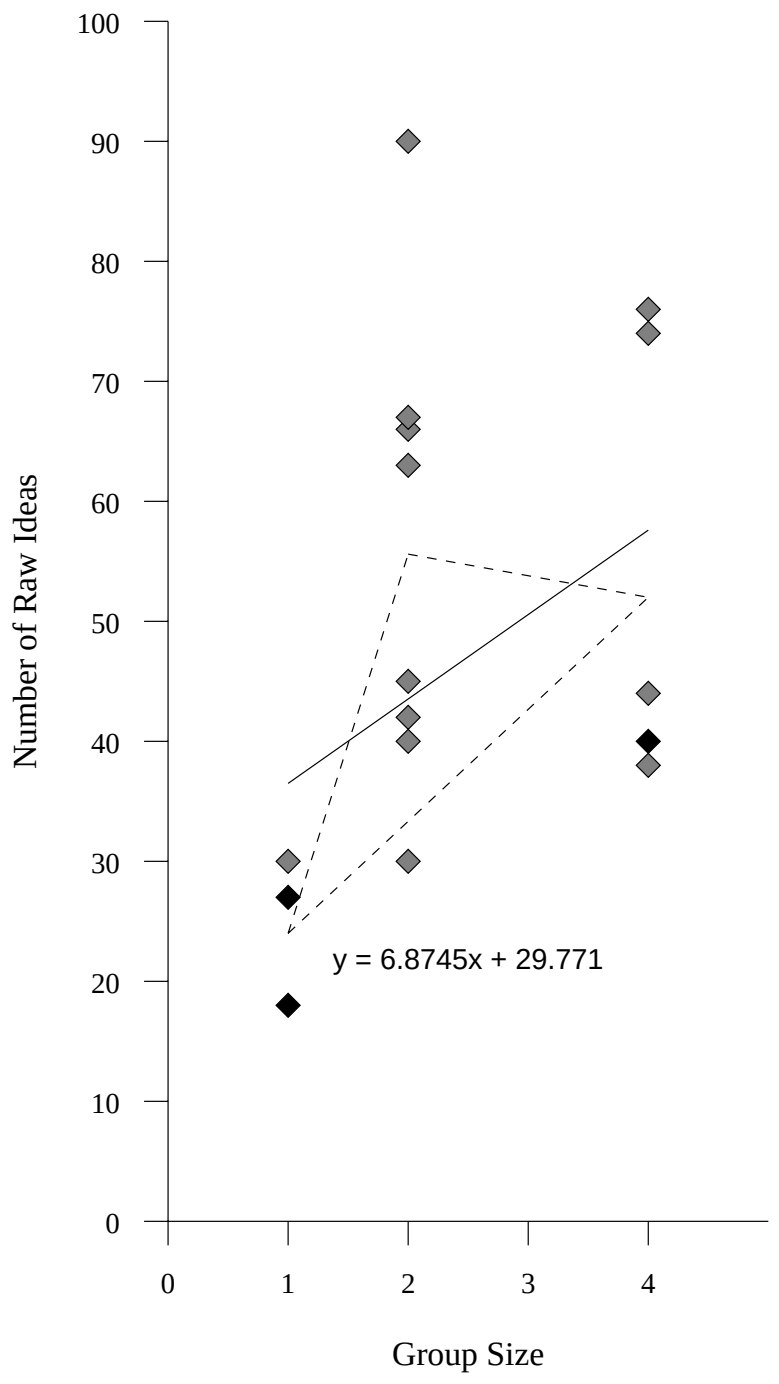
We tested the duplication of ideas among pairs of groups and found it to be uniformly less than 110.76 – 75 = 35.76!

Wow!!

Plot of PTR Data

Look at the plot of the PTR data on the next slide.

The plot for the PTN data is almost the same.


100
90
80
70
60
50
40
30
20
10
0
Number of Raw Ideas
0
1
2
3
4
Group Size
y = 6.8745x + 29.771

Plot, Cont'd

This plot shows that the overall relation between

a group's size and

the number of ideas of any kind generated by the group

is definitely not linear.

A quadratic regression would work.

Theory to Explain Result

We have developed a theory

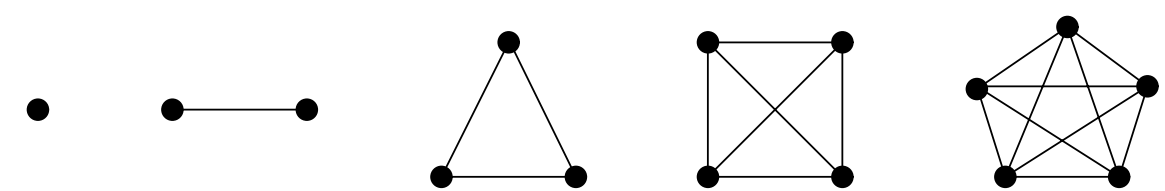
- **that explains our results,**
- **that is applicable to *any* CET, and**
- **that is testable.**

Theory, Cont'd

Group overhead drags against group synergy.

Each of group overhead and group synergy is a group phenomenon.

Thus, each of group overhead and group synergy grows quadratically with group size.



1,0 2,1 3,3 4,6 5,10

number of persons, lines of communication

Theory, Cont'd

Let's measure synergy as the number *S* of ideas arising from it.

Let's measure overhead as the number *O* of ideas lost as a result of it.

Let *n* be the number of persons in a group, then we expect that

$$S = an^2 + b$$

$$O = An^2 + B$$

for some constants, *a*, *b*, *A*, and *B*.

Theory, Cont'd

Then, the total number *I* of ideas generated by a group of size *n* is

$$I = S - O$$

$$I = (an^2 + b) - (An^2 + B)$$

For each CET, *a*, *b*, *A*, and *B* are set to cause the peak at a different *n*.

For example, for BS, the peak is at $n = 1$,

Theory, Cont'd

For POEPMcreate, the peak is some where between 2 and 3, inclusive.

Lacking POEPMcreate data for $n = 3$, we cannot say where the peak is for POEPMcreate.

For example if a group with three people generates the same number of ideas as a group with two people, the peak would be at $n = 2.5$.

Theory, Cont'd

So, for each CET *c*, the constants are a_c, b_c, A_c, and B_c, and

$$I_c = (a_c n^2 + b_c) - (A_c n^2 + B_c)$$

We propose this equation for I_c as a theory to be tested empirically for a variety of CETs.

Theory, Cont'd

For each CET, an experiment similar to those described in this talk

will be conducted with all group sizes ranging from 1 through at least 4,

or more if necessary,

to establish the constants for the CET.

We invite the promoters of the various CETs to conduct these experiments with their CETs.

Future Work

More experiments to increase and balance the numbers of each size of group, to add group sizes, to try

- **to confirm and strengthen these results,**
- **to answer the speculation, and**
- **to confirm the theory.**

More survey data for better triangulation.

Now Read Our Paper!

I hope that we have gotten you excited enough that you will now go and read our paper!

It's at

http://link.springer.com/article/10.1007/s10664-016-9475-z

☺