Productive Pairs and the Power of Provisionality: Experimental Findings on Dyadic Creativity in the Management Context

D I S S E R T A T I O N
of the University of St. Gallen,
School of Management,
Economics, Law, Social Sciences
and International Affairs
to obtain the title of
Doctor of Philosophy in Organizational Studies and Cultural Theory

submitted by

Lawrence McGrath

from

New Zealand

Approved on the application of

Prof. Dr. Martin J. Eppler

and

Prof. Dr. Sabrina Bresciani

Dissertation no. 4545

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The University of St. Gallen, School of Management, Economics, Law, Social Sciences and International Affairs hereby consents to the printing of the present dissertation, without hereby expressing any opinion on the views herein expressed.

St. Gallen, May 23, 2016

The President:

Prof. Dr. Thomas Bieger
For Ella – dream big and live big.
Table of Contents

1 Introduction .............................................................................................................. 11
  1.1 Visualisation ........................................................................................................ 13
  1.2 Dyads .................................................................................................................. 18
  1.3 Theoretical Foundations ....................................................................................... 21
  1.4 Research Questions ............................................................................................ 23
    1.4.1 Research Scope: Definition of Group ............................................................. 26
    1.4.2 Research Scope: Definition of Ideation ........................................................ 27
  1.5 Methodology ........................................................................................................ 29
  1.6 Study Outline ....................................................................................................... 30
  1.7 Conclusion ............................................................................................................ 32
  1.8 References ........................................................................................................... 34

2 Study 1 Overview ..................................................................................................... 44
  2.1 References ............................................................................................................ 46

3 Study 1: When Pairing Reduces Scaring: The Effect of Dyadic Ideation On Evaluation Apprehension .............................................................................................................. 48
  Abstract .................................................................................................................... 48
  Keywords .................................................................................................................. 48
  Introduction .............................................................................................................. 48
  Literature Review .................................................................................................... 51
  Creativity in Dyads .................................................................................................. 51
  Integration of Dyads into Groups ............................................................................ 53
  Evaluation Apprehension ....................................................................................... 53
  Theory of Social Impact ......................................................................................... 55
  Idea qualification ..................................................................................................... 57
  Methods ................................................................................................................... 61
    Research design ...................................................................................................... 61
    Participants ............................................................................................................ 61
    Procedure ............................................................................................................. 61
  Results ...................................................................................................................... 65
    Focus Group Results ............................................................................................. 67
  Discussion ................................................................................................................. 68
    Practitioner Implications ...................................................................................... 72
    Limitations ............................................................................................................ 77
    Future research .................................................................................................... 78
    Conclusion ............................................................................................................. 79
4 Study 2 Overview ................................................................. 93
4.1 References ......................................................................... 96

Study 2: Cognitive Antifreeze: The Visual Inception of Fluid Sociomaterial Interactions for Knowledge Creation .......... 97
Abstract .................................................................................. 97
Introduction ............................................................................. 97
Literature Review & Hypothesis Development ......................... 97
Dyads .................................................................................... 97
Need for Cognitive Closure (NFCC) ........................................ 98
The Dual Pathway to Creativity Model .................................... 99
Visualisation .......................................................................... 100
Hypothesis Development ....................................................... 102
Method .................................................................................. 104
  Research Design .................................................................. 104
  Participants .......................................................................... 105
  Procedure ............................................................................ 105
Results .................................................................................... 107
Discussion ............................................................................... 112
Conclusion .............................................................................. 112
References ............................................................................. 115

5 Study 3 Overview ............................................................... 121
5.1 References ......................................................................... 125

6 Study 3: The Power of Provisionality: An Experimental Evaluation of Idea Appearance in Online Knowledge Creation ......... 127
Abstract .................................................................................. 127
Keywords ................................................................................ 127
Introduction ............................................................................ 127
Literature Review .................................................................. 129
  Search in Semantic Memory ................................................. 129
  Disfluency .......................................................................... 130
  Perceived Finishedness (PF) ................................................ 131
  Idea Generation Dialogue .................................................. 132
<table>
<thead>
<tr>
<th>Hypotheses Development</th>
<th>............................................................. 133</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>........................................................................ 136</td>
</tr>
<tr>
<td>Research Design</td>
<td>...................................................................... 136</td>
</tr>
<tr>
<td>Participants</td>
<td>........................................................................ 136</td>
</tr>
<tr>
<td>Adobe Connect CSS</td>
<td>...................................................................... 137</td>
</tr>
<tr>
<td>Procedure</td>
<td>....................................................................... 138</td>
</tr>
<tr>
<td>Dependent variables</td>
<td>........................................................................ 139</td>
</tr>
<tr>
<td>Results</td>
<td>........................................................................ 140</td>
</tr>
<tr>
<td>Discussion</td>
<td>........................................................................ 142</td>
</tr>
<tr>
<td>Implications for Practice</td>
<td>........................................................................ 143</td>
</tr>
<tr>
<td>Implications for Research</td>
<td>........................................................................ 144</td>
</tr>
<tr>
<td>Limitations</td>
<td>........................................................................ 144</td>
</tr>
<tr>
<td>Conclusion</td>
<td>........................................................................ 145</td>
</tr>
<tr>
<td>References</td>
<td>........................................................................ 146</td>
</tr>
</tbody>
</table>

7 Conclusion ........................................................................ 152

7.1 Summary of Findings ................................................................ 152

7.1.1 Study 1 ........................................................................ 152

7.1.2 Study 2 ........................................................................ 153

7.1.3 Study 3 ........................................................................ 154

7.1.4 Synthesis of Study 1, Study 2 and Study 3 Findings ............ 157

7.2 Theoretical Implications ................................................................ 157

7.2.1 Study 1 ........................................................................ 157

7.2.2 Study 2 ........................................................................ 159

7.2.3 Study 3 ........................................................................ 161

7.2.4 Synthesis of Theoretical Implications of Study 1, Study 2 and Study 3 ........................................................................ 165

7.3 Limitations ........................................................................ 166

7.4 Managerial Implications ................................................................ 168

7.5 Outlook & Future Research ................................................................ 169

7.6 Personal Reflections ........................................................................ 175

7.7 Concluding Remarks ........................................................................ 178

7.8 References ........................................................................ 180

8 Curriculum Vitae ........................................................................ 192
Table of Figures and Tables

Table 1: Visualisation Ideation Enablers ...........................................14
Figure 1: A ‘Do Not Touch’ Line on a Museum Floor ............................17
Table 2: Parallels between Relational and Ideation Task Dyads ..........21
Table 3: Typology of Groups .........................................................26
Figure 2: Creative Process Model ....................................................27
Figure 4: Research Model ...............................................................59
Figure 5: Outlined processes of NGT and Combined Dyad Conditions .62
Figure 6: Mind Map Output of a Combined Dyad Group .................63
Table 4: Means Comparison .............................................................65
Figure 7: Primary and Secondary Planes of the Social Impact of Evaluation
   Apprehension in a Combined Dyad Group .....................................70
Figure 8: Primary Plane of the Social Impact of Evaluation
   Apprehension in a Combined Individual Group ..............................71
Table 5: Summary Table of Relative Performance Advantages
   of Nominal Group Technique and Dyad Combination ....................74
Figure 9: Dyad combination Process and Foci of Study 1, 2 & 3 ..........94
Table 6: Knowledge Creation Enablers of Visualisation ....................100
Figure 10: Artificial and natural lines .............................................101
Figure 11: Conceptual Model ........................................................104
Table 7: Operationalisation of Fluid and Frozen Inscription
   and Display Devices .................................................................106
Figure 12: Worksheets and Materials Provided ...............................106
Table 8: Factor Means .................................................................108
Table 9: Factor One Way ANOVAs ................................................109
Table 10: Univariate Analysis of Variance Moderation Test ..............110
Figure 13: Moderating Effect of Worksheet and Instrument
   for Within Category Fluency (WCF) ...........................................111
Figure 14: Remote Associates Test (RAT) ........................................123
Figure 15: Theoretical Model .........................................................135
Table 11: Item Examples and PF Pretest Results ..............................137
Figure 16: Video Still Frame from Tailored Adobe Connect CSS .......138
Table 12: Factor Means .................................................................140
Figure 17: The Interaction of Icon PF and Typeface Fluency on Idea Originality 141
Table 13: Univariate Analysis of Variance Test 141
Figure 18: Isometric Reporting of Multiple Planes of Social Impact 159
Figure 19: Redrawing of Pentimenti, Restructuring and Refining in Physical Design 163
Abstract

The world in which we live is not short of problems - it is short of ideas. It is thus imperative that science advance the process by which we generate ideas. This set of three studies investigates social psychological and visual means by which to raise the quality of ideation processes. In terms of social psychology, ideation task dyads, or groups of two are a major focus of this study. Although they show high potential, dyads have received relatively little research attention. Existing research shows that dyads respond well to visual support; therefore this set of studies seeks the optimal visual support for ideation in dyads - at a foundational level. This set of three studies examines the fundamentals making up visualisations in ideation task dyads. The visual aspect of this study uses two laboratory experiments to focus upon the social effect which differing levels of perceived finishedness (PF) in the lines dyads base their interaction upon has. A pilot study on active managers found that low perceived finishedness visual representations function as an effective cognitive antifreeze that raises cognitive persistence – within a purely explorative visual space. In a subsequent laboratory experiment on active managers using an explorative visual space, low perceived finishedness lines - such as those used in sketching - are found to invite the co-construction of ideas and thus raise originality. The visual dimension of low perceived finishedness can thus be used to raise both paths to creative ideation in dyads - cognitive flexibility and persistence. Processually, these conditions are the ideal preparation for the social psychological aspect examined herein – dyad combination. A third mixed methods study incorporating a laboratory experiment on active managers found that when a four person group is made by fusing two dyads, individuals experience lower fear of being judged upon what they say than when four individuals form a group. Such fear of evaluation is a persistent burden upon ideation processes. This chronologically-presented set of three studies concludes that dyad combination and low perceived finishedness lines are effective means by which to enhance the quality ideation processes. Moreover, the course of these three studies finds theoretical implications for social psychology, ideation and visualisation. The chief driver of these theoretical ramifications is the finding that visual line types influence our lines of thought. In the visually-supported task ideation dyads, to which we all belong at one time or another, the nature of our social interaction is dependent upon the type of line our discussion is based around.
Abstract

1 Introduction

Today’s managers are faced with a dizzying range of problems that need to be solved at breakneck speed. Customers are increasingly fickle and vociferous. Competition and espionage have accelerated product development times. New entrants can undermine entire industries overnight. Solutions are in high demand. Fortunately ICT enables managers to connect with a diverse global pool of expertise to tease out and refine solutions. But how can managers use ICT that their competitors can also access to ‘outcreate’ their competitors? Idea generation is at the core of problem solving and creativity, so this is where this set of studies begins looking for means to attain creative advantage. This study finds visualisation and dyadic structures to be useful tools to help managers’ idea generation.

Connections of diverse talents and knowledges (Demarest, 1997) from around the globe will help to innovatively end tussles for transient and sustainable competitive advantage (McGrath, 2013; Porter, 1985). Group creativity takes advantage of diversity, yet requires intelligent fixes to overcome some inherent drawbacks of group dynamics. The current set of studies presents ideation research that precludes no type of divergent thinking non-insight problem. The findings present a small set of tools that are thus equally applicable to all activities involving ideation; with final results that are directly applicable to remote collaboration via computer-mediated communication. This is a priority research area for virtual team researchers (Gilson, Maynard, Young, Vartiainen & Hakonen, 2015).

Organisation is a hallmark of human capability that has enabled humanity to harness and synergise enormous amounts of diverse resources. Amongst these resources, knowledge has long been recognised as being of critical value (Drucker, 1966). Today the knowledge intensive work with which we solve our problems is increasingly being carried out by distributed teams (Dingsoyr & Smite, 2014). According to a recent survey, approximately 66% of multinational organisations employ distributed teams. (Society for Human Resource Management, 2012). Of those organisations who use distributed teams, 53% use them to source otherwise unavailable knowledge from geographically remote locations (Society for Human Resource Management, 2012). Whilst organisations using distributed teams report meeting some success with ideation tasks (Society for Human Resource Management, 2012), 78% of chief human resource officers in global organisations report major difficulty supporting face-to-face and remote teamwork (IBM, 2010). Figures for ad-hoc remote collaboration are more difficult to find, but Cisco Systems representatives report a rise in intermittent periods of remote colla-
boration by face-to-face teams (Beer, 2015). Added to this is the increasing frequency with which nomad workforces work from home, hotels, airports and trains (Fried & Heinemeier Hansson, 2013) and we begin to see the scale of scenarios to which the current set of studies can be applied. Moreover, the knowledge workers most heavily dependent upon these communication technologies are those at the very edges of human discovery and exploration – conducting research in places such as the Mariana trench, Antarctica, and the International Space Station (Brady, Hienz, Hursh, Ragusa, Rouse & Gasior, 2004).

There will be no single factor which remedies the challenges managers are facing. Humans are social animals (Caspi, Harrington, Moffitt, Milne & Poulton, 2006), and modern organisations demand that a diverse range of individuals work together (Fine, 1995; Kozlowski & Bell, 2008). Indeed, research into creative best practice extols the virtues of functionally diverse work groups (Keller, 2001). Remote collaboration is but one component which will help pull talents together to solve problems. In turn, visualisation or “drawing inferences from pictures and reasoning with pictures” (Goebel, 2015) will greatly facilitate remote collaboration through intelligent interface optimisation.

An interesting point is the fact that despite visual perception and reasoning being fundamental to us, we take its power - and its potential - for granted. In a recent interview with the popular press, the current US President Barack Obama stated that “One of the things we have to think about… Is how do we join together in a common conversation around something other than the superbowl?” (Stewart, 2015). Visualisation researchers have been thinking about this for decades. Research shows that the visualisation of meetings brings a range of benefits such as attracting attention (Suthers & Hundhausen, 2003), deictic referencing (Hundhausen, 2005) and insight support (Shimojima, 1996). Moreover visual objects function as boundary objects (Star, 2010) – heterogeneous groups can meaningfully reference them in conversation, despite retaining their own interpretations.

This introduction to the set of three studies in this dissertation will now briefly examine the visualisation literature relevant to ideation before looking into the scarce research on dyadic ideation.
1.1 Visualisation

Below, Table 1 presents a summary of the means by which visualisation enables ideation. Study 1 uses visualisation, but this set of studies truly begins to dive deep into visualisation mechanisms in Study 2. Accordingly, Study 2 provides a literature review of the range of means by which visualisation enables knowledge creation. Table 6 from Study 2 has been slightly adapted and reproduced below. First of all, Table 1 has been re-titled to reflect the true focus of this set of studies upon ideation as a subprocess of the larger creative process (Mumford, Medeiros & Partlow, 2012). Table 1 also differs from the table in Study 2 in that the fifth category of benefits has been widened to include external, not only internal, dialogue. The category entitled dialogue development now also covers the external dialogue pattern of elaboration (Hogan, Nastasi & Pressley, 1999), which emerges as a key object of interest in this set of studies. A brief review of the visualisation literature most relevant to this set of dyadic ideation studies will follow.
Table 1: Visualisation Ideation Enablers

<table>
<thead>
<tr>
<th>Visual knowledge creation enabler</th>
<th>Reference(s)</th>
</tr>
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<tbody>
<tr>
<td>1 Assistance of remote association triggering</td>
<td>Chambers &amp; Reisberg (1985)</td>
</tr>
<tr>
<td>2 Common ground creation</td>
<td>Carlile (2002); Star &amp; Griesemer (1989)</td>
</tr>
<tr>
<td>3 Explicitation of potential connections between elements</td>
<td>Martin &amp; Schwartz (2014)</td>
</tr>
<tr>
<td>4 Freeing working memory</td>
<td>Lurie &amp; Mason (2007)</td>
</tr>
<tr>
<td>5 Dialogue development</td>
<td>Ewenstein &amp; Whyte (2007); Whyte, Ewenstein, Hales &amp; Tidd (2007)</td>
</tr>
<tr>
<td>6 Inviting reflection</td>
<td>Knorr-Cetina (2001)</td>
</tr>
<tr>
<td>7 Provision of overview for creative sensemaking</td>
<td>Larkin &amp; Simon (1987)</td>
</tr>
</tbody>
</table>

Adapted from: McGrath (2015a)

Of the visualisation benefits to creativity listed in Table 1, the single most important to this set of studies is dialogue development (Ewenstein & Whyte, 2007). Ewenstein & Whyte (2007) conducted an ethnographic study of an architectural practice and were struck by how central visualisations were to architects’ work. Ewenstein & Whyte (2007) found that visual representations, such as floorplans, had two major functions within the practice: a communicative and interactive function. The communicative function of visual representations is familiar – the architects would use visual repre-
sentations to express and exchange ideas. The interactive function of visual representations uncovered by Ewenstein & Whyte (2007) is less apparent, but arguably of greater bearing. Visual representations shape the type of interaction around them.

Ewenstein & Whyte (2007) find that individuals or groups can interact with visual representations, and the nature of the representation impacts the nature of the interaction. Like previous authors such as Do & Gross (1996) or Lawson (1997), Ewenstein & Whyte (2007) note that individuals can converse with drawings by getting immediate feedback upon their ideas. Ewenstein & Whyte (2007) add that, as an epistemic object, a visual representation sets the tone for the interaction with it. Ewenstein & Whyte further develop the concept of epistemic objects in a highly focused sister study (Whyte, Ewenstein, Hales & Tidd, 2007). Whyte et al. (2007, p. 25) refer to “frozen and unfrozen” epistemic objects. These are objects that respectively resist and invite change. As this set of studies unfolds to explore elaborative dialogue (Hogan, Nastasi & Pressley, 1999) in ideation task dyads with visual support, the high relevance of frozen and unfrozen visual objects to dyadic creativity will become increasingly clear.

Beyond Ewenstein & Whyte (2007), the two most highly relevant visualisation studies to the current work are Martin & Schwartz’s (2014, p. 80) recent literature review of “visual representation and creative thinking”, and the work Schwartz (1995) has done on visualisation in dyadic problem solving. These two contributions to the literature will be briefly examined below.

Martin & Schwartz (2014) focus upon cognitive means by which visualisation supports creative thought, not only ideation. Martin & Schwartz (2014) extract four means by which visualisation enables creative thinking: Reinterpretation, borrowing structure, flexible abstraction and combination. These will be briefly discussed in turn; and considered within the Mumford, Medeira & Partlow (2012) Creative Process Model (see Figure 2). Reinterpretation refers to the mechanism by which visualisation enables individuals to view matters in a different light. Mumford, Medeira & Partlow (2012) would refer to this as problem definition, or re-definition as the case may be. Flexible abstraction is the manner in visual problem representations allow individuals to hone in on the key factors within a problem and relegate less important issues to the area of background noise. Within the Mumford, Medeira & Partlow (2012) Creative Process Model, this is information organisation.

The third category Martin & Schwartz (2014) produce is combination. This is a key visual creativity support factor which this set of studies will ex-
amine in detail as this research unfolds. Combination pertains to the fashion by which visual representations expedite the integration of elements and addition of details. The work of Whyte, Ewenstein, Hales & Tidd (2007) on epistemic objects mentioned above, and described in detail below, comes under the category of combination. Mumford, Medeira & Partlow (2012) state that combination is a critical assumption underlying their entire model. For this reason, combination is a slightly cumbersome item to fit into a single category of the Creative Process Model (Mumford, Medeira & Partlow, 2012). At a superficial level combination fits most closely within the category of concept combination, and this fit cannot be ignored. However, upon close examination - combination is such a key element of ideation (Koestler, 1964) that it would be remiss to omit it from the idea generation phase of the model. Koestler (1964) coherently proposes the combination of mental models as the basis of ideation. Therefore, within the iterative, recursive Creative Process Model presented by Mumford, Medeira & Partlow (2012), combination must straddle both the conceptual combination and idea generation phases.

The final category of Martin & Schwartz (2014) is easier to place. Borrowing structure (Martin & Schwartz, 2014) is the appropriation of the structures and conventions from a visualisation, and their application to a new problem. Visual metaphors are the most apt example of borrowing structure. In the Creative Process Model (Mumford, Medeira & Partlow, 2012) borrowing structure belongs to the category of information organisation.

The final visualisation study this brief review will elucidate is that of Schwartz (1995). The ideation literature has long compared individual ideation with group brainstorming (Osborn, 1953). This focus left a blind spot around dyads; and relative disparity between ideation research on dyads and demonstrations of their inherent ideation strengths, for example high cognitive flexibility (Torrance, 1971) and ideation task endurance (Torrance, 1970). In three laboratory experiments on visualisation in dyadic problem solving, Schwartz (1995) assigned tasks to dyads and lone individuals, then examined the working methods that emerged. Schwartz (1995) found that problem solving dyads use more sophisticated, abstract visualisation techniques than even the most competent visual thinkers solving problems as lone individuals. Without instruction, dyads created visualisations such as numerical models, network maps and matrices whilst lone individuals tended towards non-abstract pictorial visualisations (Schwartz, 1995). Schwartz (1995) reasoned that dyads initiated more sophisticated visualisations to form common ground (Carlile, 2002; Star & Griesemer, 1989).
As demonstrated by Schwartz (1995), dyads have a natural proclivity for visual mechanisms during ideation. Moreover, visual support appears crucial to creative processes in dyads. Therefore optimal visual support struck me as the ideal driver by which to generate higher quality ideation in the high potential composition of dyads.

The visual dimension of perceived finishedness (PF) becomes of such centrality to this set of studies that a brief introduction of some nomenclature is already in order. PF is a reflection of apparent, not actual, finishedness. This presentational factor is a completely separate dimension to the actual substance of an idea. An object’s appearance of being finished or unfinished is a matter of perception, hence the term “Perceived finishedness” (PF) is used (Bresciani, Blackwell & Eppler, 2008, p. 4). Visual cues suggest whether or not an object appears finished and is thus not to be tampered with—or if it appears unfinished and possibly in need of completion. These presentational factors run without regard to actual potential for improvement. An item perceived to be finished cannot be improved upon – regardless of objective reality. Participant observation studies have noticed that high PF visual representations seem to freeze knowledge (Whyte et al., 2007) because viewers feel inclined to remain exactly that – a viewer. Even in emergent knowledge creation scenarios, this set of studies finds that a high PF representation is unlikely to be altered by another individual (McGrath, 2015b). High PF representations are an in-built ‘do not touch’ line, such as the one below in Figure 1.

**Figure 1: A ‘Do Not Touch’ Line on a Museum Floor**
The lines shown above instruct museum visitors not to touch display objects. The unapproachable, inaccessible nature that high PF gives visual representations does the same. This led to the term “museum effect” (SFU Beedie School of Business CMA Innovation Centre, 2015).

1.2 Dyads

The creativity literature on dyads is scant. This dissertation presents the three studies that comprise it in the chronological order in which were undertaken. Study 1 presents a review of this tightly defined literature stream. Some interesting and tangentially relevant work may be found in the adjacent research stream of long-term creative pairs, and this is reviewed directly below.

Recognising an area in need of illumination, a book entitled “Powers of Two” emerged in late 2014 (Wolf Shenk, 2014). This book examines the formation, maintenance and decomposition of long-term, relational creative pairs such as Paul McCartney and John Lennon or Warren Buffet and Charlie Munger. Although, not the same as the short-term pairs within the scope of this study. The characteristics and dynamics of these long-term, relational pairs can reveal insights into task dyads which have a twenty minute lifespan – like all of those upon which the research herein was conducted.

Wolf Shenk (2014) creates a classification of relational creative pairs. Wolf Shenk presents four types of relational creative pair: the star and the director, the liquid and the container, the dreamer and the doer, and generators and resonators. Wolf Shenk’s typology devotes a chapter to each type of relational dyad and illustrates aspects of dyadic work played out over decades. At a much finer level, the same processes and patterns can be seen in the greatly shortened time span for which task dyads exist. In explicit recognition of this, Wolf Shenk devotes an entire chapter to the moment when dyads such as Lennon and McCartney first meet. In tacit recognition of this, Wolf Shenk entitles the final chapters in his typology section “The Psychology of Dialectics” and “The Dialogue of Creative Thinking”. Controlled conditions laboratory experiments have a microscopic view that can expose the same psychological and dialogical factors in task dyads as Wolf Shenk sees in exploratory interviews with long-term dyadic partners. After all, long-term relational dyads begin with a first introduction, and a situation which either enables or forces them to work as an embryonic task dyad.
The star and the director speaks to the fact that the joint creativity and perseverance of two has often been attributed to one. This is known as the lone genius myth (Montuori & Purser, 1995). Charlie Munger is Warren Buffett’s long-time business partner and confidant. No doubt some of Berkshire Hathaway’s success is attributable to him. To explain this phenomena, Ford (1996) points to society’s need to glorify creative heroes, and build myths around them. Researchers have long been moving away from this model of lionised individual creativity, most notably with Amabile’s tri-componential model of creativity (Amabile, 1997). This model recognises that all are capable of creativity when the three factors of motivation, knowledge access and learnable creative thinking skills align (Amabile, 1997). Thomas Edison is a prime example of an individual creative tour de force. Without detracting from his achievements, modern creativity research also views Edison as an excellent manager of the three forces Amabile (1997) sees behind creative performance (Wolf Shenk, 2014). Indeed, Francis Jehl, a long-time engineering assistant of Thomas Edison has stated that “Edison is in reality a collective noun and means the work of many men” (Hargadon, 2003, p.93). The creative impact of groups, and dyads in particular, has long been underestimated. Wolf Shenk’s book on relational dyads (2014) and this set of studies on task dyads add to the growing body of work that rectify this oversight.

Wolf Shenk’s typology also presents a relational dyad category entitled “the liquid and the container” (Wolf Shenk, 2014). This type of relational dyad consists of an orderly, and a chaotic member. One who moves a process forward in an orderly fashion, another who disrupts and disappears on tangents only to have the container pull the pieces together again – and so the cycles continues. The container organises, the liquid is restless and unpredictable. The liquid and the container category speaks to both the costs and benefits of relational creative dyads (Fliasterer & Schloderer, 2010); and the iterative process within creative task dyads. According to biographers, Paul McCartney and John Lennon had such a relationship. For temporary task dyads, the liquid and the container relational classification gives us a vivid insight into the creativity process within task dyads. The splintering of previously ordered thoughts leads to reactive ideation in task dyads. These new ideas are incorporated into the previously shattered mental model as re-organisation progresses (Hewing, 2013). The original idea thus develops. This process of disruption, improvisation and re-ordering points to the valuable role of critique in ideation (Nemeth & Ormiston, 2007). Since 1953 the brainstorming instruction of “Withhold criticism” (Osborn, 1953) and the associated descriptive norm (Cialdini, 1993) have denied idea generation meetings the benefit of “enriched improvisation” (Hewing, 2013, p. 16). Dyads are especially well-suited to such rounds of critique and recovery as
nobody loses face in front of an audience. Moreover, the formation of minority and majority groups is numerically impossible in dyads. The concept of enriched improvisation (Hewing, 2013) is a central and recurring theme in this examination of task dyads.

Wolf Shenk’s third category is that of the dreamer and doer. Essentially the dreamer introduces the raw form of an idea, before dropping it in favour of the next notion. The doer subsequently picks up and implements the discarded ideas (Wolf Shenk, 2014). This mirrors the interplay of impulses for originality and drives for feasibility in task dyads. Such a process is fostered by functional diversity (Reiter-Palmon, Wigert & de Vreede, 2012) with a shared focus. Two different skill sets attacking a set of problems from two different perspectives and chiseling out the most original, most feasible idea they can. Creative processes are iterative by nature (Brown, 2008); and a task dyad’s set of ideas has been repeatedly sieved through two different filters by the time it is finalised. Just as Michelangelo is not solely responsible for hewing his famous sculpture David out of Carrara marble, dyads chisel raw ideas down together to create their own final showpiece. Study 2 and Study 3 illustrate this process on a micro-level.

The concluding category in Wolf Shenk’s classification is that of generators and resonators. This group of relational creative dyads devote much energy to “developing each other, inspiring each other,[and] egging each other on” (Wolf Shenk, 2014, p. 90). The generator offers an idea, and the resonator volleys an improvement back – and the process of refinement repeats. Pedagogists term this type of dialogue elaboration (Hausmann, 2006; Hogan, Nastasi & Pressley, 1999). Elaboration is “Detail that is added to the subtopics that are brought up” (Hogan, Nastasi & Pressley, 1999, p. 398). Of all the subjects that Wolf Shenk’s typology raises, elaboration has the highest potential for improving the performance of task dyads. Elaboration is highly beneficial to the task dyad ideation process (Hausmann, 2006). Newly acquainted dyads are those who can most surprise each other with unexpected details that spark new thoughts. In Study 3, this set of studies culminates with a focus upon the visual encouragement of elaboration.

Ideation task dyads are best thought of as an embryonic relational creative dyads. A miniscule proportion of ideation task dyads pass through the developmental pitfalls and even begin to become relational creative dyads. Table 2 below summarises the commonalities between Wolf Shenk’s (2014) typology of relational creative dyads and the ideation task dyads within the scope of this study.
Table 2: Parallels between Relational and Ideation Task Dyads

<table>
<thead>
<tr>
<th>Relational creative dyads (Wolf Shenk, 2014)</th>
<th>Ideation task dyads (McGrath, 2015a, 2015b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Stars and directors</td>
<td>Hidden value of dyads</td>
</tr>
<tr>
<td>2 Liquids and containers</td>
<td>Value of enriched improvisation (Hewing, 2013)</td>
</tr>
<tr>
<td>3 Dreamers and doers</td>
<td>Value of functional diversity</td>
</tr>
<tr>
<td>4 Generators and resonators</td>
<td>Value of elaboration</td>
</tr>
</tbody>
</table>

As all relational creative dyads begin as task dyads, researchers and managers can learn from research into ideation task dyads. Practitioners can use ideation task dyads to foster social interaction, trust, and goal congruence in the many spaces where they cannot directly manipulate relationships (De Clercq, Thongpapanl & Dimov, 2011). After all, “The first impression has no second chance” (Keller, 2015).

1.3 Theoretical Foundations

Creativity researchers have conducted a wealth of empirical studies since Guilford first made theoretical ingress into creativity in 1957. However, until now a unifying theoretical approach been missing from ideation research (Pope, 2005). This is due to the inherently paradoxical nature of creativity (Andriopoulos, 2003). Indeed, Pope (2005) writes that theorising on creativity can be likened to attempts to charm the serpent Ouroboros which inspired Kekulé’s conception of the benzene’s molecular structure. This aspect of the field may however be poised for change. The Dual Pathway to Creativity Model (DPCM) has emerged from a leading group of Dutch ideation researchers (Nijstad et al., 2010). It is theorising with signifi-
cant explanatory power for creativity at individual, group and organisational levels (Nijstad, et al. 2010). Study 2 and Study 3 each draw upon one of the two DPCM creativity pathways, and it forms the theoretical background for this set of studies.

The Dual Pathway to Creativity Model (DPCM) is a processual model of search paths in semantic memory. It is the extension and refinement of Search in Associative Memory (SIAM) (Nijstad & Stroebe, 2006). The DPCM posits two separate cognitive pathways, which lead to the discovery of creative ideas. Separately, or in combination. The two pathways are the flexibility pathway and the persistence pathway.

The flexibility pathway enables access to broad categories of memories and flexible transition between memory categories. This enables the combination of distantly associated concepts, or bissociation (Koestler, 1964). The concept of flexibility has been with the field of creativity research since its beginnings (Guilford, 1957; Paulus, Dzindolet & Kohn, 2012).

In contrast, the persistence pathway to creativity involves the in-depth inspection of few categories. This is a structured search pattern which exhausts all possibilities within a narrow range of memory categories (Nijstad et al., 2010).

The DPCM views creative pathway usage output as being influenced by factors external to individuals, for example group dynamics (Nijstad et al., 2010). The DPCM will be reviewed in depth in Study 2 and Study 3.

Study 1 employs and extends the theory of social impact (Latané, 1981). This is a social psychological theory that is widely used to describe and predict group dynamics by force of numbers. It is thus highly applicable to dyads and dyad combination. Before defining the key terms of “group” and “ideation”, our attention will now turn to the research questions this set of studies seeks to address.
1.4 Research Questions

Competitive advantage has been operationalised as creative advantage. To outcompete is to ‘outcreate’. By definition, the much-needed innovations will stem from creativity (West, 2002). Idea generation is at the core of creativity (Mumford, Medeiros & Partlow, 2012). Despite much research advocating individual idea generation (Mullen, Johnson & Salas, 1991), naïve group ideation practices such as formal brainstorming (Osborn, 1953) remain the norm (Deuja, Kohn, Paulus & Korde, 2014). Such outdated practices will not deliver high quality raw creative ideas to innovation managers. Group ideation must be refined by easily-adoptable, attractive means if organisations are to think their way out of the volatile, uncertain, complex and ambiguous (VUCA) (Shambach, 2004) world within which we now find ourselves. Research needs to provide managers with the tools they need to generate high quality ideas to feed into, and rekindle innovation processes.

The need for new tools and methodologies has not gone unnoticed by creativity researchers. Numerous avenues for the improvement of ideation have been examined. For example: criticism (Nemeth, Personnaz, Personnaz & Goncalo, 2004), eye-tracking (Michinov, Jamet, Métayer & Le Hénaff, 2015) and even hormones (De Dreu, Baas & Boot 2015). Task dyads, and particularly dyad combination, are yet to be researched in depth. Study 1 contains a literature review which will illustrate this.

The present set of studies contributes to the body of work on pairwork in ideation, computer-mediated communication and visualisation. In 2009 Dew & Hearn ran an initial experiment with an innovative group composition they called “networked nominal pairs” (Dew & Hearn, 2009 p. 530). Essentially, during problem solving Dew & Hearn created short-term teams of two, they then combined these two person subgroups to make a four person problem solving group – split along the “faultline” of earlier pairwise interaction (Lau & Murnighan, 1998, p. 325). Dew & Hearn (2009) found networked nominal pairs to perform at an equal level to nominal groups (see Figure 5) on a visual problem solving task. This was a surprising result as numerous earlier studies had established nominal groups as the gold standard in ideation and problem solving (Mullen, Johnson & Salas, 1991). Dew & Hearn (2009) did not examine the cause of networked nominal pairs’ high performance level and called for further research on causality. The present course of studies uses this research gap as a starting point and Study 1 renames “networked nominal pairs” (Dew & Hearn, 2009 p. 530) “combined dyads".
Dew & Hearn (2009) examine problem solving, which is itself a complex, multi-staged process. From the outset, this set of studies tightly focuses upon ideation – a discrete phase in the larger processes of creativity and problem solving (Mumford, Medeiros & Partlow, 2012; see Figure 2). Bearing Dew & Hearn’s wide problem solving scope in mind, this set of studies begins with the initial research question below:

Does dyad combination benefit ideation? If so, how?

In group ideation, elaborative dialogue – or adding detail to the topics of others (Hogan, Nastasi & Pressley, 1999) – has traditionally been seen as the main potential benefit of group ideation over individual ideation (Mullen, Johnson & Salas, 1991). This benefit is elusive – it has far from always been realised (Bouchard, Drauden & Barsaloux, 1974; Campbell, 1968; Dunnette, Campbell & Jaastad, 1963; Graham & Dillon, 1974; Taylor, Berry & Block, 1958; Vroom, Grant & Cotton, 1969).

Different visual representations of group members’ knowledges inherently carry different advantages and disadvantages (Eppler, 2006). Visualisation can thus help or hinder collaboration. A vast body of work exists on visualisation methods, and new methods such as the BCG matrix and Ease of Capture Map are continually being developed for specific uses. The current set of studies aims to step behind visualisation methods and into the nature of visual marks themselves. The precise focus is upon the social effect of provisionality in visual marks.

The existing research on the provisionality, or perceived finishedness (Bresciani & Eppler, 2013), of visual marks is ethnographic (Ewenstein & Whyte, 2007; Whyte, Ewenstein, Hales & Tidd, 2007) and theoretical (Bresciani & Eppler, 2013; Green & Petre, 2006) in nature. Therefore a set of laboratory experiment studies on visual marks was designed to bring precision to this field, and see if using visual mark with differing provisionality levels to convey and record pairs’ knowledges inherently carries different advantages and disadvantages for face-to-face ideation. A core research question for this set of studies is:

Does the perceived finishedness of visual representations affect dyads’ interaction? If so, how?

The concept of provisional visual marks emerged from computer science (Green & Petre, 2006). The set of studies at hand reciprocally fos-
ters human–computer interaction (HCI) research. As the monitor provides the primary interface for communication between computers and human interaction of any type, the present set of studies is designed to synergistically benefit the fields of visualisation and computer-mediated communication. In particular, the findings of Study 3 are equally applicable to face-to-face and computer-mediated communication.

Ideation research has been criticised for lacking theoretical grounding. However, in recent years a robust and versatile theory of ideation has emerged from primary research and meta-analyses. This theory is the Dual Pathway to Creativity Model (DPCM) (Nijstad, De Dreu, Rietzschel & Baas, 2010), which forms the primary theoretical underpinning for this set of studies. The DPCM is a schema theory (Wyer, 1980) that incorporates the same researchers’ earlier theory Search in Associative Memory (SIAM) (Nijstad & Stroebe, 2006). The DPCM (Nijstad et al., 2010) posits that there are two cognitive paths to highly original, highly feasible ideas: the persistence pathway and the flexibility pathway. The first of these involves the invoking of numerous closely related ideas to produce a high quality idea by a stochastic mechanism. The flexibility pathway proposes that high quality ideas are the result of drawing upon a highly diverse range of knowledges. The two cognitive pathways to highly creative ideas can work independently or in tandem. Bearing the DPCM (Nijstad et al., 2010) in mind, the current set of studies aims to answer the following research questions:

- Can provisional visual marks support the persistence pathway in dyadic ideation? If so, how?
- Can provisional visual marks support the flexibility pathway in dyadic ideation? If so, how?

Study 2 and Study 3 will discuss the details of the DPCM in depth. This set of studies delivers concrete findings on how provisional visual marks can support the persistence and flexibility pathways in dyadic ideation.

As can be seen by the two research questions above, at its core this dissertation explores “creative reasoning” (Cheng & Simon, 1995, p. 205) with pictures, or visualisation, within small groups. The smallest group size is two – a dyad. To be precise, this dissertation examines dyadic subgroups and the visual enablement of dyadic idea generation. The overall topic uniting the four research questions is how can pairs be most effectively used as an ideation tool?
1.4.1 Research Scope: Definition of Group

Dyads are a type of group. The term “group” is highly subjective. In practice researchers choose or construct definitions of “group” which apply to their research question. Indeed, despite offering definitions for “group dynamics”, “group polarization” and “groupthink”, the APA’s glossary of psychological terms does not attempt to define the term “group” (APA, 2015). This definitional issue is not helped by today’s rapid pace of communication technology development and adoption, which has already rendered the typology of groups in one of the latest social psychology handbooks obsolete (Hackman & Katz, 2010). Baron & Byrne (2000, p. 480) offer a broad definition of “group” which has so far withstood changes in interaction types. This definition can be used as departure point into a closer examination of groups framed as: “Two or more persons who interact with one another, share common goals, are somehow interdependent, and recognize that they belong to a group”.

With Baron & Byrne’s (2000) general definition of a “group” as a frame, we can now examine types of groups. Lickel et al. (2000) provide a pragmatic manner of classifying groups by using intimacy of association, or entitativity (Campbell, 1958), as the basis of categorisation. Table 3 shows the four types of group which can be distinguished using intimacy of association as a basis.

<table>
<thead>
<tr>
<th>Entitativity (Campbell, 1958)</th>
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<tbody>
<tr>
<td>Type of group</td>
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</tr>
<tr>
<td>1</td>
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<tr>
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<td>3</td>
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Adapted from: Crisp & Turner (2010)
Entitativity provides a useful means of distinguishing group types. The current research examines two person task groups, which are referred to throughout this work as dyads, pairs, task dyads or task pairs. Long-term working relationships are also excluded from the current work; and the findings of the three studies herein do not necessarily extrapolate to long-term working pairs. Wolf-Shenk (2014) examines intimacy groups. Study 1, Study 2 and Study 3 focus upon ad-hoc pairings. Study 1 is unique in the creativity literature in that it closely examines dyads as subgroups. Subgroups are defined as groups (Baron & Byrne, 2000); with the difference that they recognise that they simultaneously belong to a superordinate group and a subgroup within the superordinate group (Brewer, 1993; Hornsey & Hogg, 1999). All other group types are irrelevant to the research at hand.

1.4.2 Research Scope: Definition of Ideation

Creation is a task. Needless to say, there are many types of task (McGrath, 1984). Even the task of creativity can be broken into the stages presented in the Creative Process Model depicted in Figure 2. Like all models, the model of Mumford et al. is a simplification that streamlines the turmoil inherent to the “flux of things” (Whitehead, 1928, p. 208).

Figure 2: Creative Process Model

Source: Mumford, Medeiros & Partlow (2012)
The model makes the process more approachable by highlighting and ordering its most essential elements. This work focuses upon the processual task of idea generation (Mumford, Medeiros & Partlow, 2012), or ideation, which will be closely defined below.

Ideation is the response to a problem by production of potential solutions, alternatives or hypotheses (Osborn, 1953). Ideation is a cognitive task which environmental and social factors influence (Nijstad & Stroebe, 2006). Ideation is best characterised as “a repeated search for ideas in associative memory” (Nijstad & Stroebe, 2006, p. 187). The ideation process thus bears much similarity to the free recall of memories (Nijstad & Stroebe, 2006). The goal of ideation is the production of ideas that are simultaneously high in originality, feasibility and instrumentality (Briggs & Reinig, 2010). Associative, or rather semantic, memory is of absolute centrality to ideation. Chapter 5 will discuss the finer differences between associative and semantic memory.

There are three points worth noting in relation to idea generation and the Creative Process Model depicted in Figure 2. Firstly, the steps in the model are recursive in nature. This is crucial in regard to the cluster of information organisation, conceptual combination, idea generation and idea evaluation. Idea generation is thus at the core of a range of key steps in the creativity process. Idea generation is also at the core of the present work, and despite the great effort made within to delimit idea generation from other stages of creativity, the four sub-processes mentioned above underlie, intervene and overlay the process of idea generation. Secondly, Mumford, Medeiros & Partlow (2012, p. 32) emphasise “the combination and/or reorganization of extant knowledge structures provide(s) the basis for generation of the new ideas” as the key assumption underlying their entire model. In line with Mumford, Medeiros & Partlow (2012) and Koestler (1964) before them, this work consistently examines knowledge combination as central to idea generation. Thirdly, Mumford, Medeiros & Partlow (2012) write that idea generation is the hallmark of creativity and this is reflected in the consistent appearance of idea generation as a process or task in other models of the creative process (Eppler, Hoffmann & Pfister, 2014; Wallas, 1926).

Bearing the definitions of group, idea generation and the Creative Process Model (Mumford et al., 2012) in mind, this set of studies examines the following type of group: Two interdependent managers who interact with one another in an ad-hoc pairing, recognise that they are temporarily a group and share the common goal of idea generation. The behavior of this type of task group is examined over the course of a set of three idea generation
experiments. The methodology of these three mixed methods experiments is delineated below, before this introduction begins to draw to a close.

1.5 Methodology

Methodological discipline has helped to answer the research questions above. All three studies are specifically focused upon ideation, and not another aspect of creativity. All three studies employ visualisation. All three studies use the same type of task. All three studies measure idea quality. All three studies collected qualitative and quantitative data based around laboratory experiments.

The work presented here contributes to the stream of group idea generation literature that began with the introduction of brainstorming into the advertising industry (Osborn, 1953), and its subsequent scientific evaluation (Taylor, Berry & Block, 1958). The stream of idea generation, or ideation, research continues until the present day (Rietzschel, Nijstad & Stroebe, 2014; Paulus, 2015). A rich vein of research examines process losses in group ideation (Steiner, 1972; Diehl & Stroebe, 1987). Cognitive, social and emotional levers to unlock the ideation potential of groups are explored with qualitative (Yang & Hung, 2015), quantitative (Wang, Schneider & Valacich, 2015) and mixed methods (Hewing, 2013). Fortunately, the “Paradigm wars” (Guba & Lincoln, 1994 as cited in Bergman, 2008) and “Ontological politics” (Law, 2004, p. 13) have not divided this research stream. Nor does this set of studies seek a political aesthetic (Steyaert & Hjorth, 2002); if anything this set of studies is actively apolitical towards the ‘paradigm wars’.

Methodologically, this set of studies has largely used extremely close analysis via quantitative means to explore the themes of creative dyads and knowledge representation. These themes are drawn from predominantly qualitative studies such as Whyte, Ewenstein, Hales & Tidd’s (2007) ethnographic study of epistemological objects in architectural practices. The three studies had many common elements such as approximate sample size and sample population. All three studies drew samples of middle or upper managers from central Europe with at least 10 years of professional experience. The sample covered a wide range of organisational functions and industries. Participants in each experiment were given very similar tasks - all of which were non-insight problems with highly open solution spaces (Briggs & Reinig, 2010).
Study 1 differed from Study 2 & 3 in terms of dependent variable measurement. Study 1 collected survey data to measure evaluation apprehension level, while Study 2 & 3 both relied upon behavioural measurements visually recorded by participants themselves as part of the experimental procedure.

All three studies employed controlled laboratory experiments followed by a focus group discussion. However, only Study 1 reported the focus group discussion results. The focus groups in Study 2 & Study 3 found the topics difficult to approach and did not produce any results relevant to their respective studies. The implications of this will be discussed in the concluding methodological remarks of this set of studies.

The three studies that build this body of research into ideation task dyads methodologically proceed as follows. Study 1 uses mixed methods to uncover dyad combination as a means of reducing evaluation apprehension in groups. Ideation groups have long been plagued with evaluation apprehension, or fears of being negatively judged by other group members. Study 2 and Study 3 use experiments under controlled laboratory conditions to examine visual levers for optimising dyadic ideation prior to the combination of dyads with increasing focus. These latter studies are a visual communications perspective on group ideation. To those who would prejudge experimental studies and automatically reject them on the basis that “Numbers are special” (Horbert, 2013), in that they are simultaneously opaque and highly persuasive, I ask that you read this dissertation first.

1.6 Study Outline

This set of studies into ideation task dyads chronologically and presentationally unfolds as follows. After first establishing the precise nature of the benefit of dyad combination to ideation, the two subsequent studies presented in this dissertation complement and build upon each other. Study 1 finds that the combination of dyads, not individuals, into ideation groups lowers evaluation apprehension. Visual mechanisms for improving dyadic ideation prior to dyad combination are then examined in depth. Search in semantic memory has two major phases - knowledge activation and idea production (Nijstad & Stroebe, 2006). Study 1 concerns itself with idea production, Study 2 and Study 3 take a step forward in the ideation process and drill down into knowledge activation (Nijstad & Stroebe, 2006) via the persistence and flexibility pathways (Nijstad et al., 2010).
Study 2 and Study 3 peel layers away from the original focus of dyad combination by first examining visual interaction tools for dyads, and then the finer layer of visual interaction style. More exactly, Study 2 establishes that blank spaces, not pre-existing mindmap templates, are preferable for mindmapping as an explorative ideation task. Pre-existing mindmap templates create overly controlling affordances (Gibson, 1977) which participants merely follow, instead of actively exploring and incrementally constructing a shared mental model (Lewis & Sycara, 1993). This finding is carried forward into Study 3, which uses a blank space for ideation. Secondly, Study 2 finds that graphite pencil markings, or natural lines (Bradley, 2013), allow more leeway from central idea category-defining attributes (Ward, 1994). Study 2 finds that this aids persistent search within categories of thought. The effect of unstructured blank spaces and graphite pencil markings is most dramatically seen as an interaction which raises participant usage of the persistence pathway (Nijstad et al., 2010).

As the granularity of the set of studies narrows, so too does the interaction mode examined. Study 1 is primarily social psychological in nature and examines the specific interaction mode of face-to-face dyad combination. Study 2 begins the journey into the visual support of ideation in dyads. The interaction mode is face-to-face. Study 2 effectively serves as a pilot study for Study 3, and introduces the key concept of PF (Bresciani & Eppler, 2013) as a shaping factor on dialogue development (Whyte et al., 2007). Study 3 employs computer-mediated ideation between unknown parties in an effort to isolate visual PF effects upon interaction. Computer-mediated ideation allows absolute control over the visual input which dyadic parties give each other, and removes the influence of back channel communication channels such as gesture, vocal intonation and body language (Duncan, 1975). Dyadic communication in Study 3 is unequivocally visual.

The highly focused nature of Study 3 is designed to allow the examination of any effect line type has upon social interaction within the dyad. It is discovered that line type of visual anchor does indeed have an interaction effect with typeface ease-of-processing to impact upon social interaction. This in turn impacts upon access to flexibility pathway (Nijstad et al., 2010). As a result, experiment participants generated more original ideas when using visual idea anchors made of natural lines.

Upon reflection, some readers may consider the preceding paragraph overly positivistic. These readers need not be alarmed. This summary paragraph simply points at the finding of Study 3 without the caveats detailed.
within the study itself. This set of studies has dug deeply into the specific issue of emergent knowledge representation within dyads, and culminated with the finding of Study 3. However, the findings of Study 3 require further examination from a range of perspectives. This is particularly true of the DPCM pathway findings from which these effects are rationalised to originate.

1.7 Conclusion

In conclusion, these studies link different perspectives upon visually-supported dyadic ideation to feed new material into the continual research cycle of induction and deduction (Jannsens & Steyaert, 2009; Bergman, 2014) on dyadic ideation and provisional visual marks. This introductory chapter has underlined the importance of the ideation research; and defined the key terms central to this set of studies. The following chapters will subsequently explore dyad combination and visual means by which to optimally prepare dyads for this exchange. Pairs with appropriate visual support will be shown to be an effective ideation tool for both face-to-face and computer-mediated communication.

Appropriate visual support enables the optimal exploitation of the dyadic features highlighted by Wolf Shenk (2014). In particular, the visual integration of functional diversity leads to enriched improvisation (Hewing, 2013) and elaborative dialogue (Hogan, Nastasi & Pressley, 1999). Interaction of this kind benefits high quality ideation by improving access to the persistence and flexibility pathways (Nijstad et al., 2010).

As the reader will experience, the scope of this set of studies grows increasingly tight. Study 1 examines the novel group composition of dyad combination within a purely ideational setting. The subsequent studies will gradually shed light upon ideation task dyads and the perceptual factors responsible for the success (Pfister & Eppler 2012) and longevity (Salway, 1930) of visual interaction forms such as collaborative sketching. Having established the value of dyad combination in Study 1, Study 2 sets out to explore provisional visual markings in explorative knowledge creation; and focuses upon the DPCM persistence pathway (Nijstad et al., 2010). Study 2 finds value in provisional visual markings and serves as a pilot study for Study 3. Study 3 uses computer-mediated communication to exclude confounds such as body language and tightly focus upon the influence of provisional visual markings on dyads’ “creative reasoning” (Cheng & Simon, 1995, p. 205). Study 3 focuses upon the DPCM flexibility pathway (Nijstad et al., 2010).
Chapter 2 will now present an overview of Study 1, which examines the structuring of ideation groups via dyad combination. After all, man is not an island, and creativity researchers need not treat him as such. Creativity occurs not only in the mind but also in the interaction between individuals (Howes, Healey, Panzarasa & Hills, 2015). Moreover, researchers need not assume that groups are composed of single individuals. Instead, groups can be composed in line with a variety of bases such as task dyads.
1.8 References


Goebel, R., (23.07.2015), Personal communication.


2 Study 1 Overview

The ideation literature was long embroiled in a debate over whether the presence of others facilitated (Zajonc, 1965) or inhibited ideation (Taylor, Berry & Block, 1958). Over decades, researchers ran experiments comparing group ideation – operationalised by rule-based brainstorming (Osborn, 1953) and lone ideation – operationalised by nominal group technique (NGT) (Delbecq & Van de Ven, 1971). Over time, NGT emerged from the laboratories as the gold standard (Mullen, Johnson & Salas, 1991). Meanwhile, practitioners grew increasingly attached to brainstorming and have not moved to adopt NGT (Deuja, Kohn, Paulus & Korde, 2014). This disconnect is clearly a problem.

NGT is not as solitary as it might at first sound. NGT has two phases – solo ideation, the combination of solo ideators to pool ideas and re-ideate (Delbecq & Van de Ven, 1971). The prospect of suddenly having to share the ideas which one has developed alone with a group of unknown disposition has the potential to evoke evaluation apprehension. Evaluation apprehension is the fear of being judged negatively for sharing an idea (Rosenthal & Rosnow, 2009). It has long been recognised as a potent ideation disruptor (Camacho & Paulus, 1995; Collaros & Anderson, 1969; Girotra, Terwiesch & Ulrich, 2010; Henchy & Glass, 1968; Kavadias & Sommer, 2009; Paulus & Dzindolet, 1993).

The advantages to be gained from ideating alone are debatable (Hausmann, 2006; Howes, Healey, Panzarasa & Hills, 2015); and these are all lost if an individual withholds his or her ideas due to evaluation apprehension (Collaros & Anderson, 1969). The inherent assumption in much literature on groups, particularly the group ideation literature, is that groups are composed of single individuals interacting together. This need not be the case, groups can be composed of sub-groups interacting together. Groups can be composed of dyads interacting together.

It was the realisation that individuals meeting need not be the basis of the second phase of NGT that led to the examination of dyad combination. A single article had previously compared NGT and dyad combination for problem solving – of which ideation is a component (Bardach, 2011) – and found them to have no significant difference (Dew & Hearn, 2009). As the dyads would have suffered inefficiencies such as production blocking (Diehl & Stroebel, 1987) in comparison with the lone ideators, they must have been at an integration advantage during the second stage of their process.
Having previously observed apparently lowered evaluation apprehension in dyads, I chose to investigate lowered evaluation apprehension in dyads as their second stage advantage. My hypothesis that dyads would have lower evaluation apprehension was confirmed, although this did not impact idea quality in Study 1. Means by which dyads could bring higher quality ideas into the low evaluation apprehension environment of dyad combination would need to be evaluated in further studies. The work of Schwartz (1995) suggested that visualisation would be a powerful means by which to accomplish high quality ideation within the dyads themselves.

The social psychology of dyad combination is the focus of Study 1. It is discovered that man is not an island, even ten minutes of time alone can impact his or her subsequent interactions in the delicate ideation process.
2.1 References


3 Study 1: When Pairing Reduces Scaring: The Effect of Dyadic Ideation On Evaluation Apprehension

Abstract

The formation of idea generation groups through the combination of dyads, rather than individuals, is examined. The results show that pairwise group structuring is an effective method by which to reduce evaluation apprehension within idea generation groups composed of managerial participants in a controlled experimental environment. The integration of solitary ideators into an interactive group in nominal group technique (NGT) is shown to be problematic in terms of participants’ evaluation apprehension. The study's sample consisted of 72 middle and upper managers from a broad range of functions and industries. This demographic is heavily involved with cross-functional collaboration in industry. The results open up a new research area and suggest that pairwork within groups be leveraged to optimise creativity in groups by addressing common problems such as evaluation apprehension, the common knowledge effect, hidden profile and free riding.

Keywords

Creativity, idea generation, evaluation apprehension, dyad, theory of social impact

Introduction

No man is an island,
Entire of itself,
Every man is a piece of the continent,
A part of the main.
John Donne, 1624
Creativity researchers have long realised that no man is an island, yet one of the most widely used and empirically-supported creativity techniques, nominal group technique (NGT), forces individuals into exactly such quarantine conditions. NGT is defined as the use of “Groups in which individuals work in the presence of one another but do not interact” (Delbecq & Van de Ven, 1971, p. 472) before interactively pooling their ideas in a second phase (Paulus, Brown & Ortega, 1996; Robbins & Judge, 2006; Stroebe & Diehl, 1994).

Creativity researchers’ enthusiasm for NGT is based upon its regular outperformance of purely interactive brainstorming groups (Osborn, 1957) in idea generation (Bourchard, Barsaloux & Drouden, 1974; Campbell, 1968; Dunnette, Campbell & Jaastad, 1963; Graham & Dillon, 1974; Mullen, Johnson & Salas, 1991; Taylor, Berry & Block, 1958; Vroom, Grant & Cotton, 1969). Despite strong empirical evidence for creative benefits, practitioner adoption of NGT remains low. Practitioners have long required a more palatable alternative to brainstorming (Paulus, Dzindolet, Poletes, Camacho, 1993); and this study investigates the alternative of pairwise group structuring in depth.

The current study makes a departure from sixty years of research comparing NGT and interactive brainstorming to test the effects of combining pairs, not individuals, on group creativity. In doing so, this study breaks the ingrained assumption of the creativity literature that a group “consists of two or more interacting persons” (Paulus, 1989) by building an ideation group from two interacting sub-groups. No other study has looked at the effect of combining ideating pairs on creative idea quality, and by doing so this study opens a new stream of pairwise creativity research, and gives practitioners an accessible new creativity tool. Specifically, this study addresses the following questions:

1) Is group formation via the combination of pairs, not individuals, associated with decreased evaluation apprehension?
2) Is group formation via the combination of pairs, not individuals, associated with the increased originality of groups’ final ideas?
3) Is group formation via the combination of pairs, not individuals, associated with the increased feasibility of groups’ final ideas?

Evaluation apprehension is known to researchers and practitioners alike as an insidious influence in ideation groups, which has repeatedly been shown to reduce levels of creativity (Camacho & Paulus, 1995; Collaros & Anderson, 1969; Girotra, Terwiesch & Ulrich, 2010; Henchy & Glass, 1968; Kavadias & Sommer, 2009; Paulus & Dzindolet, 1993). Lowered evaluation
apprehension leads to each individual’s expression of more ideas, with higher originality (Camacho & Paulus, 1995; Collaros & Anderson, 1969; Henchy & Glass, 1968; Paulus & Dzindolet, 1993) – which makes for more fruitful discussions. Unlike any previous study, the current study examines the combination of pairs as a possible means by which to lower evaluation apprehension in ideation groups. The use of pairwise structuring to reduce evaluation apprehension is foreseen to act as a mechanism by which groups can reach their creative potential, as measured by the quality of their final ideas. Not only is the reduction of evaluation apprehension conducive to the sharing of creatively fertile unconventional ideas (Henchy & Glass, 1968); but also the debate and defence of ideas within a group. Conflict has also been linked to heightened creative output (Nemeth et al., 2004), and productive conflict requires the confidence to both critique and defend ideas (Kelly & Thibaut, 1954; Puccio & Cabra, 2012). The lowering of evaluation apprehension via pairwise group structuring offers a potential path by which to reliably raise the quality of groups’ creative output in both laboratories and workplaces.

Researchers and dyads need to form dyads prior to using them as group composition elements, and this process itself offers advantages. The smallest possible interactive group—the dyad—appears to be a high potential composition for the enablement of creativity. Dyads are sufficiently small groups not to raise evaluation apprehension to impairing levels whilst providing interactional benefits such as cognitive stimulation (Brown et al., 1998; Nijstad & Stroebe, 2006; Paulus et al., 2000) and a sounding board for the assessment and refinement of ideas (Kuhn, Shaw & Felton, 2009). The literature on dyads in creativity research is scarce but promising, and will be reviewed in this article.

There is a relative wealth of literature comparing the performance of interactive brainstorming (Osborn, 1957) and NGT groups. Unfortunately, this literature is united by a scarcity of theoretical grounding. However, the theoretical basis of NGT’s comparatively high performance level is Latané’s theory of social impact (1981) from the social psychology domain. Application of this theory’s reasoning points to nominal groups’ relatively high performance being due to negligible evaluation apprehension during solitary ideation which drives later interactive momentum.

Nonetheless, evaluation apprehension remains a factor in NGT, particularly the secondary interactive phase. The secondary interactive phase of NGT mirrors the structure of interactive brainstorming (Osborn, 1957), and thus suffers the same flaws of evaluation apprehension, groupthink (Janis, 1982) and social loafing. Dyad combination offers an escape from these dra-
wbacks, with additional benefits such as rapid idea refinement during dyad formation.

This article on the effects of transitioning dyads into ideation groups is structured as follows— the literature on creativity in dyads, the integration of dyads into groups, evaluation apprehension in idea generation, Latané’s theory of social impact (1981) and idea qualification are reviewed and lead into the development and statement of hypotheses. The sample, experimental design and procedure are then documented before the presentation of results and a discussion of this study’s implications for researchers and practitioners.

Literature Review

The potential of ideation group formation through dyad combination is further raised when the qualities of dyads themselves are examined. This study forms and combines dyads, and examines the creative output in relation to the typical NGT combination of singletons. The existing literature on creativity in dyads will therefore be examined in detail, before the literature on the combination of dyads to form groups, the moderating variable of evaluation apprehension, the theory of social impact and idea qualification.

Creativity in Dyads

NGT uses individuals to compose groups, which is a simple combination exercise. To compose a group from dyads requires two steps – dyad formation and combination. The formation of dyads requires a minimum of a recent, brief shared history. Research into idea generating dyads, and their creative output is examined below.

Creativity research on dyads is sparse, yet dyads are a highly promising creative unit in their own right. In 1960 Cohen, Whitmyre & Funk (1960) compared small idea generation groups and found cohesive, trained dyads to be equivalent to two individuals’ pooled responses in terms of fluency. This is a higher performance level than Taylor, Berry & Block (1958) found when comparing interactive brainstorming (Osborn, 1957) and NGT groups of four participants. Torrance later (1970) observed increased task persistence in idea generating dyads compared to individuals, as well as improved flexibility and participant perceptions of enjoyment, originality of expression and stimulation (Torrance, 1971). In 1976 Shiflett found shared labour dyads to
be more creatively effective than dyads with an individual level division of labour. In 1984 Pape & Bölle conclusively demonstrated higher fluency results for ad hoc, untrained dyadic ideation than solitary ideation. Schwartz (1995) later found evidence that dyads using visualisation techniques use their own initiative to create sophisticated, abstract means by which to examine relationships amongst variables, such as matrices, up to five times more than individuals do. Larger groups, such as those used in brainstorming studies, cannot boast the same levels of performance (Bourchard, Barsalou & Drouden, 1974; Campbell, 1968; Campbell & Jaastad, 1963; Graham & Dillon, 1974; Taylor, Berry & Block, 1958; Dunnette; Mullen, Johnson & Salas, 1991; Vroom, Grant & Cotton, 1969), where groupthink (Janis, 1982) is a common problem. At the root of brainstorming’s (Osborn, 1957) inadequacies lie a lack of debate and conflict – a result of rules such as “do not criticize one another’s ideas” (Osborn, 1957). Within dyads, the challenge raised by constructive critique has been shown to initiate improvised divergent thinking and “deliberate debate” (Hewing, 2013, p. 13). Moreover, critique can be a form of knowledge transmission (Hewing, 2013) and creative expression (Puccio & Cabra, 2012).

The findings of Cohen, Whitmyre & Funk (1960), Pape & Bölle (1984) are explained by dyads’ enablement of participants to generate otherwise inaccessible ideas through elaboration, just as happens within larger groups (Brown et al., 1998; Nijstad & Stroebe, 2006; Paulus et al., 2000) but with minimal amounts of procedural, social psychological or economic hindrances (Mullen, Johnson & Salas, 1991). For example, Gallupe et al. (1992) and Latané, Williams & Harkins (1979) respectively report that the social psychological hindrances of both evaluation apprehension and social loafing increase with group size; therefore dyads are a group size with high potential for collaborative cognition and a minimum of evaluation apprehension and social loafing.

One of the most detailed and insightful analyses of dyadic creativity to-date is Hewing’s (2013) content analysis of the creative process of dyads composed of potential and current product users. Whilst dis-abstracting the manner by which heterogenous knowledge is assimilated in a creativity context; Hewing sets forth a holistic framework with which the collaborative process undertaken by these two parties can be interpreted; and adds valuable concepts such as “predictable consent” (Hewing, 2013, p. 16) and “enriched improvisation” to the collaborative creativity lexicon. Hewing outlines the generative advantages of potential user/current user dyads in a fuzzy front end setting.
Dyads are promising, but not a creative panacea. The primary disadvantage is dyads’ volatile performance levels. Dyads depend upon maintenance of a single contact channel. Cohesion is needed for high performance in dyads (Cohen, Whitmyre & Funk, 1960; Triandis, Hall & Ewen, 1965). Research also shows that both positive and negative emotions are stronger when experienced in dyads rather than larger groups (Moreland, 2010)–yet individuals must directly interact with each other. These factors make dyads something of a tinderbox.

Integration of Dyads into Groups

With the exception of Dew & Hearn (2009), every prior study comparing NGT and interactive brainstorming (Osborn, 1957) has essentially concerned itself with the combination of individuals to form groups. This study marks a departure from this path, and explores the result of combining pairs to form groups. This area remains almost completely unexamined by creativity researchers. Research shows that dyads have high ideation potential yet their truly unrecognised value may lie in the manner in which they enable participants to transition into creatively productive interaction within larger groups.

The strength of NGT is that first stage isolation prevents the early development of uniformity of thought. This study’s immediate combination of individuals into dyads promptly sacrifices some of the associative diversity available to the group; and, as Ziegler, Diehl & Zijlstra, (2000) suggest, this may lead to significant uniformity of thought. Yet the only previous study to combine dyads in a similar manner, Dew & Hearn’s (2009) examination of creative problem solving, reported no significant difference in the creative performance of combined dyads or combined individuals – both of which out-performed interactive groups. It seems that any loss in diversity of thought is offset by an undetermined process gain, and this study responds to Dew & Hearn’s call for further research into the combination of dyads to examine what the process gain may be.

Evaluation Apprehension

The term evaluation apprehension was coined in 1965 by psychology professor Robert Rosenthal (Rosenthal & Rosnow, 2009). Following Collaros & Anderson’s 1969 introduction of the concept of evaluation apprehension into creativity research, it has remained one of the major recurring
creativity blockers in group ideation (Camacho & Paulus, 1995; Kavadias & Sommer, 2009).

Evaluation apprehension is particularly salient in regard to fluency (Girotra, Terwiesch & Ulrich, 2010), or “the number of relevant responses produced“ (Torrance, 1974, p.12). Early research showed that evaluation apprehension compromised creative output by inducing the withholding of ideas due to fear of criticism (Collaros & Anderson, 1969), and the production of dominant, pedestrian responses instead of subordinate, original responses to prompts (Henchy & Glass, 1968).

The impact of evaluation apprehension has been downplayed by some creativity researchers. One of the idea generation literature’s seminal papers, Diehl & Stroebe (1987), attributed more importance to the influence of production blocking on group creativity than evaluation apprehension – and sparked a literature stream that did likewise. Paradoxically, the popular contemporary definition of evaluation apprehension—“the fear of negative evaluations from other group members prevents subjects who are working in groups from presenting their more original ideas” stems from this influential work (Diehl & Stroebe, 1987, p. 498); yet these authors’ 1987 study attempted to induce evaluation apprehension through perceived external supervision of the group. Soon after another study also showed perceived surveillance external to a group to have a weak negative effect on creative output (Amabile, Goldfarb & Brackfield, 1990). Evaluation apprehension in idea generation concerns itself with the impact of the potential judgements of fellow group members, not outsiders.

Mullen, Johnson & Salas’ (1991) subsequent meta-analysis of research comparing nominal and brainstorming (Osborn, 1957) groups firmly established social psychological factors such as evaluation apprehension as being of more detrimental weight than procedural factors such as production blocking. Camacho & Paulus (1995) later clearly demonstrated the impact of evaluation apprehension; and also highlighted the fact that evaluation apprehension is particularly acute when one perceives evaluation from within one’s own group, not from manipulations external to the group - in line with Diehl & Stroebe’s 1987 definition of the term. Evaluation, and the minimisation of evaluation apprehension are now rightfully recognised as being a significant levers of a group’s creative potential (Gibson & Mumford, 2013).

The withholding of ideas has a long history as a symptom of evalua-
upon this in their theoretical modelling work. In line with the concept of “self-weightings” (Kelley & Thibaut, 1954), Kavadias & Sommer reason that during interactive ideation, members with a “better than the current best” idea contribute, and induce members with a “worse than the current best” idea to withhold (Kavadias & Sommer, 2009, p. 1904). In line with other research (Collaros & Anderson, 1969), their model showed lowered evaluation apprehension to consistently increase the performance of both NGT and brainstorming (Osborn, 1957) groups.

This study focuses upon interactive idea pooling. NGT’s weak point is that evaluation apprehension and the associated idea withholding can limit the group’s potential in the second - interactive group idea pooling. Without the contribution of adventurous ideas born of subordinate responses, discussion will not reach highly creative levels. This is especially true if otherwise valuable dissent (Nemeth, 1995) and criticism (Gibson & Mumford, 2013) are present and interpreted in a manner that fosters expectations of conflict (Carnevale & Probst, 1998). Exactly these conditions are likely in diverse ad hoc groups (Pelled, Eisenhardt & Xin, 1999), such as occur in industry, and are replicated in this experiment.

Earlier research has found a number of factors which increase or decrease evaluation apprehension in small groups. For example, evaluation apprehension is increased by the presence of experts (Collaros & Anderson, 1969), perceived surveillance (Amabile, Goldfarb & Brackfield, 1990), perceived peer evaluation (Camacho & Paulus, 1995) and is decreased by electronic brainstorming (Gallupe et al., 1992).

Despite the multitude of evaluation apprehension studies already done, the effect of combining pairs to form ideation groups on evaluation apprehension has not been previously tested. In light of dyads’ ideational strengths, this gap in the literature invites the question: What is the effect on evaluation apprehension of combining pairs to form an ideation group?

**Theory of Social Impact**

Latané’s theory of social impact (1981) specifies the impact that the presence of others will have on an individual; and is thus extremely pertinent to evaluation apprehension. The theory of social impact forms the theoretical underpinning of this study.
The theory of social impact (Latané, 1981) states that the impact of social forces, such as evaluation (Henchy & Glass, 1968), are multiplied by the number of source individuals exerting that social force. Conversely the effects, such as evaluation apprehension, are diffused by the number of individuals addressed as the target of the social force in question. This concept, as originally depicted in two-dimensions by Latané (1981), is shown below.

**Figure 3: The Multiplication and Division of Social Impact**

The left side of Figure 3 clearly shows the cumulative impact of a large number of sources projecting a social force intensely focused upon a single target. On the right, Figure 3 shows the diffusion of a social force amongst co-targets, thus each individual is weakly impacted. The multiplication and division of social impact are crucial to the relative value of dyads during the entering of a larger group.

Latané states that the strength of the social force exerted upon targets by sources also varies according to the importance of the source to the target. Individuals with whom participants dyadically worked with before entering a larger group function as marginalised sources of evaluation due to their shared responsibility for ideas previously discussed. Other sources emanate more evaluative force.

Latané’s social impact theory (1981) makes it clear that evaluation apprehension is lower in the solitary phase of NGT or in dyads, than in larger interactive groups. The second phase of NGT is essentially a large interactive group, with all of the accompanying issues though, and evaluation apprehension levels in the interactive phase of NGT should not be distinguishable from those of completely interactive brainstorming (Osborn, 1957) groups.
What is unclear from the literature is the effect of pairs accompanying one another into interactive ideation groups. Pairs who all perceive as a unit may disperse evaluative social force, and each individual would then experience lower evaluation apprehension.

**Idea qualification**

This study operationalises the construct of creativity as consisting of idea quality, as has been done in previous studies (Kohn, Paulus & Choi, 2011; Reinig & Briggs, 2008; Puccio & Cabra, 2012). In turn, idea quality is operationalised as consisting of two components – the originality and feasibility of an idea, as has been done in many seminal studies (Diehl & Stroebe, 1987; Gallupe, et al. 1992; Rietzschel, De Dreu, Nijstad & 2009).

In a meta-analysis of studies on groups of combined individuals, Nijstad et al. (2010) found a negative correlation between originality and feasibility - as one metric raises, the other lowers accordingly. Such idea qualification is difficult enough for distanced experts, yet even ostensibly objective idea qualification is an onerous task for idea generating participants (Grohman, Wodniecka & Klusak, 2006; Runco & Smith, 1992) clouded by cognitive load (Sweller, 1954), and riddled with evaluation apprehension.

Latané’s theory of social impact has extremely strong explanatory power in terms of the interpersonal factors invoking evaluation apprehension involved in this case. However, an intrapersonal factor, besides those initiated by social conditions, is also likely to play a significant role in the level of evaluation apprehension felt by an individual contributing his or her ideas into an interactive group’s pool. This factor is the difficulty of qualifying ideas (Grohman, Wodniecka & Klusak, 2006; Rundco & Smith, 1992), which relates directly to the idea withholding symptomatic of evaluation apprehension (Camacho & Paulus, 1995; Cottrell, 1972; Collaros & Anderson, 1969; Kavadias & Sommer, 2009; Kelly & Thibaut, 1954).

The intangibility and non-demonstrability of newly-generated ideas make them difficult to evaluate (Laughlin & Ellis, 1986), especially for lone individuals. NGT participants are considering the voicing of their previously undiscussed potential contributions for the first time. The ideas are making a live debut, without an externally judged trial performance and the contributor is the lone target of evaluation. Interactive groups larger than two put an individual in immediate contact with a majority of evaluators, and the limitations of engagement or rebuttal grow as group size does. Heightened evaluation
apprehension, and idea withholding (Camacho & Paulus, 1995; Collaros & Anderson, 1969; Kavadias & Sommer, 2009; Kelly & Thibaut, 1954) are the outcomes.

The transition into an interactive group as part of a dyad is predicted to lead to lower levels of evaluation apprehension than solo transition into an interactive group. Ideas may be critically examined and have their quality internally noted by dyad members. Ironically, the more polarisation (Myers & Lamm, 1976), dissent (Schultz-Hardt, Joachims & Frey, 2002) and conflict (Jehn, 1995) in a pairs’ dynamic, the more robustly ideas will be tested (Amigues, 1988; Bos, 1937; Davis, 1992; Kerr, MacCoun & Kramer, 1996; Shaw, 1932) - provided that the line of communication remains open.

The questions posed in this study are not ‘eureka’ problems (Lorge & Solomon, 1955), They are open-ended and it is foreseen that dyad members will have more certainty on their ideas’ quality than solitary individuals (Runco & Smith, 1992), and will thus contribute or withhold ideas (Camacho & Paulus, 1995; Collaros & Anderson, 1969; Kavadias & Sommer, 2009; Kelly & Thibaut, 1954) with less cognitive dissonance (Festinger, 1962). Combined dyad participants are foreseen to have more definitive idea valuation entering the second, interactive phase of ideation; and will therefore experience lower evaluation apprehension relative to that experienced by individuals transitioning into an interactive group. The lowering of the inefficiencies of unnecessary cognitive load associated with evaluation apprehension (Eppler & Mengis, 2004; Kanfer & Ackerman, 1989; Kanfer & Heggestad, 1997, Kelley & Thibaut, 1954; Tindale & Sheffrey, 2002 Sweller, 1954) may also aid dyads transitioning into groups. In exception to Nijstad et al.’s (2010) meta-analytical findings on originality and feasibility’s negative correlation, lowered evaluation apprehension has previously been associated with increases in both originality and feasibility (Collaros & Anderson, 1969). Therefore, any decrease in evaluation apprehension which may result from pairwise structuring could lead to heightened originality and feasibility. This previously unexplored possibility is supported by both the ideational strengths of dyads and the theory of social impact (Latané, 1981).

Two diverging group dynamic scenarios arise out of a review of the creativity literature. Interactive group participants originating from idea generating dyads are theoretically only subject to marginalised and diffuse evaluative force (Latané, 1981). As a consequence, they should experience lower evaluation apprehension than NGT participants, although this is as yet empirically unaddressed by the literature. Combined dyad participants’ confidence is also likely to be bolstered through higher certainty of
their ideas’ quality than those who previously ideated alone (Grohman, Wodniecka & Klusak, 2006, Hewing, 2013, Runco & Smith, 1992). In contrast, NGT participants are required to present unrehearsed ideas of indeterminate quality while facing focused, undiluted evaluative pressure. As conceivable as these scenarios are, they remain sketches as yet untested in the creativity literature. Consequentially, hypothesis 1 relates to evaluation apprehension and is stated as:

H1: In ideation, the combination of two dyads to form a group will result in lower individual evaluation apprehension than the combination of four individuals to form a group.

In other words, it is expected that those individuals who have previously worked alone will experience more evaluation apprehension when they move into a group of four and present their ideas than individuals who have previously worked in pairs.

Figure 4: Research Model

As depicted in Figure 4, this study views evaluation apprehension as a moderating variable impacting upon the construct of creativity, as measured by quality of the idea each group selects as their best (Girotra, Terwiesch & Ulrich, 2010). As in numerous other studies, idea quality is operationalised by the division of each idea into separate originality and feasibility values (Diehl & Stroebe, 1987; Gallupe, et al. 1992; Rietzschel, De Dreu, Nijstad & 2009); followed by an aggregation of these two values to provide an idea’s total quality.

The effect upon originality of evaluation apprehension lowering through pairwise structuring is unclear, and untested elsewhere. Lowered evaluation apprehension has long been associated with an increase in idea originality (Collaros & Anderson, 1969; Henchy & Glass, 1968) and this is a logical consequence of participants being emboldened to share, critique and
defend adventurous ideas. It is predicted that lowering evaluation apprehension through pairwise structuring will lead to an increase in originality. This hypothesis can be formally stated as:

H2: A lowering of evaluation apprehension during secondary, group ideation will be associated with increased originality of final ideas.

The vast majority of previous studies combining individuals which have found a negative correlation between originality and feasibility (Nijstad et al., 2010). The review of the literature gives reason to believe that combined dyads will not face the same issue, and this subject is yet to be examined in other studies. Collaros & Anderson's (1969) finding that lowering evaluation apprehension through perpetuating uniformity in perceived expertise levels gave rise to increases in both idea originality and feasibility is exceptional in this regard. Pairwise structuring and Collaros & Anderson's perceived expertise levelling both employ social mechanisms, and are explainable by the theory of social impact (Latané, 1981) which lends credence to the fact that pairwise structuring may increase both originality and feasibility through the lowering of evaluation apprehension. Besides lowered evaluation apprehension, mechanisms such as collaborative elaboration (Brown et al., 1998; Nijstad & Stroebe, 2006; Paulus et al., 2000) and refinement (Hewing, 2013; Kuhn, Shaw & Felton, 2009) exist for the raising of both originality and feasibility when dyads are formed and combined. Moreover, the combination of dyads is expected to lead to cognitively stimulating conflict (Nemeth, 1995) in the interactive group as dyads’ pre-validated ideas are vigorously debated. Pairwise structuring is foreseen to lead to increased feasibility, and hypotheses 3 can be formally stated as:

H3: A lowering of evaluation apprehension during secondary, group ideation will be associated with increased feasibility of final ideas.

The simultaneous raising of both originality and feasibility is a rarity in the creativity literature, and the achievement of this via a method both accessible and palatable to practitioners would be a potent discovery. The resulting research model can be seen in Figure 4.
Methods

Research design

A quantitative experiment supported by concurrent qualitative data gathering was selected as the most robust manner by which to test the hypotheses. The independent variable is group structure, the dependent variables are final group idea originality and feasibility; and the moderating variable is evaluation apprehension. The independent variable was operationalised as groups created through the combination of four individuals who had generated ideas alone, and groups created through the combination of two pairs who had generated ideas together. The ideation task was “How could we use social media for the implementation of a business strategy?” This task was chosen because of its interest and accessibility to a broad group. A social media literacy survey were given lastly and used as a control variable. Large variations in the amount of social media literacy between the conditions would have distorted the results as knowledge translates into creative ability (Amabile, 1997). Neither control variable influenced the results.

Participants

All 72 participants were middle or upper managers from central Europe and the US with at least 10 years of professional experience in departments such as IT, legal, and marketing. Participants’ industries ranged from financial services and IT to logistics, healthcare and energy. Participants had only superficial, if any, knowledge of each other. The sample was comprised of 71% males and 29% females.

Procedure

Two iterations of the experiment took place in the opening sessions of executive MBA courses on strategic management. The procedure, timing, and time period was identical in both iterations. As visualising has been shown to be conducive to creativity in the development of implementation plans (Eppler & Platts, 2009), both conditions used mind maps (Buzan, 1996; Buzan, 2003; Buzan, 2004). Radial mind maps were chosen for their ubiquity (Eppler, 2006) and accessibility (Martin & Schwartz, 2014), and their use for ideation was briefly explained according to the instructions in Eppler & Pfister (2011). The problem statement was publicly announced and noted at this stage. The participants were then randomly divided into two conditions and put into separate rooms, accompanied by one facilitator. In the control group (individual condition), participants were randomly assigned to a four
person group, and randomly seated. The experimental group (dyad condition) simultaneously ran through exactly the same process, and were then randomly assigned into dyads from within the randomly assigned groups of four.

One sheet of A3 paper with the problem statement pre-printed in the root of the mind map (Buzan, 1996; Buzan, 2003; Buzan, 2004) was then given to each individual or dyad. More paper was available upon request. Participants were instructed to ideate for 10 minutes.

**Figure 5: Outlined processes of NGT and Combined Dyad Conditions**

**NGT: Control Condition**

**Combined Dyads: Experimental Condition**

*Note. NGT: Nominal Group Technique*

After 10 minutes had elapsed, all participants were told to stop ideating. All participants were then re-seated together in their randomly assigned groups of four. The problem statement was verbally repeated, an identical new A3 mind map (Buzan, 1996; Buzan, 2003; Buzan, 2004) with a pre-printed central problem statement was given to each group and the group was instructed to share, combine and create new ideas for 10 minutes. Ideation was halted after 10 minutes and participants in both treatment groups were
instructed to select their group’s best idea for public sharing with all members of both treatment groups. Each group was given an idea pitch sheet and 10 minutes to select an idea (Girotra, Terwiesch & Ulrich, 2010).

**Figure 6: Mind Map Output of a Combined Dyad Group**

Following pitch creation, every individual in both treatment groups was given the exact seven item survey on evaluation apprehension in interactive ideation groups developed, validated and reported by Bolin & Neuman (2006). This validated scale on the moderating variable of evaluation apprehension has a reported internal consistency coefficient alpha of 0.82. Social media literacy was also measured by a four item scale adapted from a more extensive social media survey (Bucher, Fieseler & Suphan, 2012). Participants were given 10 minutes to complete the survey. All participants were then brought into the same room for the presentation of their ideas.

The presentation of groups’ ideas was followed by a focus group discussion on participants’ experiences. This sequential explanatory design was implemented in order to assess the experiment’s quantitative results and gain explanatory insight into the evaluation apprehension and creativity experiences of participants (Creswell, Piano Clark & Garrett, 2008; Bischof,
Comi & Eppler, 2014; Comi & Eppler, 2011). The quantitative data collection was prioritised over the complementary qualitative data collection (Bryman, 2008) which it preceded. The qualitative data collection consisted of a focus group-type discussion which lasted 15 minutes, and included all participants. The discussion was centrally moderated, using a moderation guide (see Appendix 1) as a basis. Audio of the entire focus group discussion was recorded, and details were later transcribed verbatim.
Results

A survey error result firstly was removed, and then Cronbach’s alpha was calculated to establish the reliability of Bolin & Neuman’s scale via internal consistency measurement. The Cronbach’s alpha of the seven items on the scale was 0.781. The scale was thus deemed internally consistent, as according to the standards reported by Cortina (1993). The table below shows the resulting means for the study’s dependent variables in both conditions.

Table 4: Means Comparison

<table>
<thead>
<tr>
<th></th>
<th>Individuals</th>
<th>Dyads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluation</td>
<td>1.95 (s.d. 0.62)</td>
<td>1.49 (s.d. 0.41)</td>
</tr>
<tr>
<td>apprehension</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Originality</td>
<td>6.00 (s.d. 2.16)</td>
<td>5.33 (s.d. 0.81)</td>
</tr>
<tr>
<td>Feasibility</td>
<td>6.42 (s.d. 1.13)</td>
<td>6.00 (s.d. 1.54)</td>
</tr>
</tbody>
</table>

Descriptive statistics on the total evaluation apprehension score resulting from the evaluation apprehension survey were then examined. The minimum possible score on Bolin & Neumann’s ideation evaluation apprehension scale (2006) is 7, and the maximum 35.

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1 One outlier had clearly mixed the direction of the scale points, as another individual in the same ideation group had initially done, and then corrected. The results of this outlier were an aggregate evaluation apprehension score over three times the mean, and nearly twice the magnitude of the nearest other response for his or her treatment.
For 71 participants, the results were a mean aggregate evaluation apprehension level of 13.64 (s.d. 4.37) for combined individual groups and 10.46 (s.d. 2.89) for combined dyad groups. An independent samples t-test showed that this mean difference is significant (p<.001, two tailed; t=3.623) and thus the result supports the hypothesis that the composition of interactive groups from dyads leads to lower levels of evaluation apprehension than the composition of interactive groups from individuals, which is in line with social impact theory (Latané, 1981).

The influence of the control variables of social media literacy in the sample was examined with a one-way ANOVA. When social media literacy is taken into account as a confounding variable, the significance of the results does not change (F=4.188, df=1, p=.048).

The independent samples t-test outcome indicates that the results obtained can be confidently attributed to the treatment. Hypothesis 1 is supported is thus fully supported by the quantitative data - pairwise transition into interactive groups lowers evaluation apprehension relative to an individual transition.

The construct of creativity was next investigated. In examining the originality and feasibility components of the creativity of ideas, the two rater coding methodology described by Diehl & Stroebe (1987) was followed in coding the entire set of 18 final ideas, generated by 72 participants. Ideas generated by a single group of three were omitted from examination. The two independent raters, blind to the hypothesis, agreed on 88.88% of the originality ratings, and 83.33% of the feasibility ratings.

A two-tailed Pearson correlation test revealed no positive or negative correlation between originality and feasibility; and the moderating impact of evaluation apprehension on the components of originality was next examined using linear regression. In accordance with the foreseen effect of lowered evaluation apprehension leading to increased originality, linear regression revealed a t value of -1.659. However, due to the low number of final ideas generated by the sample, the significance level is p=.125. Despite this, the adjusted R2 is .127, tentatively indicative of a moderating relationship between evaluation apprehension and originality. Thus, unlike in other research displaying increased originality by dyad participants (Torrance, 1970, 1971); hypothesis 2 did not gain enough evidence to be supported in this study.

Hypothesis 3, the effect of evaluation apprehension on feasibility of final ideas was next examined using linear regression. The relationship
between evaluation apprehension and feasibility was found to be non-significant \((p=.838)\). Hypothesis 3 was not supported.

**Focus Group Results**

In spite of these non-supportive results on the effect of evaluation apprehension on creativity, the experiment’s concluding discussion with the participants yielded some revealing insights on the managers’ experiences during the experiment. The integration of these reflections with the t-test finding of lower evaluation apprehension in the combined dyad condition provided an otherwise unattainable level of illustrative depth on participants’ perceived experiences (Bergman, 2008; Bischof, Comi & Eppler, 2014; Comi & Eppler, 2011). Treatment participants’ rationales for the lowered levels of evaluation apprehension they felt during the combined dyad phase untested elsewhere is particularly well shown by contributions such as “I felt more at ease sharing my ideas with the larger group because in the dyad my ideas had already been pre-nodded” (male, electrical engineer, combined dyad condition). Such pre-validation of discrete ideas is an as yet unconsidered aspect of dyad formation in idea generation. This perspective reveals that dyads can be a test bed for ideas, and perceived partner support can be conditionally anchored to specific ideas. Insight into the process of the dyad’s immersion into the larger group was revealed by another participant when she disclosed that “There was a definite social proof aspect. You already have someone who has agreed with what you’re saying and is going into the next step for confirmation” (female, corporate sponsorship associate, combined dyad condition). This contribution brings “completeness” (Tashakkori & Teddie, 2008, p. 103) closer and shows that the dyadic phase was experienced as exploratory bonding and support mustering by this participant. When perceptibly-supportive dyads are combined, the ground is already laid for the advancement and defence of ideas which leads to the flying of creative sparks (Nemeth, 1995).

These qualitative findings are in alignment with the black-and-white of this study’s main finding that combined dyads experience lower evaluation apprehension than combined individuals, and lend additive nuances of colour (Bergman, 2008) greater than the sum of their parts (Tashakkori & Teddie, 2008). The points listed above were all met with expressions of support by other participants, and the qualitative phase yielded no findings contradicting the survey results.
Discussion

This study has shown the combination of previously-ideating dyads rather than previously-ideating individuals to be an effective means of reducing evaluation apprehension in interactive groups. Lowered evaluation apprehension is directly linked to higher levels of creative performance (Camarcho & Paulus, 1995; Collaros & Anderson, 1969; Girotra, Terwiesch & Ulrich, 2010; Henchy & Glass, 1968; Kavadias & Sommer, 2009; Paulus & Dzindolet, 1993); and this condition is present at the juncture with the maximum potential for cross-pollination of ideas (Kohn, Paulus & Choi, 2011) and exploration of remote associative structures (Nijstad & Stroebe, 2006).

Participants repeatedly stated that prior dyadic partners supported each other in the larger interactive group. Indeed, one participant stated that in the dyadic process “I was showing ‘This is what we came up with’ – as a unit, not as an individual” (female, assistant controller, combined dyad condition). Whilst this perceived availability of support, and dispersion of evaluative force through shared responsibility (Latané, 1981) helped to allay evaluation apprehension; the opportunity to “work off each other”(male, head of retrocessions, combined dyad condition) and evaluate creative output with a partner prior to the combination of dyads was even more appreciatively recounted by the relevant participants.

The valuation of one’s own ideas is a task fraught with difficulty due to the subjectivity and abstraction involved in evaluating a judgemental task’s solution (Culvenor, 2003; Laughlin & Ellis, 1986). Participants who had a prior dyadic exchange had more certainty about the strength of their ideas, and were prepared for criticism. The participant who explicitly stated that he could express “pre-nodded” ideas (male, electrical engineer, combined dyad condition) is emblematic of this phenomenon. Without the benefit of a prior dyadic exchange, this participant’s ideas may never have been contributed to later discussion. An interactive exchange in the relatively psychologically safe dyad allowed participants to test their ideas’ reception, develop counter-arguments and form a firm appraisal of their ideas and approach before transitioning into a larger group (Fliaster & Schloderer, 2010). Such conditions are not only conducive to insight (Csikzentmihalyi & Sawyer, 1995); but the certitude on ideas and their perceived value were thus increased and the likelihood of ideas contribution was therefore raised (Collaros & Anderson, 1969; Kavadias & Sommer, 2009; Kelly & Thibaut, 1954). Moreover, participants able to receive feedback in a dyad would have spent less cognitive resources in a state of cognitive dissonance (Festinger, 1962) over their ideas’
merits, and thus been more effective group members.

In spite of the low number of final ideas available for evaluation by coders, it is curious that more support for hypothesis 2 was not found. After repeatedly finding higher originality in dyads than lone ideators, Torrance (1970, 1971) attributed their higher performance on originality, fluency and flexibility measures to higher levels of stimulation, enjoyment and perceived creativity – an element of creative self-efficacy (Tierney & Farmer, 2002). The effects of the factors of perceived enjoyment and stimulation may be too frail to endure the dyad combination process, after which creative output was measured in this study.

The fact that lowered evaluation apprehension was found to be unrelated to the feasibility of final ideas is telling in itself. Previous work, such as the well-known creativity model of Paulus (Paulus, 2000), have tended not to decouple originality and feasibility when examining evaluation apprehension. Collaros & Anderson (1969) did decouple these two components, and found both to be increased by lowered evaluation apprehension. More balanced is the non-significance of the evaluation apprehension-feasibility relationship found in this study which, when compared to the findings on originality, implies that the raising of feasibility issues requires less boldness than the adventurous contributions which build originality. Hence, evaluation apprehension is seemingly unrelated to contributions which anchor evolving ideas in organisational realities – these are consistently perceived as ‘safe’ territory for participants. This is in line with the meta-analysis of Nijstad et al. (2010), which found a negative correlation between originality and feasibility; and implies that lowered evaluation apprehension is related to the originality component of ideas only.

Latané’s theory of social impact has high explanatory power in this study. The female assistant controller’s statement that she felt judged “as a unit, not as an individual” precisely describes the diffusion of social impact (Latané, 1981), as depicted in Figure 7. In contrast, Figure 8 shows three participants exertion of evaluative social force focused upon a single target results in heightened evaluation apprehension in the combined individual condition. Indeed, one participant described the difficulty of the singletons’ idea sharing process as follows “First there’s shame, then embarrassment – it’s more personal if it’s your idea” (female, business systems manager, combined individuals condition). This participant uncom fortably perceived that her personal values, perspectives and capabilities were exposed via the sharing of her ideas. Her reluctance in voluntarily and wholeheartedly revealing herself are both palpable and comprehensib-
Moreover, the alternative of withholding ideas is particularly attractive for individuals who have not been previously discussed them. The dyadic co-creation of an idea carries an obligation to share.

**Figure 7: Primary and Secondary Planes of the Social Impact of Evaluation Apprehension in a Combined Dyad Group**

Figures 7 and 8 build upon Latané’s original diagramatisation of social impact forces (1981). These figures use the exact same principles as in the original plan perspective diagram (cf. Figure 1) but employ an isometric view which facilitates depiction of not only the surface level primary plane of social impact, as in the original diagram, but also sub-surface planes of social impact. The stature of the arrows reflects the approximate intensity of the social force exerted by sources. For visual simplicity, only the first two planes of social impact are indicated. As detailed below, this study has extended Latané’s (1981) theory of social impact, and the diagramatisation of the theory has been accordingly enhanced.

Figures 7 and 8 show the divaricating evaluative forces at play in interactive groups as a result of whether the units used to construct the group were individuals or pairs. The combined dyad condition shown in Figure 7 is typified by a pairwork partner who absorbs a quotient of the evaluative social
force, on the primary plane of social impact, while the other partner contributes ideas. The non-contributing partner exerts only a marginalised level of evaluative social force. These factors result in the contributing partner experiencing low evaluation apprehension levels relative to the contributing individual in Figure 8.

Figure 8: Primary Plane of the Social Impact of Evaluation Apprehension in a Combined Individual Group

Latané’s existing theory of social impact (1981) is known not to have explanatory power across a full range of situations. According to Jackson (1987), the theory of social impact cannot account for situations in which individuals are both social force sources and targets—yet the theory of social impact does exactly that in this study. As depicted in Figure 7, combined dyad participants watching their pairwork partner contribute their co-created ideas are simultaneously evaluating their pairwork partner, as well as being evaluated as a co-target by the main source of evaluative force—the dyad listening to the contribution. This study’s results suggest that any social impact from such co-targets is negligible; and best considered as a separate secondary sub-layer of reduced social force. Therefore, a plane of social impact theoretically exists for each individual or group every exuding a unitary social force—as depicted in figures 7 and 8.
Each plane of social impact follows the same principles set forth in Latané’s original single layer theory (1981), but the higher the plane of social impact, the stronger it is relative to other planes. Therefore, the strength of any social force exerted by a co-target is lowered in accordance with the co-target’s relative importance as they are also an object of main source, non co-targets’ social force. When dyads are combined to form groups, dyad partners have a lowered impact (cf. Figure 7), which is in accordance with Latané’s original theory of social impact. Co-targets are thus of more salience as a medium for the absorption of primary plane social impact, as shown in Figure 7. The layering of planes of social impact increases the explanatory power of the theory of social impact by making simultaneous source and target effects ordinally transparent.

The results suggest that Latané’s theory of social impact (1981) needs to accommodate multiple planes of social impact to increase its explanatory power. This has implications for the domain of social psychology as it widens the inclusivity of the theory of social impact’s explanatory power. Using multiple planes of social impact, the theory of social impact can be applied as a framework to explain situations such as the co-creation of theatre by a performer and audience members, and by extension a multitude of service encounters (Baron, Harris & Harris, 2003).

Practitioner Implications

The direct implications of this study apply to the structuring innovation managers and other practitioners use in ideation meetings. Nominal group technique has been proven more creatively productive than brainstorming (Bourchard, Barsaloux & Drouden, 1974; Campbell, 1968; Dunnette, Campbell & Jaastad, 1963; Graham & Dillon, 1974; Mullen, Johnson & Salas, 1991; Taylor, Berry & Block, 1958; Vroom, Grant & Cotton, 1969). Nonetheless, brainstorming (Osborn, 1957) remains popular with practitioners due to participants’ enthusiasm for ideating together (Paulus, Dzindolet, Poletes & Camacho, 1993). Combined dyads retain a continuous element of collaboration, which should this make this technique more readily adopted by ideation session participants than NGT has proven to be. Indeed, research shows that individuals or groups of two have higher levels of involvement and satisfaction than larger groups, such as brainstorming uses (Bray, Kerr & Atkin, 1978). With a sample size of 100 individuals, Torrance (1971) has also shown that ideators in dyads not only have more original ideas than lone ideators, but also that they perceive they are being more original, and report higher levels of stimulation and enjoyment. Dyad combination may thus be a useful tool for breaking unproductive cycles of brainstorming (Osborn, 1957).
and re-invigorating participants to set new benchmarks in creative productivity (Bandura, 1997).

The dyad combination benefit found by this study is the reduction of evaluation apprehension in comparison to groups composed of individuals, such as produced by NGT. Lowered evaluation apprehension allows participants to express ideas they may have otherwise withheld for fear of negative judgement from other group members (Camacho & Paulus, 1995; Cottrell, 1972; Collaros & Anderson, 1969; Kelly & Thibaut, 1954; Rosenthal & Rosnow, 2009). Creativity is thus encouraged through experimentation. More adventurous ideas are not only more likely to be shared during dyad combination; but unique ideas are more likely to be integrated into a group’s conversation (Parks & Cowlin, 1996). A fuller exchange is the outcome – the common knowledge effect is more likely to be minimised (Gigone & Hastie, 1993), hidden profiles are more likely to be discovered (Stasser & Titus, 1985) and opportunities for fruitful elaboration maximised (Kohn, Paulus & Choi, 2011). These effects are especially useful when radical innovation or the construction and sharing of overwhelmingly intrinsically-motivated (McMeekin & Coombs, 1999) specialists’ domain-specific knowledge is sought (Rundquist, 2012; Collaros & Anderson, 1969) – assuming that a conscious decision to share, not conceal, knowledge has been made (Husted, Michailova, & Olander, 2013). Effective knowledge sharing is a consistently strong driver of creativity (Chang & Chiang, 2008), yet low evaluation apprehension effects could be especially valuable in high radical innovation potential low density networks, which are typically composed of distantly-connected specialists (Colazo, 2010).

Previous studies have shown that cross-functional teams foster creativity, interfunctional communication and cooperation (Bunduchi, 2009; Ernst, 2002; Prester & Bozac, 2012) and stronger financial performance (Nybakk & Jenssen, 2012). Yet such results depend upon the appropriate management of a group; and as Bunduchi (2009) explains, heterogeneous functional perspectives also create misunderstandings, conflict, lowered cohesion and raised stress levels. Bunduchi (2009) recommends openness of communication as the remedy for optimising cross-functional teams’ output. Reduced evaluation apprehension, as effected by dyad combination, translates into more open communication. The lowering of evaluation apprehension in this study’s cross-functionally structured sample is evidence of the value of dyad combination as a cross-functional team management tool.

Dyad combination provides a strong platform for the “essence of organisational capability” (Grant, 1996, p. 375) – stakeholder knowledge in-
The integration of external stakeholders such as suppliers into the fuzzy front end is fraught with difficulty (Jörgensen et al., 2011) yet of vital importance to innovation (Arbore & Ordanini 2006). The low evaluation apprehension of dyad combination scenarios offer the innovation project “leader as facilitator” (Hemlin, 2006) a powerful tool for the creation and maintenance of relationships (Dwyer, Schurr & Oh, 1987) amongst employees and other stakeholders (Payne, Ballantyne & Christopher, 2005). Uniquely, dyads offer an uninterrupted communication channel, as well as the affordance for communication and continuation of the relationship (Moreland, 2010). In addition, dyads offer an audience-free, psychologically safe arena for disagreement bereft of judgement by neither majority nor minority. “Network webbers” (Heikkinen & Tähtinen, 2006, p. 283) can thus use dyad creation and combination for accelerated stakeholder bond creation and maintenance.

The far-reaching effects of dyad formation and combination emanate from the use of the technique during ideation meetings. The dyad combination at the focus of this study will not suit every ideation situation however – scenarios will arise in which practitioners will need to judge whether NGT or dyad combination will be more suitable. In order to facilitate the selection of an appropriate approach, a table comparing the concrete benefits of these techniques at the core ideation meeting level is presented below.

**Table 5: Summary Table of Relative Performance Advantages of Nominal Group Technique and Dyad Combination**

<table>
<thead>
<tr>
<th>Phase</th>
<th>Criteria</th>
<th>Combination of individuals (NGT)</th>
<th>Combination of dyads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary ideation</td>
<td>Challenge initiation through constructive criticism (Hewing, 2013)</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Primary ideation</td>
<td>Number of idea categories generated (Torrance, 1970)</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Primary ideation</td>
<td>Number of ideas generated (Pape &amp; Bölle, 1984)</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Primary ideation</td>
<td>Originality of ideas (Torrance, 1970; 1971)</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>------------------</td>
<td>--------------------------------------------</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Primary ideation</td>
<td>Perceived enjoyment (Torrance, 1971)</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Primary ideation</td>
<td>Perceived originality of expression (Torrance, 1971)</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Primary ideation</td>
<td>Perceived stimulation (Torrance, 1971)</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Primary ideation</td>
<td>Task persistence (Torrance, 1970)</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Primary ideation +</td>
<td>Uniformity of thought (Ziegler, Diehl &amp; Zijlstra, 2000)</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Secondary ideation/pooling</td>
<td>Creative problem solving outcome (Dew &amp; Hearn, 2009)</td>
<td>=</td>
<td>=</td>
</tr>
<tr>
<td>Secondary ideation/pooling</td>
<td>Evaluation apprehension level (new finding)</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Secondary ideation/pooling</td>
<td>Task persistence (new observation)</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

Note. NGT: Nominal Group Technique

Although Dew & Hearn’s original study of combined dyads, or “networked nominal pairs” (2009, p. 521), found little difference in the problem solving outcome of NGT and dyad combinations, the current study and many
others point to many relative differences in the process. Participant adoption of either NGT or dyad combination in lieu of single phase interactive brainstorming (Osborn, 1957) will be influenced by their perceived enjoyment (Torrance, 1971); yet it is Torrance’s 1971 findings on perceived originality of expression and stimulation which are the most insightful.

Confidence is needed for creativity. Heightened perceptions of originality of expression and stimulation in the primary phase can contribute to a temporary increase in performance-boosting creative self-efficacy (Tierney & Farmer, 2002) for the duration of the secondary phase. The relative creative self-efficacy building advantage of dyads is evidenced by Torrance’s (1970) significance-approaching finding that vis-à-vis individual ideation, dyadic ideation increases the number of idea categories generated; which is in line with the findings on heightened idea number (Pape & Bölle, 1984) and originality (Torrance, 1971) in dyads. Dyads with heterogenous views, particularly from a functional perspective (Hülsheger, Anderson & Salgado, 2009; Paulus, Dzindolet & Kohn, 2012), have particularly high potential due to “enriched compensation and improvisation” (Hewing, 2013, p. 18).

The advantages which accrue during the primary phase of dyadic ideation do not come without a price. Although originality and flexibility of thought have been shown by other researchers to be increased by dyadic ideation, dyad combination’s early co-mingling of participants logically results in a loss of available cognitive diversity (Ziegler, Diehl & Ziljstra, 2011). Communication can lead to uniformity of thought, and collaborative fixation (Kohn & Smith, 2011). However, the elsewhere reported ideational performance advantage of dyads suggest that this loss is more than compensated for by synergies in the process gains previously mentioned.

The contributions of the current study relate to the secondary idea pooling and ideation phase of both NGT and dyad combination. Combined dyad participants experience lower evaluation apprehension than individuals combined into a group. This is a clear relative performance advantage of dyad combination over NGT. Especially in situations when participants may feel a pronounced need to withhold ideas for fear of negative evaluation such as in the presence of experts (Collaros & Anderson, 1969) or superiors then dyad combination is a valuable technique. Reduced evaluation apprehension has consistently been tied to heightened creative performance (Camacho & Paulus, 1995; Collaros & Anderson, 1969; Girotra, Terwiesch & Ulrich, 2010; Henchy & Glass, 1968; Kavadias & Sommer, 2009; Paulus & Dzindolet, 1993).
During this study, it was observed that groups of combined dyads ideate for longer than groups of combined individuals. While combined individual groups often fell silent before the ten minute time limit had elapsed, combined dyad groups were still deeply involved in conversation. This persistence is symptomatic of a reduced need for closure – which is strongly associated with heightened creative performance in groups (Chirumbolo, Livi, Mannetti, Pierro, & Kruglanski, 2004; Chirumbolo, Mannetti, Pierro, Areni, & Kruglanski, 2005). In effect, it seems that the conditions of dyadic work induce both flexibility of thought and persistence (Nijstad, et al. 2010) in participants.

In summary, combined dyad ideation is a useful idea generation technique for practitioners, which is likely to enjoy higher acceptance and adoption rates amongst idea generation meeting participants than NGT has. The strengths of dyad combination are individuals’ access to otherwise inaccessible ideas, the positive effect of enhanced perceived participant experience on their performance, and lowered evaluation apprehension with the accompanying willingness to share and debate ideas during secondary phase ideation and idea pooling. In comparison to NGT, dyad combination is thus particularly well-suited to groups or situations where evaluation apprehension may become an issue through the mixing of organisational hierarchies or functions. In situations where each individuals’ cognitive diversity is to be leveraged to its absolute maximum effect, the sacrificial process loss implicit in dyad combination may not be outweighed by its myriad of process gains. In these circumstances, NGT or a hybrid NGT/dyad combination procedure of individual ideation followed by dyadic ideation and dyad combination are the most suitable processes.

Limitations

This study is not without its limitations. The experiment relied upon self-reported, rather than physiological or behavioural, measures of a sample’s evaluation apprehension in a laboratory environment. The equal distribution of naturally socially-anxious and gregarious individuals without leverage over one another relied upon random sampling principles.

The sample size and procedures allowed the generation of only eighteen potential ideas for evaluation on the creativity metrics of originality and feasibility. Inter-rater reliability measures finally reduced this cache to thirteen ideas. The discovery of all but the most immensely strong relationships is unlikely in such a sample size. It is clear that a larger sample size is needed in order to replicate the findings of Torrance (1970, 1971) on origina-
lity and potentially extend these to feasibility. Factors other than evaluation apprehension, such as perceived creativity (Torrance, 1971) and performance matching (Paulus & Dzindolet, 1993), are certainly at play in determining the creative output of dyadically-structured groups, and these should also be measured to see the magnitude of their effects in relation to evaluation apprehension.

**Future research**

This study opens up several interesting avenues for further research. Besides lowering evaluation apprehension, a further social advantage of combined dyads over NGT for practitioners is that dyad use employs continuous social interaction. The shared experience of dyadic ideation could prove to be a method by which practitioners could fast-track relationship building in new creative teams. Longitudinal research is required on this issue.

Several intriguing temporal observations warrant further investigation. Firstly, dyads always needed highly animated intervention to stop their ideation after ten minutes, whereas individuals often independently halted their solitary ideation after five to six minutes. This is resemblant of Torrance’s observations (1970). Also, upon group aggregation combined dyad members would immediately begin visually contributing to mind maps (Buzan, 1996; Buzan, 2003; Buzan, 2004) whereas aggregated individuals would take up to three minutes to begin visualising. The time keeping of experimental groups empowered to start and stop visualisation as desired may prove revealing.

The experiment’s results show how evaluation apprehension can be significantly reduced through a simple adaptation of NGT to include pairwork. The exact mechanism, or interaction of mechanisms by which this functions has not yet been exhaustively clarified however. It is uncertain whether the reduced evaluation apprehension amongst dyads is a result of their prior pairwork, or the pairs’ mere accompaniment of each other into the larger group.

This study’s findings are certainly supportive of the value of further research into the optimisation of creative potential via the use of dyads and their transitioning into larger groups. Lowered evaluation apprehension has previously been shown to be indicative of higher performance on the metrics of originality and feasibility (Collaros & Anderson, 1969), fluency (Camacho & Paulus, 1995) - and by association, flexibility (Hérbert et al., 2002). To verify
these effects, larger idea sample size studies into the effect of pairwise group composition upon the metrics of ideational originality, feasibility, fluency and flexibility, as well as longer term effects on team dynamics, would be valuable.

Conclusion

In conclusion, this experiment has uncovered a procedural solution to mitigating the persistent issue of evaluation apprehension during divergent ideation. Combined dyads offer an intriguing balance of process losses and gains in ideation, which has been almost completely ignored by the literature. NGT has been shown to be a quarantine process which leaves individuals unprepared and vulnerable to evaluation apprehension in their eventual discussions with others. No man is an island – even the well-known castaway Robinson Crusoe’s confidence, and success, in exploring new territory grew after his initially hesitant acquaintance with Friday. The dyad combination procedure for group formation similarly tempers participants in preparation for meshing with others, and allows for perceived judgements to be blunted by diffusion.

The theory of social impact (Latané, 1981) has been strengthened by this study’s conceptual layering of simultaneous source and target effects in planes of social impact. Practitioners are advised to adapt NGT by forming ideation groups using dyads rather than individuals as the unit of construction. The combination of dyads to form groups is expected to be especially beneficial in situations when evaluation apprehension is heightened, such as when the groups entered are large or differentiated on the basis of power. Practitioners are advised to leverage the effects of dyadic exchanges to raise the likelihood of idea contribution and integration during interactive ideation.
References


Appendix

Focus Group Discussion Moderation Guide

- What was your overall impression of idea generation using mind maps alone/in pairs/as a group of four?
- When did you feel the most productive? Why?
- When were you free to express yourself? When less so?
- How did the work in a pair affect the work in group of four?
- How did you feel during the final selection of the best idea?
4 Study 2 Overview

Study 1 has established that dyad combination is an effective method of lowering evaluation apprehension. Lowering evaluation apprehension is conducive to creative ideation (Camacho & Paulus, 1995). This is especially relevant when other evaluation apprehension drivers such as hierarchical mixing (Paulus, Dzindolet & Kohn, 2012) are sub-optimal.

Study 1 found that dyad combination alone, however, does not raise or lower the originality or feasibility components of ideas (McGrath, 2015). Thus a dyad needs to develop highly original and feasible ideas before it is combined with another dyad. The raw ideas fed into the dyad combination need to be of the highest possible quality so the lowered evaluation apprehension climate of dyad combination can work most effectively.

Study 2 & Study 3 set out to investigate visual means of raising the originality and feasibility of dyads’ ideas. The stage ii dyad combination focus of Study 1, and the stage i dyad formation focus of Study 2 and Study 3 are depicted in Figure 9. This work steps beyond sixty years of ideation research comparing nominal group technique (NGT) and brainstorming.
The social psychology of dyad combination is now longer the focus in Study 2 and Study 3. Instead the focus moves to situational influences on dyads’ ideation processes. Accordingly the theoretical lens moves from the Theory of Social Impact (Latané, 1981) to the Dual Pathway to Creativity Model (DPCM) (Nijstad, De Dreu, Rietzschel & Baas, 2010). Study 2 will examine visual influence upon the DPCM persistence pathway (Nijstad et al., 2010). Study 3 will investigate visual influence upon the DPCM flexibility pathway (Nijstad et al., 2010). As the DPCM (Nijstad et al., 2010) reasons that the persistence pathway is associated with higher feasibility ideas, and the flexibility pathway is associated with higher originality ideas; between them Study 2 and Study 3 holistically cover the totality of idea quality components measured in ideation research (Diehl & Stroebe, 1987; Dean Hender,
One of the observations in Study 1 was that dyads showed higher enthusiasm and endurance than individuals ideating alone. This is in line with the findings of Torrance (1970). Study 2 examines this apparent strength of dyads, and explores the optimal visual tools for building the persistence of dyads.

In Study 2, dyads’ visual tools are broken into two essential groups: display tools and inscriptive tools. Display tools are the surfaces used to record the development of ideas. These are operationalised by simple A3 paper sheets - with or without a pre-printed mindmapping template. Inscriptive tools are the writing instruments used to create marks on the display tools. These are operationalised by graphite pencils or ink pens.

The markings made by ink or graphite are fundamentally different. To be exact, these markings differ in their level of perceived finishedness (PF) and modifiability (Bresciani & Eppler, 2013). Most significantly, ink lines appear to be more finished than pencil lines. Moreover, ink creates a less natural, more perfect line than pencil does. Graphite lines incorporate the imperfections of the paper and variations in graphite thickness itself. Graphite lines may thus be described as more natural lines (Bradley, 2013) than ink lines. Natural lines have a lower PF level than artificial lines.

The concepts mentioned above will be further explained in Study 2. Suffice to say that Study 2 opens the avenue of interest in the PF of inscriptive tools, and their effects upon dyadic interaction during ideation. Study 3 continues this line of thought, and examines PF in detail. Study 2 serves as a pilot for Study 3.
4.1 References


Study 2: Cognitive Antifreeze: The Visual Inception of Fluid Sociomaterial Interactions for Knowledge Creation

Abstract

This pilot study investigates the idea generation process of ad-hoc pairs using external visualisations for divergent thought. The study’s objective is to examine whether the perceived possibility to change visual representations of ideas impacts the cognitive persistence of pairs. A 2x2 factorial experiment with active middle to upper level management participants was employed. The experiment operationalised the perceived changeability, or fluidity, of visual objects through manipulation of dyads’ worksheet template and writing instruments. The results indicate that participants’ cognitive persistence towards creative thought generation is impacted upon by a sociomaterial interaction. This study finds that dyads’ perceived fluidity of writing instrument moderates dyads’ perceived fluidity of worksheets’ effect on cognitive persistence. The materials socially used by dyads influence their creativity-inhibiting need to seize upon an idea and steadfastly remain frozen to it. Fluid visual representations function as an effective cognitive antifreeze.

Introduction

It is widely known that knowledge creation [1] is crucial to competitive advantage across fields [2]. How to reliably surface effective, efficient knowledge creation is far less well known. This pilot study examines sociomateriality as a means by which to increase the cognitive persistence of creative pairs in an effort to dependably enhance knowledge creation.

Literature Review & Hypothesis Development

The research concentrates on whether the degree of perceived finis hedness of the graphical representation of a dyad’s joint problem solving space influences its tendency to exert cognitive effort on divergent thinking.

Dyads

Until recently, dyads were largely overlooked in the field of knowledge creation. However, interactive groups formed via the combination of dyads [3] have now been shown to creatively outperform nominal group technique
[4] as a function of lowered evaluation apprehension [5]. These findings on group creative process optimisation via dyadic structures create a new imperative to optimise dyadic ideation.

The creativity literature on dyads is sparse, but encouraging. In 1960 Cohen, Whitmyre, & Funk [6] found cohesive, trained dyads to be creatively efficient and effective; and this study positioned cohesion as the key success factor for dyads in creativity. Soon after Cohen, Whitmyre & Funk’s work, Janis’ influential 1971 work on groupthink [7] began emerging and creativity research on dyads became resulting sporadic at best. Two years after the second edition of Janis’ book Groupthink [8] was published, Pape & Böllle’s conclusive demonstration of higher fluency results for ad hoc, untrained dyads than pooled individuals went virtually unnoticed [9].

In the interim between Cohen, Whitmyre & Funk’s study, and the onset of the groupthink dialogue Torrance [10, 11] found increased task persistence, participant perceptions of enjoyment, originality of expression and stimulation in dyads. More tellingly, Torrance [11] also discovered increases in flexibility amongst dyads that foreshadows more recent work on co-inspiration [12].

**Need for Cognitive Closure (NFCC)**

Kruglanski’s lay epistemics concept of need for cognitive closure (NFCC) is highly relevant to group creativity [13, 14]. NFCC refers to “individuals’ desire for a firm answer to a question and an aversion toward ambiguity” [15] and consists of tendencies towards urgency and permanence of cognitive closure [15]. NFCC is both a dispositional trait [16] and a situationally-induced state [15]. Eventual cognitive closure on a subject is necessary, yet prematurely reaching closure undermines the effectiveness of cognitive operations such as formal reasoning [17]. Since 1984 “Resistance to premature closure”, or “degree of psychological openness” [18] has been an integral factor in the world’s most recognised creativity test – the Torrance Test of Creative Thinking [19, 20].

NFCC is problematic for both individual and group creativity for a range of reasons. Firstly, creative behaviour requires the processing of a variety of information [18, 21], particularly via a search of one’s own associative memory [22]. “Closure-bound pursuits” [15] bias the associative memory search choices made [22] and exploratory avenues of thought are ignored. This is particularly detrimental to divergent thinking [23] in non-insight problems [13].
The value of criticism and conflict in group ideation are being increasingly recognised [24, 25, 26]. NFCC is detrimental to productive cycles of criticism as it increases the propensity of individuals to reject differing opinions on an issue without consideration [27].

NFCC restricts information processing and the systematicity of information processing is concurrently lowered [28]. Contrary to popular belief, the dogged systematic search of associative memory is conducive to creative productivity[29]. NFCC undermines creative processes by muddling associative memory search functions.

**The Dual Pathway to Creativity Model**

The Dual Pathway to Creativity Model [29] posits creative performance as a result of two action paths - cognitive flexibility and cognitive persistence. These distinct paths may intertwine and coincide during the creative process; but one of the two acts as the primary enabler of creative output. The concept of flexibility has been used in creativity research since the field has existed [30, 31]; and the measurement denotes the number of idea categories generated during divergent thinking [10]. Using the flexibility pathway to achieve creative output involves “flexible switching among categories, approaches, and sets, and through the use of remote (rather than close) associations.”[29].

The second creativity pathway, persistence, involves “hard work, the systematic and effortful exploration of possibilities, and in-depth exploration of only a few categories or perspectives”[29]. The premise of the persistence pathway is that a concentrated search within a category results in the non-original ideas being used up, and with enough time and effort – more original ideas being produced. This pathway is operationalised by the measure of within category fluency (WCF). This is the average count of how many ideas are produced within each idea category. This is calculated by dividing the total number of ideas generated (fluency) by the number of categories used (flexibility) [29].

The Dual Pathway to Creativity Model views creative output as being contingent upon environmental factors such as approach/avoidance behaviours and group dynamics; and is inclusive towards sociomaterial interactions [32]. In presenting their model, Nijstad et al. postulate that higher working memory capacity – one of the most universally-recognised benefits of vi-
ualisations [33] - is an enabler of the persistence pathway to creativity. The potential of visualisations to delay NFCC and thus hold open the persistence path to creativity is backed by the finding that working memory aids delay NFCC [34].

Visualisation

Visualisation consists of the “mechanisms by which humans perceive, interpret, use and communicate visual information”[35]. Above and beyond freeing working memory[33], sociomaterial visual practices bring numerous well-recognised benefits to knowledge creation. Visualisation enables the emergence of knowledge creation [36] through the modalities shown below in Table 6.

Table 6: Knowledge Creation Enablers of Visualisation

<table>
<thead>
<tr>
<th>Visual knowledge enabler</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assistance of remote association triggering</td>
<td>[37]</td>
</tr>
<tr>
<td>Common ground creation</td>
<td>[38, 39]</td>
</tr>
<tr>
<td>Explicitation of potential connections between elements</td>
<td>[40]</td>
</tr>
<tr>
<td>Freeing working memory</td>
<td>[33]</td>
</tr>
<tr>
<td>Internal dialogue development</td>
<td>[41]</td>
</tr>
<tr>
<td>Inviting reflection</td>
<td>[42]</td>
</tr>
<tr>
<td>Provision of overview for creative sensemaking</td>
<td>[43]</td>
</tr>
</tbody>
</table>

The factors listed above are of value during dyadic knowledge creation because dyads rely upon visualisations for a “shared interactional space“ [44], this is known as the “joint problem-solving space” [45]. The joint problem-solving space is used as the “unfolding setting for the work at hand“ [44].

Individual visualisations have a number of discrete dimensions such as visual impact, facilitated insight, and modifiability [46]. Following Gibson’s theory of affordances [47], visual representations invite or discourage specific forms of interaction via affordances, which are the perceived opportunities for action an object or environment provides. Each contribution made by an ideator to a joint problem solving space provides an affordance for their partner to accept, question, discard or build upon it. Non-human agents also have a large bearing on the co-creation of knowledge through the mechanism of affordances. Affordances may be designed, but they are also inhe-
rent in the properties of visual markings. For example, as shown in Figure 10 - the basic visual element of the line may be more natural or artificial in nature [48]. Natural lines have more variation and this impacts upon people’s perception of, and interaction with them – as can be seen in sketches [49]. This study examines the manner in which joint problem-solving space, writing instrument and dyads entangle [50] to create emergent knowledge.

**Figure 10: Artificial and natural lines**

![Artificial line](image)

Natural line

Rheinberger [51] makes a telling distinction between technical objects and epistemic objects. An idea visually notated in a dyad’s joint problem solving space is a transitory epistemic object, yet they are often misinterpreted as factual technical objects - and fruitful opportunities for knowledge creation are missed. Whyte, Ewenstein, Hales, & Tidd [52] refer to epistemic objects as being fluid and technical objects as frozen. Persistence (Nijstad et al., 2010) is effectively the overcoming of NFCC (Kruglanski & Webster, 1996). NFCC results in the fluid being prematurely, and often permanently frozen – whilst ideators move onto completely unrelated ideas. Persistence [29] is effectively the overcoming of NFCC [15]. Overly static visual representations which provide no affordance for persistence potentially exacerbate the freezing and seizing of boundary objects’ fluidity.

In the current context, visualisations are generated by a combination of human agents, inscription and display devices. A writing instrument such as a pen is an example of an inscription device, while a sheet of paper is exemplary of a simple display device. This study’s operationalisation of inscription and display devices is fully listed in Table 7, and shown in Figure 12. Despite an increasing recognition of the importance of sociomaterial processes and objects [53] both inscriptive and display non-human agents [54] of notation, or notation materials, have gone unexamined in the realm of group creativity. In examining notation materials and their interactions, this pilot study begins to remedy this deficit.

Raw artefacts in the midst of creation by ad-hoc groups are relatively low in structure, and high in subjectivity and embeddedness within a group context [55]. Therefore, they are fundamentally epistemic [51], or fluid
This study examines whether consistently fluid notation materials will support emergent sociomaterial objects’ development more effectively than the contradictory use of frozen notation materials. Complementary sociomateriality in-sync with the group’s function is predicted to facilitate persistent creativity [29] in the face of NFCC [15].

Seeber et al. [55] introduce the idea trace phases of controversial initiation, supportive enrichment, steadfast challenge and committed integration. The concept of idea trace phases can also be applied to idea category. Each idea which steps away from the category undergoing supportive enrichment and opens up a new idea category represents at least temporary cognitive closure on the extant category, and the beginning of a new phase of controversial initiation. Through impacting upon NFCC on idea category via degree of fluidity [52], differing compositions of notation materials will affect the level of enrichment, challenge and perceived integration of an idea category’s ideas. The perceived modifiability of sociomaterial emergences impacts upon the affordance they create.

Hypothesis Development

The various actors in the entanglement of writing instrument, display device and dyad are envisaged to create replicable patterns of interaction. Bearing the literature on dyads, NFCC, the Dual Pathway to Creativity Model [29] and visualisation in mind, a hypothesis on the relationship between writing instrument and display device, and their impact upon creativity in a dyadic mind mapping context will be developed below. Figure 2 depicts a conceptual model in which display non-human agent of notation, or display device, is conceptualised to operate via affordance effects [47]. Frozen pre-existing visual templates with vacant affordances for new ideas and idea categories pre-validate any new category initiation. There can be no controversy [55] in satisfying an affordance. In the case of pre-existing mind map templates, individuals sate templates’ affordances to supply idea categories to ‘empty branches’.

In contrast, when groups create their own mind maps, there are no empty branches. New branches are only created and the first idea noted after a new idea category has been cognitively opened by at least one individual. The affordance for individuals then becomes the population of the newly created branch at hand. Prior to a new idea category passing through initial cognition and controversial initiation [55], no empty branch graphically exists to invite supportive enrichment [55]. Once a new idea category branch
has been graphically depicted and cognitively opened on a mind map, closely-related, within category ideas will be contributed until within category persistence flags [29], and a new category is opened. Within a highly modifiable joint problem solving space, the cognitive opening and public notation of a new idea category is capitulation to NFCC on idea category and the abandonment of a joint cognitive effort to flesh out the invitation of an at-hand idea category. Display devices operate according to principles of affordance, and their emergent sociomateriality interacts with other agents to develop varying levels of cognitive persistence despite NFCC [15].

Inscriptive non-human agents of notation, or writing instruments, are a fundamental component of emergent sociomaterial processes and objects. Interactions between human agents and writing instruments will impart differing degrees of fluidity [52] upon sociomaterial objects. Fluidity itself is an affordance.

A set of ideas consists of categories [30]. The emergence of idea categories is a result of “structured imagination”[56]. During the attribution of an idea to a category, human agents’ “imagination is structured by a particular set of properties that are characteristic of that category” [56]. Central aspects of idea categories derived from naïve mental models [57] define an individual’s categories, and multiple human agents subsequently use naïve mental models [58] to compare any new ideas to a prototypical category member’s central attributes in order and determine the new item’s category membership.

The acceptance of wider deviation from an idea category’s central attributes’ increases the inclusivity of an idea category. The relatively naturalistic markings of fluid writing instruments are more loosely interpreted than those of comparatively artificial frozen writing instruments [46]. Graphite markings thus lend themselves to the creation of less fine-grained categories than ink markings. Writing instrument markings communicate provisional category norms, which human agents perceive as flexible. Inclusivity of category is expected to result in more persistence [29].

Following the reasoning above, it is hypothesised that fluid non-human display agents of notation and fluid inscriptive non-human agents of notation will interact resulting in the emergence of higher levels of persistence in human agent dyads [29] than is displayed by dyads equipped with frozen non-human display agents of notation and frozen inscriptive non-human agents of notation. In other words, it is predicted that synergies between fluid display devices and fluid writing instruments will enable more persistence in
pairs than frozen display devices and frozen writing instruments. This relationship is depicted in Figure 2.

**Figure 11: Conceptual Model**

- **Independent variable**
  - Display nonhuman agent of notation

- **Moderating variable**
  - Inscriptive nonhuman agent of notation

- **Dependent variable**
  - Cognitive persistence of human agent dyad

**Method**

**Research Design**

A 2x2 factorial experiment was selected to test the hypothesis. The independent variables are instrument and worksheet used by the dyads, and the dependent variable is within category fluency. The fluidity of display non-human agents of notation was operationalised by blank sheets of A3 paper (fluid) and A3 sheets with a pre-printed mind map template (frozen). The fluidity of inscriptive non-human agents of notation was operationalised by pencils with eraser (fluid) and black pens (frozen). By inherent nature of their markings, pen ink produces relatively artificial lines whilst pencil graphite produces comparably natural lines [48] – therefore pens were used to operationalise frozen rigidity and pencils were used for the operationalization of fluidity. The exact materials used are listed in Table 7 and depicted in Figure 12.

The ideation task was “develop ideas for inexpensive giveaways to remind and inspire employees organisation-wide of a new strategy”. This task was chosen because of its universal accessibility, and applicability to participants. It is also in line with Ward’s experimental tasks [56].
Participants

All 58 participants were middle or upper managers from central Europe with at least 10 years of professional experience in departments such as IT, engineering, and marketing. The participants were from 55 different organisations. Participants’ industries were: construction (5.1%), consulting (6.8%), education (1.7%), engineering (6.8%), financial services (20.2%), fast moving consumer goods (3.4%), healthcare (13.6%), ICT (11.9%), manufacturing (10.2%), NGO (1.7%) and the public sector (18.6%). Participants had only superficial previous knowledge of each other. The sample was comprised of 79% males and 21% females.

Procedure

The experiment was twice repeated during two separate executive MBA courses on strategic management. The procedure and time of day was identical in both iterations. Participants were told that they would be assigned to dyads, required to generate ideas for a soon-to-be-assigned task using a mind map[59]; and finally select and summarise their best idea [60] using a standardised sheet. Radial mind maps were chosen for their ubiquity [61] and accessibility [40]. To ensure uniform knowledge, mind map use for ideation was briefly explained [62]. Dyads were then randomly formed by the experimenters, and materials assigned to them. Finally, participants were told that there was no minimum or maximum time limit for the simulation, and the ideation task was publicly announced and visibly noted. Upon finishing the activity, participant pairs handed in their mind maps, best idea summary sheet and writing instruments. The time of submission was noted, and participants were each given a short survey to measure control variables.
Table 7: Operationalisation of Fluid and Frozen Inscription and Display Devices

<table>
<thead>
<tr>
<th>Concept</th>
<th>Operationalisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid inscriptive non-human agent of notation</td>
<td>Pencil with eraser</td>
</tr>
<tr>
<td>Frozen inscriptive non-human agent of notation</td>
<td>Pen</td>
</tr>
<tr>
<td>Fluid display non-human agent of notation</td>
<td>Blank A3 sheet of paper</td>
</tr>
<tr>
<td>Frozen display non-human agent of notation</td>
<td>A3 sheet of paper with pre-printed mind map template</td>
</tr>
</tbody>
</table>

Figure 12: Worksheets and Materials Provided
Results

At the outset of the experiment, two participant pairs left the experimental environment, and completed the task at external tables. Their results were removed from analysis.

Mind maps were examined as representative of each group’s creative process. Fluency and flexibility require measuring to attain the persistence measurement of WCF. The first measurement taken from all mind maps was ideational fluency [25].

Flexibility was next measured following the work of Seeber, Maier, Ceravolo & Frati [55]. Category coding was begun, and a list of coded idea categories of uniform granularity gradually emerged - for example office stationary, games, and toys. If an idea did not fit into a previously created category, then an appropriate new category was created and added to the category list.

WCF was subsequently calculated using the fluency and flexibility values. The results are reported in Table 8. Neither fluency nor flexibility were significantly different as main factors. The control variables measured by survey had no effect on the result.
Table 8: Factor Means

<table>
<thead>
<tr>
<th>Condition</th>
<th>Blank worksheet with pencil (n=12)</th>
<th>Blank worksheet with pen (n=16)</th>
<th>Template worksheet with pencil (n=12)</th>
<th>Template worksheet with pen (n=14)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>s.d.</td>
<td>Mean</td>
<td>s.d.</td>
</tr>
<tr>
<td>Fluency</td>
<td>26</td>
<td>20</td>
<td>17</td>
<td>12</td>
</tr>
<tr>
<td>Flexibility</td>
<td>8</td>
<td>8</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Within Category Fluency</td>
<td>3.79</td>
<td>1.73</td>
<td>2.67</td>
<td>1.13</td>
</tr>
</tbody>
</table>

n=54

Fluency, flexibility and WCF differences between the two operational fluidity factors were next examined using one-way ANOVA. The results are presented below in Table 9.
Table 9: Factor One Way ANOVAs

<table>
<thead>
<tr>
<th>Factor</th>
<th>Worksheet (n=54)</th>
<th>Writing instrument (n=54)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ANOVA: Between Groups</td>
<td>ANOVA: Between Groups</td>
</tr>
<tr>
<td></td>
<td>df</td>
<td>Total df</td>
</tr>
<tr>
<td>Fluency</td>
<td>1</td>
<td>53</td>
</tr>
<tr>
<td>Flexibility</td>
<td>1</td>
<td>53</td>
</tr>
<tr>
<td>Within Category Fluency (WCF)</td>
<td>1</td>
<td>53</td>
</tr>
</tbody>
</table>

n=54

As can be seen, main factor alone played a non-significant role on the fluency, flexibility or WCF of creative output. Univariate analysis of variance was then used to test for moderation of writing instrument fluidity upon display device fluidity. The results are shown below in Table 10.
Table 10: Univariate Analysis of Variance Moderation Test

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worksheet</td>
<td>1</td>
<td>1.419</td>
<td>.239</td>
</tr>
<tr>
<td>Writing instrument</td>
<td>1</td>
<td>.365</td>
<td>.549</td>
</tr>
<tr>
<td>Worksheet * Writing instrument</td>
<td>1</td>
<td>6.653</td>
<td>.013</td>
</tr>
</tbody>
</table>

a. R Squared = .137 (Adjusted R Squared = .085)

b. Computed using alpha = .05

n=54

Univariate analysis of variance shows that the interaction between worksheet and writing instrument for WCF is significant at a level of $p=.013$. The univariate analysis of variance general linear model in Figure 13 shows the powerful crossover interaction between worksheet and writing instrument impacting upon WCF.
As seen in Figure 13, idea generating dyads using pencils with a blank page were approximately twice as persistent as dyads using pencils with a mind map template. A much slighter increase in WCF emerged from idea generating dyads using pens with a mind map template in comparison with pairs using pens and a blank page.

It should finally be noted that although erasers were provided on the end of every pencil in the relevant conditions, none were used.
Discussion

The hypothesis that interaction between fluid display devices and fluid writing instruments encourages the emergence of persistence in dyads [29] was supported. As hypothesised, writing instruments’ fluidity moderates worksheet fluidity resulting in higher cognitive persistence within dyads. This effect is examined in more detail below.

When the affordance of pre-supplied mind maps to create new idea categories is not present, the cognitive persistence of dyads using fluid, relatively naturalistic markings is increased due to widened category inclusivity. In contrast, when pre-printed mind map branches with multiple contribution affordances are not made available to dyads using the frozen, comparably artificial medium of pen, dyads merely open and close idea categories superficially [48]. These dyads indulged in the claiming of cognitive categories. Frozen ink markings impart very little leeway from central idea category-defining attributes [56] when used freely. To paraphrase Ward [56], ink rigidly structures imagination and the result is NFCC on idea category.

The strength of affordances is evident in both writing instrument operationalisations. As seen in Figure 12, each branch of the pre-supplied mind map templates had three affordances for within category ideas. The mean WCF in the template with pen condition was 3.04 (s.d. 0.91). The close mapping between the template affordances and results produced reveal the tempering of ink’s rigid category centrality [56] of ink by mind map affordances.

Most notably, the influence of pre-supplied templates decimated the inclusive category leeway [56] of graphite markings. The cognitive persistence of dyads freely creating emergent sociomaterial objects with fluid, somewhat naturalistic markings is shown to be delicate and easily disrupted by the rigidity of pre-supplied templates. In such cases, these templates actually induce NFCC through the affordance to create new idea categories. Graphite markings allow the loose structuring of imagination, yet the very fragility of its framing, which allows for inclusive deviations from central category attributes [56], is easily disrupted by fixed visual template affordances.

Conclusion

This study is not without limitations. This pilot study used a relatively small sample from a limited cultural range, under laboratory conditions. Coding was carried out by a single independent researcher. The current study
used only two operationalisations each of display device and writing instrument. Future studies would address these shortcomings and widen the variety of operationalisations, with the aim to include digital variants. Future data collection would include qualitative data to be used in an integrative mixed methods approach [63].

This pilot study opens numerous avenues for further research. More research into the moderation of visual working space effects by notation instrument is called for.

One factor uncovered by this pilot study particularly merits further study: the absence of externally-supplied affordances is not the absence of affordances. Groups with blank worksheets were generating their own affordances as their mind maps emerged. An exploration of differences between personally-generated and externally-supplied affordances would be a useful contribution to affordance theory.

In summary, this pilot study has found the category inclusivity effect of writing instrument to moderate the affordance effect of display devices on idea generating dyads’ cognitive persistence[29]. Emergent sociomaterial interactions have thus been shown to be capable of lessening the impact of NFCC in knowledge creation [1]. The fluidity of visualisation components acts as cognitive antifreeze upon NFCC in idea generating dyads.

This study has found the gap-filling affordance of static pre-structured templates to negatively impact the creative persistence [29] enabled by the category malleability effect of fluid, naturalistic markings. However, digital environments are dynamic, and the evident effects of affordances could be dynamically employed to foster creative contributions. For example, mind-mapping software could relatively easily detect the filling of main, category level mind map branches, and create empty new category branches to afford more contributions. At a simple level, mind-mapping software could operate via a programmed rule to automatically add a new sub-branch extending from every single new contribution to a mind map. These vacant sub-branches would de-centrally elicit knowledge. A more sophisticated phased treatment is also technically possible - a model of phased affordances could encourage participants to push themselves to gradually build up and connect layered categories of knowledge in the shared visual working space. A phased model of dynamic - not static, pre-structured – affordances in combination with natural, graphite lines [48] would invite creativity via participants’ deep, systematic search of associative memory [29],[64] and idea combination [65].
In general, software design for idea generation, including social media platforms for innovation, should take note of the malleable category inclusivity effect of natural, graphite lines [48] and mimic these. A further application of the finding that natural graphite markings have an advantageous yet delicate function as cognitive antifreeze in the absence of pre-existing structures is in tablet computers’ handwriting recognition systems. Handwriting recognition software designed for the support of divergent thought [23] should encourage the retention of user-produced natural lines, instead of transforming users’ natural lines into artificial lines by default. Furthermore, automated processes for ordering users’ knowledge structures into templates such as stakeholder maps should respect users’ existing natural lines as much as possible and produce user line/template hybrids.

Social media platforms for innovation have, at times, suffered under low quality of discussion. The duplicate addition of identical ideas contributes to this problem [66]. The fluid presentation of previously-supplied ideas to potential idea providers could lead to within-category expansion upon them and bolster the idea pool.

The findings of this study are also useful for knowledge managers who can use them to compose sociomateriality in order to elicit or rescind cognitive persistence in dyads in a range of situations. For example, knowledge managers can use the space/medium sociomaterial interaction described as a powerful tool by which to allay the deleterious effects of NFCC on creative output [14]. This sociomaterial effect is especially useful in solving problems prone to eliciting false insights [67] when persistence is needed to push past seemingly satisfactory initial solutions in order to tap into truly creative veins of cognition. Such scenarios can be found in a range of problems from the introduction of new technology into an organisation to resolving thorny programming challenges. Sociomateriality has been shown to matter to the search for creative solutions.
References


5 Study 3 Overview

Study 2 established that visual differences make a difference to dyadic interaction. Previous visualisation studies have looked into the effects of visually structuring workspaces prior to ideation (e.g. Eppler, 2006; Mento, 1999), as the pre-printed mindmap in Study 2 did. However, the effects of emergent marks created by ideators themselves during ideation have not received the same attention. It is this thread from Study 2 that Study 3 picks upon. However, while Study 2 remained largely on the level of visual tools, Study 3 uses conditions with the same tools to more closely examine the subtleties of perceived finishedness (PF) (Bresciani & Eppler, 2013).

The most striking difference between Study 2 and Study 3 is a change from face-to-face to computer-mediated communication. Study 3 directly addresses the call of Study 2 to go digital. The effect of this is fourfold: firstly contemporary relevance is increased as computer-mediated communication is increasingly poignant for ideation teams. The most cost-effective way to assemble and engage a diverse group is via computer-mediated communication. Secondly, as an experimentation arena, computer-mediated communication enables a high degree of control over the visual style of marks that participants can produce. For example, participants can only enter text using a set typeface – not their own handwriting. Moreover, the PF of marks is explicitly separated from modifiability – neither low PF nor high PF marks could be modified. Internal validity is raised. Thirdly, with the correct experimental procedures the mutual anonymity of participants is maintained. This again raises internal validity by ensuring that inter-participant relational factors are excluded from measurement. Moreover, influential backchannel communications such as gestures and facial expressions (Duncan, 1975) are excluded. Fourthly, video data of interaction is easily and unobtrusively collected from computer-mediated communication. This allows detailed examination of the ideation process as it unfolds.

Study 2, the pilot for Study 3, describes its own shortcomings. Among these are a shortness of operationalisations. Using a 2x2 experimental design focused upon the style of marks made by inscriptive tools, Study 3 doubles the number of participant-produced visual mark operationalisations to four. Moreover, these operationalisations are pre-tested.

Study 2 showed that the pre-determined visual structure of a working space interacts with participant-produced visual marks. To avoid a potential confound, all conditions in Study 3 use a blank, unstructured working space.
The conclusion section of Study 2 raises the point of handwriting, and handwriting recognition software. Whether visually-supported ideation is face-to-face or computer-mediated, the written word and its visual representation through typefaces remain central. No matter if interaction is facilitated and captured by visual metaphors, system diagrams or mindmaps, the written content participants contribute is essential. The representation of written content deserves examination. Study 3 picks up where Study 2 left off and experimentally examines a typeface that mimics handwriting against the standard computer typeface Arial. Arial is easier to mentally process than the handwriting-like typeface.

Study 2 and Study 3 share the same theoretical lens – the Dual Pathway to Creativity Model (DPCM) (Nijstad, De Dreu, Rietzschel & Baas, 2010). Study 2 looked at the effect of PF (Bresciani & Eppler, 2013) of participant-produced marks on the persistence pathway (Nijstad et al., 2010). Study 2 found that low PF resulted in a “Category inclusivity effect” (McGarrath, 2015, p.13) which ultimately resulted in more persistent ideation. Study 3 will examine the effect of PF on the flexibility pathway (Nijstad et al., 2010). The DPCM (Nijstad et al., 2010) is based around the schema theory concept of semantic memory. Semantic memory is of such centrality to this dissertation that at this point it merits a brief diversion into explanation.

Associative memory and semantic memory are two closely-related, yet crucially different, concepts that both belong to the schema theory family. Schema theory has been robustly synthesised by Wyer (1980). Essentially, schema theories encompass knowledge encoding and retrieval from individuals’ interrelated cognitive networks. In 1962 Mednick firmly established associative memory as the basis for future creativity via the simultaneous introduction of associative thinking as the basis for creativity; and a diagnostic tool called the Remote Associates Test (RAT) (Mednick, 1962; Buchanan: 2010). Importantly, the RAT is word-based. Figure 14 gives an example below. In each question, test participants must find the relationship between three words. Test participants complete a list of increasingly difficult questions, which increasingly stretch their ability to find an association between the words.
Mednick’s RAT test is theoretically sound and highly pragmatic. It greatly helped to move creativity research forward. A slight vernacular irregularity which can be traced to the Remote Associates Test has, however, complicated and undoubtedly divided research communities without need. Mednick (1962) refers to associations and the associative basis of creativity. Meanwhile, the Remote Associates Test tests both associative and semantic memory. Subsequent research has focused upon forming associations in semantic memory; but spoken of associative memory.

Modern psychology defines semantic memory as a networked mental set of facts and world knowledge obtained through life experiences (Buchanan, 2010). For example, rats are known to eat cheese in the popular consciousness. Modern psychologists narrowly define associative memory as a network of word associations independent of meaning or source (Nelson, McEvoy & Schreiber, 2004). For example, blue cheese and cottage cheese. Semantic memory is wholistic, associative memory is a far narrower lexical subset. Deceptively, much previous idea generation research has mistakenly referred to word-based associative memory instead of concept-based semantic memory (Raaijmakers and Shiffrin, 1981; Nijstad & Stroebe, 2006). In effort to unite research streams, the Study 3 uses the more inclusive term “search in semantic memory” instead of “search in associative memory” (Nijstad & Stroebe, 2006).

Search in semantic memory occurs within the minds of individuals. Within a computer-mediated ideation space, the knowledge activated during search in semantic memory is produced and recorded as written contribu-
tions on-screen. Via these contributions, participants can, knowingly or unknowingly, influence other participants search in semantic memory by such mechanisms as framing and priming. The most visible, and arguably most useful, such effect can be seen in elaborative dialogue – or elaboration.

As mentioned in the introduction to this dissertation, elaboration is “Detail that is added to the subtopics that are brought up” (Hogan, Nastasi & Pressley, 1999, p. 398). In effect, elaboration can positively build upon an idea or negatively critique it (Hewing, 2013). Both can be useful. There is a third possibility. Ignoring ideas. Particularly in ideation, unless otherwise instructed there is no particular pressure for participants to add detail to an idea. Instead they can ignore another participants’ idea while they focus on searching their own semantic memory for ideas. Consideration of the traditional ideation metric of fluency, or idea count, in this light does not show it to be an exemplary performance metric.

Study 3 closely examines the effect of PF upon elaboration. An interaction effect with processing fluency is uncovered. Study 3 and its findings are presented in the next chapter, which precedes the conclusion of this dissertation.
5.1 References


6 Study 3: The Power of Provisionality: An Experimental Evaluation of Idea Appearance in Online Knowledge Creation

Abstract

The software known as creativity support systems (CSS) have become a critical catalyst of the knowledge creation process. Nonaka and Konno integrated CSS into wider knowledge management processes with the concept of ba. Ba are shared spaces in which relationships between knowledge and individuals can develop. This study finds that minor changes to the appearance of icons users interact with in CSS impact user knowledge creation dialogue. Under laboratory conditions, this study uses a 2x2 factorial experiment to investigate the impact of icon and typeface appearance on the idea generation processes of 37 pairs of active managers within a synchronous CSS. Participants used icons which differed on their appearance of finishedness to enter ideas into a shared working space. Some icons looked like rough first drafts, others looked perfectly complete and refined. Participants initial ideas were equally unripe but the icons created different levels of perceived finishedness (PF). Participant ideas were also displayed on-screen using a typeface which was either easy or difficult to cognitively process. Icon PF and typeface processing difficulty level had a crossover interaction effect. A low PF icon and an easy-to-process typeface resulted in more original ideas. Conversely, a high PF icon and a difficult-to-process typeface resulted in less original ideas. These findings and their implications are discussed in terms of enabling spaces, or ba, semantic memory, and difficulty of information processing.

Keywords

Creativity; idea generation; idea quality; knowledge management; ba; dyad; visualisation; perceived finishedness (PF); elaboration

Introduction

Nonaka and Konno state the centrality of a “shared space for emerging relationships” between knowledge and individuals to knowledge ma-
nagement [1]. Drawing upon nineteenth century Japanese philosophy, the authors call such spaces ba, and see them as platforms for knowledge concentration. Ba can be physical, virtual or mental spaces – or a combination thereof. Software such as creativity support systems (CSS) are digital ba that enable us to create knowledge across functional and physical borders [1, 2]. CSS are defined as “computer-based systems that support individual- and group-level problem solving in an effort to enhance creative outcomes” [3: 746]. For the purposes of this study, the terms CSS and digital ba are virtually interchangeable. This study uses the term CSS to refer to the de-contextualised use of CSS software and digital ba to refer to CSS embedded within knowledge management processes.

Digital ba, do not substitute socialisation in the SECI knowledge management cycle [1]. In a world of competing priorities and time pressure CSS, or digital ba, allow individuals to at least keep their mind in touch when their body cannot be. Digital ba enable dynamic knowledge creation processes to continue when they would otherwise be interrupted. This fuels competitive advantage.

Outside dynamic knowledge management processes, in isolated single idea generation sessions under laboratory conditions, numerous studies have found that idea generation with CSS leads to more creative output than equivalent face-to-face sittings [4]. However, there is room to improve - unfortunately CSS are not conducive to group discussion [5]. Individuals using CSS focus on generating new ideas without adding detail to the ideas of others [6]. This area has high potential - overriding natural behaviours by instructing or motivating individuals to pay attention to the ideas of others has led to higher idea quantity [7] and quality [5]. However, instructions can be ignored [8] and the focus of motivation is often fleeting [9].

Importantly, implicit visual messages to the “human eye-brain system” [10] are virtually impossible to ignore. A visual invitation to add detail to ideas is a possible means by which to reliably initiate more collaborative patterns of dialogue and behaviour in CSS. This study changes the appearance of CSS users’ ideas to increase the amount of detail added and make them more original. The exact levers used are the apparent completion level of the icon marking the beginning of an idea; and the processing difficulty of the typeface used to express an idea. Giving the icon a rough appearance raised the number of ideas CSS users added detail to. An interaction between the icon and the typeface raised the originality of ideas.

As “One cannot be creative without being original” [11: 35], the re-
The results of this study are crucial to designers and managers of digital ba. Subtle visual alterations to elements in users’ working space can have great impact upon output. This paper offers researchers empirical evidence of a subtle yet powerful visual effect; as well as insights into the interplay between discussion and cognition.

The specific questions this research seeks to answer are:

Do apparently unfinished icons make participants more likely to add detail to other participants’ ideas?

Does icon appearance interact with the typeface ease of processing to raise idea originality?

This article will next review the literature on search for creative ideas in semantic memory, disfluency, perceived finished and dialogue in idea generation. Following this, the development of a formal hypothesis on the interaction between perceived finishedness and disfluency precedes a detailed description of data collection and analysis. The results of the experiment are then presented and discussed before implications for practitioners and researchers are given.

**Literature Review**

**Search in Semantic Memory**

Modern psychology defines semantic memory as a networked mental set of holistic facts and world knowledge obtained through life experiences [12, 13]. In 1962 Mednick cemented the basis of future idea generation research as the stepwise search for ideas in semantic memory network [14, 12, 11]. [15] succinctly characterised search in semantic memory as trains of images which suggest one another.

The Dual Pathway to Creativity Model (DPCM) is a model of search paths in semantic memory [11]. The DPCM forms the theoretical basis of this study. This model posits two separate cognitive processes, or pathways, which can independently lead to the discovery of creative ideas. By definition, creative ideas are those high in originality and feasibility [16]. The DPCM envisages that situational factors lead to the effective use of a single pathway, although pathway synergy is not ruled out. The two pathways are: the flexibility pathway and the persistence pathway.
The flexibility pathway is crucial to the reasoning and hypothesis of this study. The flexibility pathway enables access to broad categories of memories and flexible transition between memory categories. The DPCM reasons that idea generation via the flexibility pathway benefits from a shallow cognitive processing mode that covers many memory categories. Flexibility pathway thinking should flit between categories. This enables the combination of distantly associated concepts.

Nonaka and Konno write that engaging in a ba indicates that one “get involved and transcend one’s own limited perspective or boundary” [1:1]. Venturing into new categories of thought in a ba supports the flexibility pathway.

In contrast, the persistence pathway to creativity involves the in-depth inspection of few categories. This is a structured search pattern which exhausts all possibilities within a narrow range of memory categories. In experiments and a comprehensive meta-analysis, the DPCM authors find the flexibility pathway to access more original ideas more quickly than the persistence pathway [11].

Regardless of whether the flexibility or the persistence pathway to creativity is sought, the key obstacle to search in semantic memory is fixation. Fixation describes a thinker being unable to escape from recalling a certain idea. Fixation dramatically lowers diversity in search within and across memory categories [17]. Response competition is the mechanism responsible for fixation [18]. Response competition occurs when an unwanted memory recall signal is stronger than the desired memory recall signal. Most destructively, the more recently an item has been recalled, the stronger its recall signal [19]. Fixation marks the almost inevitable end of a productive search in semantic memory [17], and should be avoided for as long as possible.

This study develops the hypothesis that fixation can be delayed using visual externalisations [1] in digital ba that promote certain dialogue and search in semantic memory patterns.

Disfluency

Search in semantic memory is an internal cognitive process influenced by external factors [11]. This study reasons that in a digital ba, the nature of knowledge externalisations [1] with which one prompts a search
in semantic memory influences the nature of that search. The knowledge externalisations in this digital ba consist of two elements: an icon to mark the beginning of each idea, and a typeface to express an idea. The current section examines typeface processing difficulty. The following section examines PF, which is relevant to icon appearance.

Externalised knowledge [1] exists on a continuum between the opposite information or knowledge processing responses of disfluency and fluency. Disfluency is “the subjective experience of difficulty while processing information” [20: 252]. The opposite - finding information, or externalised knowledge, easy to process is called fluency.

Studies show that disfluency improves learning outcomes during information uptake [21]. Disfluency is typically activated by visual elements [21, 22, 23]. For example, [22] found that presenting information in a difficult-to-process typeface improved comprehension, focus and retention of information. These results are widely replicated and disfluency is often referred to as a “desirable difficulty” [24] in pedagogical circles.

Disfluency activates analytic reasoning [21], which means that disfluency does not lend itself to the flexibility pathway to creativity described above. Flexible thinking covers a large range of categories. It is shallow, global thinking that crosses categories of thought. In contrast, analysis is the deep deliberation of a narrow category selection. Analysis manipulates rule-based mental models [25]. Whilst otherwise indispensable, analysis does not support the semantic memory recall process of creative idea generation [25. 11, 26]

Disfluency is one of the purely visual independent variables manipulated in this study. The other is perceived finishedness.

**Perceived Finishedness (PF)**

This study tests the hypothesis that ease of information processing interacts with perceived finishedness (PF) to benefit or hinder flexibility pathway searches in semantic memory.

PF is purely visual. The PF of an item is a completely separate dimension to the actual substance of that item. An item with low PF appears to be unfinished and in need of completion. For example a floorplan sketch. An item with high PF appears to be complete - without need for change. For example, a schematic floorplan.
An object with a low PF level is typically irregular in shape. Our eye perceives irregular shapes as regular shapes with mass removed [27]; an irregular shape will thus have a lower visual weight than its regular counterpart. Visual weight attracts attention.

PF is thought to influence group willingness to interact, question or modify a visualisation [28]. Rheinberger’s [29] work on knowledge objects is closely linked with PF. Rheinberger introduces the terms technical and epistemic knowledge objects to differentiate between complete and incomplete items of knowledge. Technical objects are fully developed into their final state or “Frozen” [30:21]. Epistemic objects are still under development. They are still “Fluid” [30:21] Regardless of actual substance, low PF items present themselves as epistemic objects, while high PF items implicitly communicate that they are technical objects.

Increased modification of low PF items has been witnessed during ethnographic studies [30, 31, 32, 33]. However, this visual effect is yet to be experimentally shown under laboratory conditions.

The proposed low PF link to knowledge object development suggests that low PF makes tacit ‘how-to knowledge [34] on collaborative creativity explicit. The following section will examine two key dialogue features of idea generation that low PF is expected to encourage: elaboration [8] and improvised enrichment [35].

**Idea Generation Dialogue**

Dialogue is “listening and contributing to the benefit of all participants” [1:44, 36]. Whether written or spoken, dialogue supports externalisation in digital ba [1]. Elaboration and improvised enrichment are two particularly valuable types of dialogue in idea generation[8, 35].

Elaboration is the addition of detail to an idea [37]. Previous research finds higher elaboration levels to lead to improved problem solving, more sophisticated reasoning and increases in both originality and feasibility [8, 37, 38].

Enriched improvisation is back-and-forth discussion of an idea in a pair [35]. Hewing [35] highlights how partner additions to an idea spark divergent thought in the original provider of the idea. Divergent thought is the production of a wide range of responses to a single stimulus. As others add new details to an idea, individuals improvise to accommodate, build upon or
deflect the incoming comments. Nonaka and Konno see such reflection as key to interaction during knowledge creation [1].

Low levels of elaboration lessen enriched improvisation and restrict the creative potential of CSS. Without detail being added to an idea, exchanges do not develop. Elaboration upon an idea leading to enriched improvisation is the ideal scenario for a creative pair.

CSS users interact entirely by screen, so any optimization of their interaction must begin with the visual. Visual forces such as visual weight, which draws attention [39], steer visual perception which influence subsequent cognitive processes and dialogue.

**Hypotheses Development**

The literature reviewed above makes it apparent that “visual forces” [39:412] are highly likely to impact upon search in semantic memory. Importantly, PF is a visual property with cognitive and dialogical implications that support creativity. Low PF is a potential catalyst for elaboration, enriched improvisation [35] and widened search in semantic memory [11, 26]. PF has the potential to be an easily implemented lever for increasing the quality of dialogue and ideas.

This study reduces the problem solving space of a CSS to its three essential elements: icon, typeface and background. Icon PF is predicted to increase the number of ideas to which detail is added. Participants will add detail to modify ideas which they perceive as unfinished. As in many CSS, background is consistently left blank in this study.

This study hypothesises that participants will add more detail to ideas signified by apparently unfinished icons. More enriched elaboration [35] will result and lead to more categories of thought being covered [26]. This use of the flexibility pathway will lead to more original ideas [11].

The mechanism by which enriched improvisation is hypothesised to lead participants to sample more categories of thought is outlined below. Enriched improvisation is interactive dialogue in which ideas are challenged and defended [35]. When a thinker engages in such a dialogue, the ongoing search in semantic memory is disrupted. In response to a fresh challenge, a thinker needs to start a new search in semantic memory. In turn, this is discontinued as soon as another challenge arises. The result of these interruptions is a high number of short searches in semantic memory. As each
search is prompted by a new challenge, they each have a unique search start point [26]. These are optimal conditions for the flexibility pathway to creativity. Conversely, uninterrupted searches in semantic memory remain single, long searches which cover fewer memory categories and inevitably end in fixation [17, 18].

In the original DPCM, the authors propose that a long shallow search is needed to skip across thought categories and access the flexibility pathway [11]. This study hypothesises that this need not be the case – many discreet searches in semantic memory can also achieve thought category diversity. The meta-analysis contained in [11] links thought category diversity to originality.

This study predicts that the flexibility mechanism described above will increase originality in the low PF icon/easy-to-process typeface condition, but this is only part of the story. Our attention will now turn to typeface, and difficult-to-process, or disfluent, typeface in particular. Previous studies have consistently used low clarity typefaces to stimulate disfluency [20, 22, 23]. The difficulty individuals experience processing the disfluent typeface does not benefit the category skipping needed for the flexibility pathway. Individuals processing ideas written in the disfluent text will intensively focus upon them. They will also actively analyse them by sequentially manipulating mental models. These behaviours hinder search across categories in semantic memory.

An easily processed typeface neither invokes deep, analytical thought nor adds cognitive load [40]. By itself, fluent typeface processing invokes no analytical manipulation of mental structures. Search in semantic memory can thus freely range across categories [25]. In the low PF icon/fluent typeface condition, an increased number of search start cues in semantic memory is predicted to interact with freely processed information. The resultant searches in semantic memory will access highly original ideas via the flexibility pathway.

By comparison, the low PF icon/difficult-to-process typeface condition is predicted to show the impact of disfluent typeface. Relative to the low PF icon/easy-to-process, the difficult-to-process typeface condition will depress originality.

The high PF icon will lower originality. The high PF icon/easy-to-process typeface will display the least original ideas. In spite of the easy-to-process typeface support for cross-category processing. In this condition in-
Individuals will have their attention drawn to the heavy visual weight of the regular shaped icon [27] - and its message to leave ideas unmodified [28]. Participants will pay attention to the high PF icon and add detail to less ideas. In favour of originality, the high PF typeface will not induce analytical thought, which is incompatible with search in semantic memory [25]. However, individuals in this condition will not have the advantage of other participants providing new search start cues.

The high PF icon will have a knowledge freezing effect [29]. Individuals will pay attention to the regular shape of the high PF icon. Individuals will take note of its implicit message that they should not tamper with it [28]. Individuals who contribute initial ideas will thus receive no input on their ideas from others. Alone, they will conduct long uninterrupted searches in semantic memory from very few start points. Without others’ input on their ideas, they will have no cues for new search points in semantic memory. These individuals will continue along their own line of thought until they fixate upon a single idea [17, 18].

This study predicts that low icon PF will lead participants to add detail and engage in enriched improvisation [35]. The latter is synonymous with numerous short searches in semantic memory. These searches from new start cues will create the greatest originality difference in this study. This effect will positively interact with information presented in an easy-to-process typeface because processing ease facilitates memory category switching. Information presented in a difficult-to-process typeface restricts the number of categories thinkers access. It will thus nullify the positive impact of new search start cues from detail added to ideas.

H1: Low icon PF and easy-to-process typeface will interact to raise originality

The theoretical model depicting this potential relationship is shown in Figure 15.

**Figure 15: Theoretical Model**
As originality drives creativity [11] and creativity drives innovation [41], raising originality through such simple means is highly valuable.

The micro-process level variables in this study lend themselves to manipulation and measurement in a controlled environment laboratory experiment. The methodology used to test these hypotheses is described in detail below.

**Method**

**Research Design**

A 2x2 factorial experiment on computer-mediated dyads randomly paired in Adobe Connect spaces was selected to test the hypotheses. The conditions consisted of two icons with pre-tested high and low PF levels, and two typefaces with high and low fluency levels. The icons and typefaces used are depicted below in Table 11.

Operationalisations of icons with differing finishedness levels were pre-tested on a sample analogous to the experiment participants prior to experimentation. As seen in Table 11, the icons had a highly comparable form, and even shared an underlying “structural skeleton” [39: 93]. As also seen in Table 11, the high PF icon had a regular shape with heavier visual weight than the low PF shape. Three iterations involving a total sample of 61 individuals were required before comparable operationalisations with reliable perceptions of finishedness were established.

Previous disfluency studies have neither set typeface guidelines nor pre-tested typefaces [20, 21, 22, 23]. However, “unusual” [22:157] typefaces are consistently used to operationalise difficult-to-process typefaces. This study operationalised disfluency with a highly uncommon, difficult-to-read typeface called Daniel. Arial typeface operationalised the easy-to-process condition. Arial was selected for its wide-spread use and simplicity. The results of the final PF pretesting iteration are shown in Table 11 with the fluent and disfluent typefaces. The four experimental conditions used various combinations of the items below in minimalist Adobe Connect spaces.

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2 Adobe Connect is a web meeting platform. It was chosen for its representative popularity and flexibility. This flexibility allowed programmers to strip all possible confounding elements from the interface.
Table 11: Item Examples and PF Pretest Results

<table>
<thead>
<tr>
<th>Element name</th>
<th>Element sample</th>
<th>Mean PF (1-5)</th>
<th>s.d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low PF unfinished icon</td>
<td><img src="image" alt="icon" /></td>
<td>2.48</td>
<td>1.31</td>
</tr>
<tr>
<td>High PF finished icon</td>
<td><img src="image" alt="icon" /></td>
<td>4.00</td>
<td>.853</td>
</tr>
<tr>
<td>Disfluent Daniel typeface</td>
<td>The quick brown fox jumped over the lazy dog.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluent Arial typeface</td>
<td>The quick brown fox jumped over the lazy dog.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

n=23

Participants

There were 80 participants in total. 60 participants were middle or upper managers from central Europe with at least 10 years of professional experience in departments such as IT, engineering, and marketing. The 60 managerial participants were from 59 different organisations in industries ranging from the NGO to the financial services sector. 20 participants were students enrolled in master’s level knowledge visualisation courses. All participants had only superficial previous knowledge of each other. The total sample was comprised of 65% males and 35% females.

Adobe Connect CSS

The experiment employed a custom-made minimalist Adobe Connect CSS platform. Real-time participant behaviour was completely transparent. The only agency available to users was the creation, positioning and movement of knowledge units.

All features not operationalisations of independent variables were stripped away from the cloud-based Adobe Connect platform. This left a bare synchronous CSS with real-time text input and editing features, as shown below in Figure 16. The use of computer-mediated communication allowed
for realistic visual communication without confounding interference from backchannels, such as vocal intonation or gesture [42].

Pinssoneault et al. [43] indicate freeriding as a problem in anonymous CSS. The platform is an anonymous CSS system, but each participant uses a differently coloured icon. This allowed researchers to track the origin of each knowledge unit, and presumably reduces freeriding.

**Figure 16: Video Still Frame from Tailored Adobe Connect CSS**

![Video Still Frame](image_url)

**Procedure**

The experiment was repeated four times during two executive MBA courses and two master’s level knowledge visualisation courses. Participants first generated codes to ensure both the anonymity and traceability of their results in surveys and activities. Following this, participants individually completed an online survey on the trait of willingness to collaborate [44].

Using a set script, participants were next randomly assigned to: pairs, a custom Adobe Connect space and an orange or a blue icon. Participants were repeatedly told that they should use their assigned colour, and this was monitored throughout the experiment. Pairs were not co-seated. Students were next provided with a URL for their Adobe Connect space and instructed to log in. Following login, the task for ideation was verbally delivered and publicly noted. The ideation task was “You are a taskforce advi-
sing the programme’s strategic director. How can the programme’s strategic
director increase the programme’s value without significantly changing the
course price or the budget? You can suggest any type of change you like.”
Students were given ten minutes to silently and anonymously ideate with
their partner in their shared Adobe Connect space. Participants were only
able to communicate onscreen, and all on-screen interaction was remotely
recorded as video in a data centre. After ten minutes of ideation time had
elapsed, participants were instructed to remain silent and complete a survey
containing a manipulation check of the conditions.

**Dependent variables**

Ba are a platform for the advancing of individual or collective
knowledge [1]. This study examines knowledge sharing and combination wi-
thin digital ba by measuring the interaction of participant knowledge and the
originality of the knowledge created.

Manifestations of the dependent variables in screenshots and on-
screen videos were blind-coded by two independent coders of different gen-
der, nationality, professional background and age cohort. As a first step, both
coders independently coded all material independently. The coders next met
to discuss the definitions of codes, code application, inclusion/exclusion cri-
teria and to evaluate inter-rater reliability [45]. In cases of disagreement be-
 tween the two coders, the average of the two values was used.

All 386 ideas generated by participants were coded for originality
on a 5 point scale [46]. Originality considered whether the idea was new,
unusual, and infrequent in the set of ideas produced by all participants [16,
47]. The two coders originality ratings were considered to be in agreement
whenever they fell within one point of each other [16]. The Krippendorff $\alpha$ [48]
for originality was .97.

Coders independently watched video of on-screen interaction to ex-
amine the amount of detail added to ideas, or elaboration. Added detail was
coded upon the basis of the number of ideas detail was added to [37]. The
elaboration coding allowed no leeway for differences of opinion. Following an
identical inter-rater reliability check to the one used in the originality coding
process [45], the Krippendorff $\alpha$ for number of ideas with added detail was
.97.
Results

Table 12 shows the mean originality level ideas of pairs’ ideas.

**Table 12: Factor Means**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean</th>
<th>s.d.</th>
<th>Mean</th>
<th>s.d.</th>
<th>Mean</th>
<th>s.d.</th>
<th>Mean</th>
<th>s.d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low PF icon with difficult-to-process typeface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.27</td>
<td>.35</td>
<td>2.50</td>
<td>.34</td>
<td>2.27</td>
<td>.34</td>
<td>1.97</td>
<td>.31</td>
</tr>
<tr>
<td>High PF icon with difficult-to-process typeface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.77</td>
<td>.35</td>
<td>2.50</td>
<td>.34</td>
<td>2.27</td>
<td>.34</td>
<td>1.97</td>
<td>.31</td>
</tr>
</tbody>
</table>

Note: 37 dyads, n=74

Table 12 shows increased originality for the low icon PF and easy-to-process typeface condition. Meanwhile, the condition with the high PF icon and easy-to-process typeface has the least original ideas. Univariate analysis of variance was next used to examine the interaction of icon and typeface upon originality. Figure 17 and Table 13 show the results.
Figure 17: The Interaction of Icon PF and Typeface Fluency on Idea Originality

Note: 37 dyads, n=74

Table 13: Univariate Analysis of Variance Test

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Icon</td>
<td>1</td>
<td>5.360</td>
<td>.027*</td>
</tr>
<tr>
<td>Typeface</td>
<td>1</td>
<td>.090</td>
<td>.766</td>
</tr>
<tr>
<td>Icon * Typeface</td>
<td>1</td>
<td>5.542</td>
<td>.025*</td>
</tr>
</tbody>
</table>

Note: 37 dyads, n=74

* p<.05
Univariate analysis revealed a significant interaction between icon and typeface upon originality at the level of .025. H1 is supported.

Figure 17 depicts the crossover interaction on idea originality between icon PF and typeface fluency. Icons were examined more closely and it was discovered that low PF icons lead to a significantly higher number of ideas with detail added. One way ANOVA revealed a significance level of .025 ($t = 2.34, F = .021, df = 35$). Low PF icon conditions had a mean 1.68 ideas with added detail (s.d. 0.94), high PF icons had a mean 0.93 ideas with added detail (s.d. 0.96).

Prior to the analyses above, 3 data points were identified as outliers on the basis of anomalous deviation of contribution count [49]. These 3 data points were removed from all analyses. Of the initial 80 participants, this left 74 participants organised into 37 dyads.

Discussion

Michinov et al. [5: 64] have recently called for “technical solutions whereby exposure to others’ ideas will produce a positive stimulating effect during the idea generation process”. This study uses purely visual means to create exactly such a positive stimulating effect. The resulting boost to ideas’ originality helps to sow fertile grounds for innovation.

The results of this study correspond with the logic of the Dual Pathway to Creativity Model [11] and support H1. Low icon PF and fluent typeface interact to raise originality. A low PF icon raised the number of ideas with detail added, and the fluent typeface led to ease of information processing. In combination, these factors facilitated a high number of cross-category searches in semantic memory. This access to the flexibility pathway to creativity [11] raised the originality of ideas. In contrast, a high PF icon combined with a fluent typeface lowered originality. In this condition, partners added no detail to participants’ initial ideas, so participant searches in semantic memory continued without fresh input. Without external input, participants followed their own line of thought and eventually became fixated upon an idea they could not escape from.

The two conditions with the disfluent typeface display almost identical originality levels. This is interesting in itself. The disfluent typeface renders any PF effect of the icon ineffective. This is logical in light of the fact
that disfluent typefaces draw focus [22]. Recent eyetracking studies find that disfluency draws attention [50]. If little attention is paid to a visual element, such as an icon, its “visual force” [39:412] has less impact. When confronted with a difficult-to-process typeface, individuals immediately focus upon its content and are drawn into analytic thought. Any message the icon sends is thus diminished.

**Implications for Practice**

Existing collaboration software, including CSS, uses high PF icons with easy-to-process typefaces. Innovative designers of digital ba [1] can immediately apply these findings by providing users with low PF icons to work with.

In fact, the interaction effect described here can be applied in any software where the generation of original ideas is desirable, for example team chat applications like Zapier or Campfire. Conversely, authoritative top-down communications, like the knowledge for internalisation contained in brand manuals, should avoid any low PF elements.

Perhaps the highest potential application area for this finding is crowdsourced idea generation, or ideasourcing. For the crowd, the generation and addition of ideas is currently a solo activity. If users added ideas with a low PF icon and a fluent high PF typeface, then ideas could go through real-time enriched improvisation cycles by the crowd. Ideally, highly diverse anonymous pairs would spar together over ideas in real-time.

Original ideas are surprising by definition. Surprise drives virality [51]. Platform marketers could use higher originality ideas on ideasourcing platforms as viral content to fuel higher participation [52]. The PF effect thus lays the foundation for a potential virtuous circle.

Such an ideasourcing process would open data mining possibilities. Not only could ideasourcing platforms mine the original idea, but also subsequent iterations. The development of the idea could be mapped, and the iteration offering the host organisation the optimal mix of originality, feasibility and instrumentality [46] selected for further development. Moreover after mining and classification, the vast quantity of idea fragments collected could be recombined to form new ideas.
Finally, records of the stepwise development of ideas could provide strategic insights. The challenge and counter-challenge of the enriched improvisation process could provide marketing strategists with insights on competitor response and positioning.

**Implications for Research**

This study is the first to quantitatively show that a low PF appearance leads to significantly more modification than a high PF appearance. Low icon PF significantly increased the number of ideas to have detail added. These results were obtained under controlled experimental conditions that omitted non-verbal behaviour such as gesture and facial expression [42]. This confirms the ethnographic findings of [30, 31, 32, 33] and inferences of [28].

Further knowledge visualisation research is required to determine exactly which visual factors determine perceived finishedness, and how much weight they carry. Does the type of line used determine perceived finishedness?

Intrinsic, or self-driven, motivation has been demonstrated to benefit creativity [53]. Do intrinsic motivation levels mediate the PF link to modifications?

Low PF signals have been shown to interact with easy-to-process information to raise originality. Research into a complimentary visual mechanism which increases feasibility would be useful to researchers and practitioners alike.

The existing research on idea generation and fixation assumes a single, extended search in semantic memory approach. This study suggests that interrupting extended searches with new search cues is a fruitful mechanism by which to raise the number of thought categories covered. Detailed research into this topic, particularly from a fixation perspective, is required.

**Limitations**

This study is not without limitations. This study used a relatively small sample from a limited cultural range, under laboratory conditions. The study used only two operationalisations each of icon PF and typeface disfluency. Future studies should widen the variety of operationalisations.
This study found focus groups unable to comment upon the micro-level phenomena reported. The inability to recall or articulate subtle effects has previously been seen in disfluency research [54]. Open-ended surveys may provide a better means of gathering qualitative data on micro-level phenomena.

Conclusion

This study is of high value for knowledge creation and visualisation researchers. Firstly, there are a number of new contributions to the field. This study has quantitatively confirmed that low PF leads to increased likelihood of item modification. Secondly, the interaction of icon PF and easy-to-process typeface within digital ba has been uncovered. This is an interesting example of the visual directly impacting upon dialogical and cognitive processes. Moreover, this finding opens the potential research avenue of multiple short searches in semantic memory to delay fixation upon unwanted ideas.

This research refines the use of digital ba in knowledge creation. Some say that human beings no longer need collocation for collaboration [55]. This is possibly true for isolated cases of collaboration, but not the dynamic knowledge management processes of truly innovative organisations [56]. Digital ba are supplementary tools for integrated knowledge management - particularly in combination with socialization processes [1]. Digital ba enable users to remotely connect with socialization processes when they can otherwise not be present. Remote connection is better than no connection. Digital ba cannot replace the socialisation and internalisation roles of organisational culture. However, they compel knowledge externalisation as well as capture and integrate group knowledge for combination. This last point is particularly powerful when digital ba employ a low PF icon and easy-to-process typeface.
References


7 Conclusion

The 2009 publication of Dew & Hearn’s problemsolving study on dyad combination initially set the stage for this set of ideation studies. The present set of studies built upon Dew & Hearn’s work by firstly determining the precise value of dyad combination to problem solving; and located it within the discrete phase of ideation.

This final chapter will now look at these findings in more detail. This conclusion is structured as follows: Summary of Findings, Theoretical Implications, Managerial Implications, Outlook and Future Research, Personal Reflections and Concluding Remarks.

7.1 Summary of Findings

Study 1, 2 & 3 work in unison to explore task ideation dyads, the combination of such dyads and visualisation of their ideas as a support mechanism. Prior to this work, only one previous study had tested dyad combination in creativity (Dew & Hearn, 2009). Dew & Hearn saw surface level potential in dyad combination and called for deeper research.

7.1.1 Study 1

Study 1 directly answers the call for more research into dyad combination. Study 1 finds that using dyads, not individuals, as the “cellular structure” (Dew & Hearn, 2009, p. 532) for a four person ideation group lowers evaluation apprehension (McGrath, 2015c). Lowered evaluation apprehension leads to less withholding of ideas for fear of criticism (Collaros & Anderson, 1969; Kavadias & Sommer, 2009; Kelley & Thibaut, 1954). Moreover, lowered evaluation apprehension results in more original responses to prompts (Henchy & Glass, 1968). Greater quantities of more pioneering knowledge will be shared under low evaluation apprehension. Moreover, the exact same mechanism will lead to more open critiquing (Puccio & Cabra, 2012).

Puccio & Cabra (2012) observe that a criticism is fundamentally an idea. Criticisms are thus also subject to withholding under evaluation apprehension. An atmosphere of evaluation apprehension thus leads to an idea generation environment in which participants only share ‘safe’ ideas and critiques. Such a situation will not lead to highly original ideas that organisations can implement for competitive advantage.
Study 1 sets the stage for examining ideation task dyads. Lowered evaluation apprehension is of great benefit to ideation groups, yet neither Dew & Hearn (2009) nor Study 1 found any increase in the quality of ideas produced by combined dyad groups. The most logical prescriptive solution for raising the final idea quality from combined dyad groups is thus to raise the quality of the ideas which the dyads initially bring into the combination process. Study 2 and Study 3 set out to do exactly this. The literature also contains backing for this common sense approach, Paulus & Yang (2000) found that brainwriting groups carried improved ideation performance into subsequent sessions. Moreover, Munkes & Diehl (2003) report that intergroup competition between dyads ideating in parallel led to optimal effort by both dyadic partners. The high potential of parallel dyadic ideation followed by dyad combination is further affirmed by this research on social drivers, so materiality is the obvious place to seek complementary optimisation of the ideation process.

As ideation groups of all types and sizes routinely use visual means to facilitate their thinking and interaction, I decided to research easily implementable visual means as a vehicle for increasing the quality of dyads’ ideas. Previous ethnographic work has indicated the value, character and ubiquity of visualisation in various knowledge creation fields (Ewenstein & Whyte, 2007; Henderson, 1995; Whyte, Ewenstein, Hales & Tidd, 2007). Moreover, dyads are inherently apt visualisation users (Schwartz, 1995). This line of research also allowed me to gradually dig into the workings of visual modalities.

7.1.2 Study 2

As an initial study into functional visual work modes in ideation task dyads, Study 2 established that the visual tool used makes a fundamental difference to the ideation process (McGrath, 2015a). As a pilot study for Study 3, Study 2 established perceived finishedness (PF) (Bresciani & Eppler, 2013) and natural lines (Bradley, 2013) as an interesting and potentially rewarding research avenue to follow.

Study 2 led to Study 3’s in-depth study of PF, and the findings listed below under Study 3. Beyond this contribution, Study 2 uncovered the “category inclusivity effect” (McGrath, 2015a, p. 13) that low PF has on dyads’ interaction process and search in semantic memory. Study 2 also finds PF to interact with affordances and impact the persistence pathway towards the feasibility component of ideas. For explorative ideation using mind mapping, Study 2 finds the openness of blank working space preferable to pre-printed
mind maps because participants do not simply satisfy affordances to provide ideas but instead create their own knowledge structures.

7.1.3 Study 3

Prior theorising and ethnographic studies on PF reasoned that visual elements with a high PF level repel modification (Bresciani & Eppler, 2013; Whyte et al., 2007). Put conservatively, the notion was that a low PF element does not ward off modification - but quantitative studies had yet to find evidence. Study 3 is the first laboratory experiment to closely follow up and confirm the observations of Whyte et al. (2007). A low PF level invites viewers to alter it – PF impacts whether or not they make initial changes (McGrath, 2015b). However, PF level does not impact how many changes are made to a piece of knowledge. Low PF symbolises that the initial notation of a knowledge fragment is not fixed; it does not stimulate a ceaseless line of iterations (McGrath, 2015b). Thus, low PF acts like the grammatical mechanism of a question tag (Swan, 2005). Low PF elicits a single response, but not necessarily a stream of interaction.

Study 3 emerged from its pilot study – Study 2. Between Study 2 & Study 3, this set of studies covers visual support of both the persistence and the flexibility pathways from the DPCM (Nijstad, De Dreu, Rietzschel & Baas, 2010). Study 3 finds PF to interact with processing fluency to impact the flexibility pathway towards the originality component of ideas. In the ideation literature the flexibility pathway is the more established of the two pathways (Nijstad et al., 2010), and naturally drew my curiosity.

Study 3 brings this course of studies to its focal point: in ideation task dyads, visual anchor points (those elements dubbed “icons” in Study 3) that appear to be unfinished invite dyadic partners to add detail to ideas. The material thus influences the social. Moreover, Study 3 shows that the material positively influences social interaction by prompting elaborative dialogue. Using visual anchor points with low PF is the ideal starting point for dyads to develop high quality ideas to bring into dyad combination. Once dyads using low PF materials have used the complementary ‘battle and build’ processes of enriched improvisation (Hewing, 2013) and elaboration to develop ideas (McGrath, 2015b) over malleable cognitive categories (McGrath, 2015a); they are in a strong position to share and debate ideas in the low evaluation apprehension environment afforded by dyad combination (McGrath, 2015c).

Study 3 fills a precise, but crucial niche. van der Lugt (2005) compared brainsketching and brainstorming to examine sketching during ideation in
design meetings. Brainsketching is the same process as brainwriting, except that participants make sketches instead of written notes. van der Lugt’s study omitted brainwriting. Study 3 focuses upon brainwriting.

van der Lugt (2005) made a typology of benefits sketching brings to ideation which may be summarised as: idea re-interpretation for individuals, idea re-interpretation for groups and external memory storage. Using the linkography method (Goldschmidt, 1996), van der Lugt (2005) found that sketching benefits individuals’ re-interpretation of ideas, and external memory storage – but not group re-interpretation of ideas. Contrary to brainsketching, Study 3 has found that sketchy low PF brainwriting benefits group re-interpretation of ideas. Orderly high PF brainwriting does not have the same effect.

Finally, ideation research is a field that has long struggled with metrics. It is arguably the ease with ideas can be counted that has contributed to the popularity of ideation research within creativity, yet this metric neglects elaborative processes. Study 3 makes a modest contribution to ideation metrics, which will be detailed below.

The group context of Study 3 resulted in an extremely rigorous test of visually-supported elaborative dialogue. Study 3 participants experienced their partner’s ideas spontaneously appearing on-screen. In face-to-face interactive dyads, Munkes & Diehl (2003) have found that this type of scenario led participants into interpersonal competition to add ideas. Although the majority of contemporary ideation researchers have moved past fluency as a performance metric, lay people implicitly compete to create as many ideas as they can - particularly when their partner provides a benchmark.

This is not new research. Paulus & Dzindolet (1993) and Ziegler, Diehl & Zijlstra (2000) illustrate that competition drives individuals and groups to generate more ideas. What is new is this realisation - the traditional ideation metric of fluency, which dominated research from its beginnings in the 1950s into the new century, actually undermines elaborative dialogue. Adding detail to an idea is a tacit quality endorsement. Critiquing an idea validates it by paying it attention – in fact, critique is a challenge to realise the potential one sees in an idea. To ignore an idea is to condemn it. Fluency reflects the amount of others’ ideas which go ignored.

Concurrently, Study 3 and others (Hausmann, 2006; Kohn, Paulus & Choi, 2011) show elaborative dialogue to benefit idea and solution quality. Recent research on dyads’ dialogue supports this (Howes, Healey, Panzara-
sa & Hills, 2015). This research casts doubt on the reductive statement that “The idea generation process is basically a cognitive one” (Paulus, 2015, p. 45) by showing the impact of dialogue on problem space exploration. Indeed, the original brainstorming guidelines appear to place individuals at diametrical opposition with themselves by simultaneously imploring them to generate as many ideas as they can and build upon the ideas of others (Osborn, 1953). Fluency remains a convenience metric; and fluency results should be examined within the context of accompanying metrics such as idea quality, quality of the best idea (Girotra, Terwiesch & Ulrich, 2010), good idea count (Briggs & Reinig, 2010), flexibility and within category fluency (WCF) (Nijstad et al., 2010).

This section on Study 3 makes bold claims about PF. In order to assess the generalisability of the Study 3 finding that a low PF visual anchor leads to increased originality, a post-hoc statistical power test was conducted.

The power test used to confirm the findings of Study 3 was the power test for ANOVA, conducted in the statistical software environment R (version 3.2.0, with pwr package version 1.1-3), with the supervision of a data scientist from Inselspital Bern. The test used the Study 3 data comparing the experimental condition of condition 2 (low PF visual anchor & easy-to-process typeface) and the control condition of condition 4 (high PF visual anchor & easy-to-process typeface). The relevant data can all be found Table 12 and Table 13 in the Study 3 section. The F value used was 5.542. In correspondence with the number of experimental conditions, the number of groups was set at 4. The sample size was set at 7 dyads – the sample size of condition 4. As condition 4 had the lowest sample size, this setting provides the most rigorous test. The sample ratios for the conditions are sufficiently balanced to rule out the influence of skewedness or kurtosis. The test used the default α setting of .05.

The power test for ANOVA returned a statistical power of 1 for the Study 3 finding that a low PF visual anchor leads to increased originality. Thus the probability of a Type I (false positive) error is less than .001. The probability of a Type II (false negative) error is less than .001. This result indicates that the museum effect found in Study 3 is applicable to the population sampled – that is male and female middle or upper managers from central Europe with at least 10 years of professional experience. The museum effect can be cited with as much confidence as one can garner from the so-called “queen of sciences” (Guba & Lincoln, 1994, p. 105).
7.1.4 Synthesis of Study 1, Study 2 and Study 3 Findings

As a set, these three studies reveal how best to employ task dyads within an ideation situation. Considering the inherent ideation advantages of dyads over individuals such as higher persistence (Torrance, 1970) and more sophisticated visual thinking (Schwartz, 1995), optimised leverage of dyadic ideation offers practitioners a readily-adopted means to ‘outcreate’ their competitors.

Dyads respond strongly to visual support. For task dyads comprised of central European managers, the most fruitful visual support mechanisms are those using low PF visual anchors in combination with an easily-processed typeface on a blank background (McGrath, 2015a; McGrath, 2015b). Following dyadic ideation with appropriate visual support, dyad combination will reduce evaluation apprehension during further iterations (McGrath, 2015c).

The visual measures described will lead dyads to produce highly original (McGrath, 2015b), highly feasible (McGrath, 2015a) ideas to bring into dyad combination. The implicitly confrontational yet low evaluation apprehension environment that dyad combination fosters enables intrepid exploration of the ideas dyads bring in. The following section will more closely examine the theoretical ramifications of Study 1, Study 2 and Study 3.

7.2 Theoretical Implications

7.2.1 Study 1

Study 1 furthered the theory of social impact (Latané, 1981). Study 1 achieved this by integrating the concept of planes of social impact (McGrath, 2015c).

Prior to the publication of Study 1, the theory of social impact was a widely used, yet limited social psychology theory to account for the influence of others on individuals’ social behavior. Latané had usefully described how groups multiplied and diffused social forces, such as judgements, but his model only accounted for the primary impact in groups’ dynamics.

The most famous usage of the theory of social impact is in criminology. Darley & Latané (1968) first began developing the theory of social impact to explain the phenomenon of bystander effect. When many individuals witness a crime, they are less likely to intervene or report it. The theory of social impact (Latané, 1981) reasons that the responsibility to report is so
widely diffused between individuals that no one carries enough responsibility to prompt action. The theory of social impact thus accounts well for the main surface effect of non-reporting in which Latané was interested; however much sub-surface detail is missed. For example, what if one of the witnesses is a respected community leader? Will others attribute their responsibility to intervene or report to him or her? Or will they feel increased responsibility to intervene or report because they are being monitored by a leader?

These latter considerations occur on a lower plane of social impact that is completely separate from the primary plane of social impact. Without accounting for these influences, the pre-existing theory of social impact (Latané, 1981) has less richness and explanatory power. Within an organisational context exactly this richness is what helps us gain insights into complex social processes. The theory of social impact (Latané, 1981) thus becomes far more useful for organisational behaviour researchers with the addition of multiple planes of social impact (McGrath, 2015c).

A key strength of the original theory of social impact is the highly visual nature in which Latané presents it (Latané, 1981). The diagrams of Latané (1981) make the key factors of social force source strength, multiplication and diffusion of social impact extremely clear. This is extended by the isometric model used to depict multiple planes of social impact (McGrath, 2015c). Below Figure 18 gives an example of the isometric view of the primary and secondary planes of evaluative social impact during dyad combination. The original theory of social impact (Latané, 1981) would not have explained or reported impact from a dyadic partner’s expectation that an individual disclose their previous idea to others in full detail.
Besides extending the explanatory power of the theory of social impact (Latané, 1981). Study 1 introduced the DPCM (Nijstad et al., 2010) into this set of studies. Study 1 made the observation that dyadic ideation seemed to benefit both ideational persistence and flexibility. Study 2 and Study 3 respectively examined these issues in detail and aided in DPCM theorising.

### 7.2.2 Study 2

Sociomateriality (Carlile, Nicolini, Langley & Tsoukos, 2013) is the context for Study 2, however the DPCM (Nijstad et al., 2010) forms the predominant theoretical underpinning of Study 2. Relative to the flexibility pathway, studies on the persistence pathway are extremely rare. There are two reasons for the relative rarity of studies on persistence. Firstly, the persistence measurement was first introduced in 2010 (Nijstad et al., 2010). Ideation researchers have been measuring flexibility since the middle of last century. Secondly, cognitive flexibility is implicit in the dominant, and more captivating, idea that creative ideas arise from access to a highly diverse range of vivid thoughts. This is not wrong according to the DPCM (Nijstad et al., 2010) – but there are two complementary cognitive mechanisms at work.
Cognitive persistence as a means to creative ideas simply does not fit with the implicitly attractive flexibility paradigm. Persistence seems pedestrian in comparison. The attractiveness of this paradigm is not helped by the fact that Roskes, De Dreu & Nijstad (2012) find persistence pathway use related to the pessimistic motivation to avoid negative outcomes, rather than achieve positive outcomes. Moreover the persistence pathway is cognitively taxing (Roskes, De Dreu & Nijstad, 2012). The persistence pathway is not the glamorous “royal road” (Freud, 1955, p. 604) to creative ideation.

For this simple reason, the empirical contributions of Study 2 aid theorising on the persistence pathway by simply contributing to the germinal body of persistence pathway work. Moreover, this is the first known study to integrate the natural partners of situational Need for Cognitive Closure (NFCC) (Kruglanski & Webster, 1996) and the persistence pathway (Nijstad et al., 2010).

Study 2 raises two issues highly relevant to affordance theory (Gibson, 1977). The first of these is PF, which Study 3 examines in detail. The second is the idea of affordances emerging from visualisations. Affordance theory focuses upon interactional invitations, or affordances, which objects or visualisations present to individuals. For example, Bowers & Martin (1999) describe a vehicle availability map in an ambulance station that affords viewers to examine information from more than one perspective. This affordance was present before individuals began interacting with the vehicle availability map. Likewise, the pre-printed mindmap used in Study 2 contains a static, existing affordance for individuals to generate 24 ideas (see Figure 12). Study 2 refers to this conventional notion of affordances as “externally-supplied affordances” (McGrath, 2015a, p. 13); Cook & Brown (1999, p. 389) call them “static”. In contrast, emergent, or dynamic, affordances are those that individuals generate while they are interacting with a visualisation. Whilst writing about objectual knowledge practices, Cook & Brown (1999) consider this issue and label such emergent affordances “dynamic affordances” (Cook & Brown, 1999, p. 390). Despite the popularity of Gibson’s affordance theory in visualisation research, visualisation researchers are yet to adopt the processual approach of “dynamic affordances” (Cook & Brown, 1999, p. 390). For example, mindmaps are one of the most commonly used - and researched – visualisations. They are manifest with “dynamic affordances” (Cook & Brown, 1999, p. 390) – yet this has not been researched despite digital technologies making this entirely possible.

The flux and idiosyncrasies of dynamic affordances make them very difficult to study, and Study 2 does not attempt to conclusively study emer-
gent affordances in depth. Instead, Study 2 discusses emergent, dynamic affordances and raises them as a worthy area for future research efforts in visualisation.

7.2.3 Study 3

The tight focus and robust conditions of Study 3 allowed it to contribute much to visual and DPCM theorising. These implications will be detailed below.

Study 3 examines PF in detail, and thus directly contributes to the collaborative dimensions framework under development by Bresciani & Eppler (2013). By clarifying the role of PF, Study 3 allows some conclusions on sketching and the manner by which elaboration begins to be drawn. In addition to this, as in Study 2 the theoretical basis is the DPCM (Nijstad et al. 2010), however Study 3 focuses upon the second of the two proposed pathways to creative ideas – the flexibility pathway.

In regard to PF within the collaborative dimensions framework (Bresciani & Eppler, 2013), the culminating study in this set is of great value. Study 3 provides empirical evidence that low PF results in individuals’ increased propensity to change visual representations; whilst high PF results in decreased propensity to change visual representations.

Prior to Study 3, PF was often entangled with the visual property of modifiability (Bresciani & Eppler, 2013). High or low modifiability relates to the question or whether or not “the items of the visualisation [can] be modified in response to the dynamics of the discussion”. In other words, regardless of how open an item appears to change (PF), can it be changed? As raised in the original Bresciani, Blackwell & Eppler paper (2008), PF and modifiability are often inter-linked. By experimenting with equally unmodifiable low and high PF visual anchors, Study 3 was able to decouple PF and modifiability. Thus Study 3 not only verifies the effects of high and low PF, but provides the concept of PF with discriminant validity from modifiability. This represents progress for the collaborative dimensions framework.

In looking at PF, Study 3 essentially examined line type. The natural lines (Bradley, 2013) that characterise low PF visual anchor points are reminiscent of sketches. Previous work by Ewenstein & Whyte (2007), Henderson (1991), Suchman (1988), Tversky (2005) and Whyte, Ewenstein, Hales & Tidd (2007) illuminate various types of sketches as being both participatory - and perceptibly available for change. Using a sketchy low PF style,
even highly thought-out engineering plans can convey low PF (Henderson, 1991), and be improved upon. As Tversky writes “Graphics created to be ambiguous… allow reinterpretation and discovery” (Tversky, 2005, p. 230). It seems that low PF natural lines are partially to thank for the utility of sketches in design work (Scrivener & Clark, 1994).

Martin & Schwartz (2014) offer a means by which to make sense of the PF role in creativity. These authors review the literature on creativity and visualisation, and create a taxonomy of the creativity benefits of visualisation. The four categories Martin & Schwartz (2014) offer are: reinterpretation, flexible abstraction, combination and borrowing structure. By inviting elaboration (McGrath, 2015b), low PF visual anchors encourage combination of perspectives or ideas (Martin & Schwartz, 2014). Study 3 opens up possibilities to research the comparative weight of PF effects within and beyond individual and collaborative sketching.

Continuing the same line of reasoning which gave birth to the high PF term museum effect, I dub the low PF permission to modify an epistemic object the “workshop effect”. This term emphasises the ‘hands-on’ nature that low PF has. The workshop effect is evocative of an artist’s studio, within which works are in a constant state of flux towards ‘perfection’ as conveyed by Rembrandt’s 1628 masterpiece “Le Peintre dans son Atelier”. Low PF visual representations can be approached and manipulated. They can be cognitively ‘handled’ and passed onto others. Leonardo da Vinci was using the workshop effect 500 years ago, now his work hangs in museums.

Study 3 brings the ideation literature into direct contact with the design literature. Study 3 benefits both the theoretical design and ideation literature streams. The focus of Study 3 is an exploration of a visual design element within the context of visually-supported ideation. Study 3 extracts and minutely examines a stylistic aspect of design sketches – namely low PF - in this new ideation context of ever-expanding divergent thought (Runco, 2011) within a consistently open problem space (Briggs & Reinig, 2010). Sketching theory will be examined in detail below.

Coherent theories that bring the wealth of observations on design sketching together are few and far between, however Fish & Scrivener offer the spatial-hybrid theory of sketching (1990). According to the spatial-hybrid theory of sketching “sketches are incomplete visual structures that amplify the inventive and problem-solving uses of mental imagery” via three primary mechanisms (Fish & Scrivener, 1990, p. 124). These are: pentimenti (Multiple alternative contour lines, see Figure 19 below) which can be exchanged
in and out of malleable mental images to allow dexterous mental model manipulation; polysemous markings act as stimuli to prompt imagery streams; and sketches enablement of mental transition between abstract (e.g. symbols) and concrete (e.g. illustrations) modes of visual representation (Fish & Scrivener, 1990). These mechanisms combine to facilitate the primary benefit of an individual “thinking with a pencil” (Do & Gross, 1996, p. 1); which Tversky & Suwa (2009) identify as reconfiguration. Suwa, Gero & Purcell have identified the reconfiguration of reinterpreted “unintended discoveries” (Tversky, 2005, p. 231) as the source of most new ideas that arise from sketching (Suwa, Gero & Purcell, 2000).

**Figure 19: Redrawing of Pentimenti, Restructuring and Refining in Physical Design**

The reconfigurative mechanisms described above apply to lone sketching. The three defining attributes of sketches – “hurried or untidy lines”, ethereal patches of watercolour and choppy cross hatching (Fish & Scrivener, 1990, p. 117) – enable a uniquely productive interplay of perception and cognition within individuals. These three qualities of sketching activate the three mechanisms listed above (Fish & Scrivener, 1990). However, it is not only lone individuals who benefit from sketching, group collaboration such as group ideation also benefits from sketching (Tversky & Suwa, 2009; Pfister & Eppler, 2012).

Some of the benefits sketching brings to ideating groups are equally applicable to visualisations in general. For example, acting as a working memory support or helping to make implicit knowledge explicit. Others, such as enhanced idea co-construction (van der Lugt, 2005) are not universally found in visualisations. The present set of studies suggest that the first item Fish & Scrivener (1990) use to characterise sketches – “hurried or untidy lines” contains the quality that enables the three mechanisms by which sket-
ching opens divergent possibilities, elicits imagery streams and facilitates mental transition. In turn, these mechanisms capacitate the co-construction of ideas via mental ‘redrawing’, restructuring and refinement (Do & Gross, 1996). The key quality of “hurried or untidy lines” is low PF. Those items that are perceived as unfinished are the most malleable items for reconfiguration. Low PF is at the heart of sketching’s modus operandi.

Do & Gross (1996) highlight the major role that perception plays in creative processes. In particular, Do & Gross (1996) highlight the inescapable role of perception when using an “object to think with” (Do & Gross, 1996, p. 3). The workshop effect initiates physical and mental redrawing. Physical redrawing, or pentimenti creation, can be seen above in Figure 19. Mental redrawing is elaboration within a problem space. In both physical design and ideation, it is the implicitly low PF, natural line-based character that sketches have that invokes the workshop effect. The first input that the workshop effect elicits is the first piece of physical or mental redrawing. This in turn leads to restructuring and subsequent refining. Without the workshop effect, the reconfiguration process described above would not begin.

This set of studies illuminates the role of visual finishedness perceptions in groups, and the concrete benefit low PF brings to ideating groups. By doing so, this study contributes to the spatial-hybrid theory of sketching by closely examining the social effect of the integral sketching element of low PF lines. In a group, the signal that one may mentally manipulate and add to an idea arises from the low PF lines intrinsic to sketching. Our attention will now turn to the interruption of extended search in semantic memory via elaborative comments, and the unexpected benefits this can bring.

Study 3 makes a significant contribution to theory on search in semantic memory, in particular theorising on the flexibility pathway to creative ideas (Nijstad et al., 2010). The original DPCM paper (Nijstad et al., 2010) logically proposes that accessing the flexibility pathway is best achieved via a long shallow search in semantic memory that skips across categories of thought. Other studies back this long shallow search approach to achieving flexible thinking (Gasper & Middlewood, 2014; Rietzschel, Nijstad, & Stroebbe, 2014). However, Study 3 finds evidence for an unconsidered alternative point of access to the flexibility pathway. Instead of a long search over many semantic categories, many short searches in semantic memory can also access a highly diverse number of thought categories (McGrath, 2015b). That this short search mechanism accesses the flexibility pathway is a safe assumption (Nijstad, 2015).
Study 3 uses improvised enrichment (Hewing, 2013) within a dyad to generate multiple short searches. After partners’ comment discontinue the existing search, every new search starts in a slightly different position to the last – due to the input of a fresh, unexpected perspective. Previous schema theorising (Anderson, 1983) and empirical evidence (King & Anderson, 1976) show that searches in semantic start with great strength and gradually dissipate - without new input, lone searches in semantic memory stagnated. Multiple short searches have the potential to be of significant value to idea- tion researchers.

A less powerful and surprising theoretical contribution is the role that information processing difficulty plays in category searches. In congruence with the existing literature on processing difficulty activating analytic thinking (Alter, Oppenheimer, Eppley, & Eyre, 2007), Study 3 found that information processing difficulty hinders flight across cognitive categories during search in semantic memory. Flexibility is reduced. Being that persistence is the flip-side of flexibility (Nijstad et al., 2010), this finding may prove useful to future researchers aiming to optimise persistence pathway access.

7.2.4 Synthesis of Theoretical Implications of Study 1, Study 2 and Study 3

Latané’s theory of social impact (1981) is a cornerstone of social psychological theory. It is cited in a diverse range of areas – from evolutionary psychology (Buss, 1995) to military psychology (2009). The Study 1 extension of this theory via the addition of multiple planes of social impact adds great detail to the explanatory power of this highly-cited theory.

Stepping slightly back from social psychology, Study 2 and Study 3 make useful contributions to the DPCM (Nijstad et al., 2010). Study 2 sheds light upon an under-explored area – the persistence pathway (Nijstad et al., 2010). Besides this, Study 2 raises dynamic affordances (Cook & Brown, 1999) as a visualisation blindspot.

The major contribution of Study 3 to the DPCM is the addition of a fresh perspective to the body of literature on the flexibility pathway (Nijstad et al., 2010). This is done by showing the value of multiple short searches in semantic memory. Prior to this the assumption had always been that rewarding searches in semantic memory were both continuous and tortuous. Study 3 shows that a number of direct, interrupted searches access the flexibility pathway to originality.
The now-demonstrated value of short searches is a step forward for the DPCM, however the major contribution of Study 3 is to the development of the collaborative dimensions framework, which has its origins in Bresciani, Blackwell & Eppler (2008). The PF museum effect and workshop effect now have empirical evidence with discriminant validity from the related concept of modifiability (Bresciani & Eppler, 2013). Moreover, future sketching theorists can now incorporate PF as part of the sketching value proposition.

7.3 Limitations

This set of studies informatively helps to build theory, but it is not without limitations. The enunciation of limitations is inherently reflective, and the following section contains some reflective elements. A more detailed section completely dedicated to reflection upon my role in this set of studies follows the Outlook and Future Research section.

While mixed methods research offers researchers a number of benefits, it also has the potential to raise some problems. Study 2 and Study 3 set out to collect post-experiment focus group data, exactly as Study 1 before them had done. However, participants in the Study 2 and Study 3 focus groups simply could not offer candid commentary on their experience without researchers explicitly leading them to the topic under consideration. In contrast to the valuable insights gained from Study 1 focus groups, the Study 2 and Study 3 focus groups produced no meaningful data. As a researcher, I must then ask myself why this was the case. My initial thought was that PF (Bresciani & Eppler, 2013), NFCC (Kruglanski & Webster, 1996), affordances (Gibson, 1977) and information processing fluency (Alter, Oppenheimer, Eppley & Eyre, 2007) are too abstract for participants to grasp. However, the psychological aspects of NFCC (Study 2) and information processing fluency (Study 3) are arguably less abstract than evaluation apprehension. I then considered the possibility that participants were embarrassed to openly speak about these topics. However, evaluation apprehension is a subject associated with far more bashfulness than any of the other topics. Indeed, prior to Study 1 I was concerned that participants would not openly share on the subject of evaluation apprehension. Upon reflection I noted that the primary difference between the rewarding Study 1 focus group on evaluation apprehension and the low value Study 2 & Study 3 focus groups was methodological. In Study 1, after the experiment and prior to the focus group, all participants completed a survey on evaluation apprehension. Study 2 & Study 3 did not employ surveys relevant to the focus group discussion. It seems that the survey served to prime participants to broach the typically ta-
boo topic of evaluation apprehension. Moreover, it appears that the discrete scale items dissected evaluation apprehension and gave participants a shared mental model with which to discuss evaluation apprehension. Perception processing aspects remain difficult for participants to articulate (see Figure 3 below), yet NFCC is a feeling at least as perceptible and easy-to-articulate as evaluation apprehension. Researchers using interviews have since told me that they have had similar experiences, and regard surveys as extremely good openers to interviews (O'Reilly, 2015a).

This course of studies has demonstrated that the limits of our perception, and articulation, need not limit research. Behaviour can be examined. However, mixed methods data offer such rich and compelling insights that they are worth pursuing and integrating as closely as possible. Study 1 bears witness to this. In future I will introduce focus group discussions via a short survey. Each of the three studies in this set, also contained their own unique limitations which will be detailed below.

Study 1 relied upon self-reported measures, as the means to physiologically or behaviourally test for evaluation apprehension levels were unavailable. The sample cache of ideas for coding was also low. These limitations can both be corrected for given ample time and other resources.

Study 2 served well as a pilot to Study 3, and for this reason the strengths of Study 3 are the limitations of its predecessor. Study 2 simply contains too many extraneous factors to reliably measure the delicate measure of within category fluency (WFC) (Nijstad et al., 2010). The most serious of these are participant identity effects, backchannel communication (Duncan, 1975) and the heterogeneity of markings produced in a pen & pencil environment. Moving from face-to-face to computer-mediated communication in Study 3 eliminated these potential confounds in a single blow. Beyond this, the reporting style of Study 2 is not clear. I became bound up in the intricacies of socio-material interaction and associated jargon - to the detriment of clarity.

In hindsight, Study 3 has an important omission. Flexibility was not coded. The research focus was upon the link between PF and elaboration. This required timely and intensive coding; as did idea quality. Flexibility was simply overlooked during the coding process. When the results affirmed higher originality in connection with higher incidence of elaboration, the flexibility pathway was the obvious candidate. The exploration of a higher number of idea categories is connected with the flexibility pathway (Nijstad et al., 2010). It is a safe assumption that heightened elaboration raised flexibility which in
turn drove up originality (Nijstad, 2015), however it remains an assumption. The coding of flexibility is relatively straightforward, so this oversight can easily be remedied. Since fluency has already been recorded for Study 3, coding for flexibility will also allow the calculation of within-category fluency (WCF) – the metric for the persistence pathway (Nijstad et al., 2010).

Beyond these specific limitations, all of these studies are limited by the inherent limits created by laboratory experiments. For example, participants were out-of-context and non-probability sampling procedures were relied upon.

7.4 Managerial Implications

This set of studies fits together elegantly, and offers an organisation level solution to the numerous knowledge-intensive organisations struggling to foster collaboration (IBM, 2010). These organisations would benefit from cultivating the workshop effect by making low PF tools available for dyad-based knowledge work (Study 1). Such tools range from simple pencil and blank paper (Study 2) to low PF digital tools (Study 3). For exploratory, generative work such as making mind maps (Buzan, 1996) or concept fans (De Bono, 1993), employees would ideally receive basic training and documentation to enable them to develop emergent visualisations with an underlying logic.

Wise communicators will able to differentiate between when they elect to leverage the museum effect or the workshop effect. Communications professionals can put both the workshop and the museum effect to good use - depending upon their objectives communicators can select whether to invoke the workshop or the museum effect. The workshop effect in particular shows great promise not only within group settings such as those discussed here; but also for application in marketing communications materials. For example, virtually any communications that seek co-creation (Vargo & Lusch, 2008) with a market would benefit from invoking the workshop effect. This could be particularly valuable in a b2b context, where individual customers are often treated as valued stakeholders. Within this context, the central European middle and upper level managers experimented upon represent an attractive segment. On a broader scale, mass-customisation initiatives targeting this segment would be wise to employ the workshop effect at the early customer design stage, and the museum effect further into the sales process.

The clear results of Study 3 require little interpretation for project managers involved with creativity support system (CSS) development. These
systems would benefit from designers adding low PF visual anchors (McG-rath, 2015b) and natural lines (Bradley, 2013). The most applicable area for these visual elements is ideation phases in which elaborative dialogue (Hausmann, 2006; Hogan, Nastasi & Pressley, 1999) is called for.

The following section outlines directions for future research. The limitations previously recognised in this set of studies help to inform the research proposed below.

7.5 Outlook & Future Research

Creativity, including the crucial phase of idea generation (Mumford et al, 2012), has recently been identified as a priority area of exploration for virtual team researchers (Gilson, Maynard, Young, Vartiainen & Hakonen, 2015). The limitations identified above can feed into future research. The current set of studies thus opens numerous future directions for research using a range of methodologies, and blends thereof. The future outlook for research on ideation, elaboration and visualisation offers a range of possibilities. Before looking into more method-specific future research directions, this section will discuss a number of potential research areas identified during the course of these studies.

First of all, it should be remembered that this set of studies has only found the workshop and museum effects within a certain segment of the population. That is, male and female middle or upper managers from central Europe with at least 10 years of professional experience. This is a very particular sample (Hofstede, Hofstede & Minkov, 2010). One should not take figures of speech too literally, but this is a culture in which being “Gradlinige” or “straight-lined/no-nonsense” is a highly regarded quality (Da Zübi, 2015). Further research needs to establish the presence of the workshop effect in members of different cultures and professional worlds.

The current set of studies embeds itself within the idea generation research that developed in the wake of brainstorming (Osborn, 1953; Taylor, Berry & Block, 1958). This literature stream focuses upon idea generation as solution generation – a problem is given as a task, and solutions for it are generated. A typical, oft-repeated task in this research tradition is the tourist problem – ‘How can tourists be attracted to our area?’ (Cohen, Whitmyre & Funk, 1960; Lamm & Trommsdorf, 1973; Paulus & Dzindolet, 1993; Ruback, Dabbs & Hopper, 1984). Contemporary models of the creativity, or problem solving process within which idea generation forms a distinct stage, con-
istsently feature problem definition (Mumford, Medeiros & Partlow, 2012), problem identification (Amabile, 1996) or understanding (Eppler, Hoffman & Pfister, 2014) as a critical first stage. Roland (1985) has developed a practical technique for generating problem definition ideas, which is modelled on brainstorming (Osborn, 1953). Roland calls the technique questorming (1985). To build upon and optimise questorming and similar methods, a fundamental question needs to be answered: is ideation for problem solutions exactly the same as ideation for problem definitions? The current ideation research assumes so, but no study directly answers this question.

Moving beyond problem definition (Mumford, Medeiros & Partlow, 2012), Study 1 showed that combined dyads carry ideation advantages into later creativity phases. Dew & Hearn’s initial study (2009) on combined dyads covered the entire spectrum of problem solving. Study 1 focused exclusively upon idea generation (Mumford, Medeiros & Partlow, 2012). Other problem solving phases, such as selecting performance criteria (Bardach, 2011) or idea evaluation (Mumford, Medeiros & Partlow, 2012) may also be significantly affected by dyad combination. Further research needs to discover whether dyad combination is a source of process gains or losses during other problem solving phases.

Having established the ideation value of dyad combination in Study 1, Study 2 & 3 concentrated upon visual levers within dyads. Schwartz (1995) had previously shown a natural proclivity for visualisation in dyads, and I decided to leverage this. Study 3 determined that low PF visual anchors impact elaboration and originality in dyadic brainwriting. Following the work of Do & Gross (1996) on physical designers’ sketches as conversational partners, an interesting question for future research is whether or not low PF brainwriting has an impact on individuals’ re-interpretation of their own ideas during ideation.

As mentioned above, more research is required to examine the link between low PF natural lines and sketching. For example, how much does the workshop effect contribute to the value of sketching? What is the relative weight of the workshop effect in regard to sketching benefits such as the integration of viewpoints and experiences (Pfister & Eppler, 2012)? Does the workshop effect contribute to the memorability of sketching (Pfister & Eppler, 2012)? Future research in this area should take care to note that ideation research is carried out with non-insight problems (Runco, 2011); and not blend insight-related issues (Suwa, Gero & Purcell, 1998).
Since its discovery, PF has remained a two-dimensional visual aspect. It need not be. Amateur makers and professional design thinkers work with a range of three-dimensional prototypes in a myriad of materials. At a certain point, these three-dimensional prototypes are considered to be finished. Aside from time pressure, when does a design thinker consider a funky prototype complete and ready to transition into the functional prototype phase (Vetterli, Uebernickel & Brenner, 2012)? In other words, when is the optimal moment for divergent thinking to end, and convergent thinking to begin?

The preceding section has simply elucidated issues to serve as a base for future researchers. Below, more detailed avenues for future research are grouped by primary research method. The reader should note that the present set of studies has convinced me that mixed methods studies make high levels of insight more accessible to researchers and their audiences alike. Method integration at the level of analysis is preferable to triangulation (Tashakkori & Teddie, 2008), however mixed method triangulation can also be useful (Bergman, 2008). Thus, the future research possibilities below are all intended to use mixed methods, and are grouped by the primary method upon which researchers would triangulate another method.

For better or worse, the ideation research stream is steeped in the tradition of laboratory conditions experiments. Study 3 introduces stop/start searches in semantic memory as an interesting area of examination, which is suited to a controlled conditions experiment on individuals. The findings could be supplemented by neuroscience (Yoruk & Runco, 2014) and video elicitation-based interviews (Kennelly, 2015; Suwa & Tversky, 1997). Participants could narrate video of their own ideation. Such video elicitation is not technically difficult, however simultaneous interviewing in a laboratory situation poses a logistical problem. Many interviewers, with their own space, would be required simultaneously. The value of this procedure would lie in the complementary mixing of qualitative and quantitative methods at the level of analysis, instead of mere triangulation of results (Bryman, 2008).

An interesting ideation phenomena to study closely under laboratory conditions is that of the ‘flip flop’ (Pfister & Eppler, 2012). Participant observation has already established that this technique effectively promotes fresh ideation. It is unclear if this a result of category or association priming (Hills, Todd & Jones, 2015), the escape from a pattern of sequential response production processes (Fu, Hills & Todd, 2015) or a combination of any other cognitive mechanisms. This and many other cognitive search curiosities could be examined using laboratory conditions and schema theory approaches.
(Wyer, 1980; Anderson, 1983). For example, beyond intrinsic motivation (Amabile, 1997) – what produces a stronger initial search impulse in semantic memory? An abstract visual cue or a concrete visual cue?

The “dynamic affordances” (Cook & Brown, 1999, p. 390) within visualisations considered during Study 2 are a micro-level, processual phenomenon highly suited to research using laboratory experiments. The same technical procedures as used in Study 3 could be used to record screenshot video capturing the development of dynamic affordances. Screenshot video could be coded using re-play analysis (Alexander, Bresciani & Eppler, 2014). Patterns within dynamic affordances could then be used to build a typology of dynamic affordances in visualisation.

Dynamic affordances are likely to play a role in group sketching as well as other group visualisation activities. As mentioned, Study 3 has aided theorising on sketching. Further research is needed to examine PF within sketching, and experimental methods lend themselves to this. Previous experiments such as those on reconfiguration (Suwa, Tversky, Gero & Purcell, 2001) and rotation (Shepard & Metzler, 1971) have used natural lines. The repetition of these experimental procedures with groups using low PF natural line representations and high PF artificial lines (Bradley, 2013; Bresciani & Eppler, 2013) would allow triangulation against comparable results and potentially provide interesting insights.

Study 3 finds that multiple short searches in semantic memory access the flexibility pathway to creative ideas (Nijstad et al., 2010). Study 3 used improvised enrichment (Hewing, 2013) in dyads to generate many short searches. Future laboratory experiments using an alternative means to generate a high number of short searches in semantic memory would lend more weight to the short search findings of Study 3.

Not all new studies require new data sets. To return to the earlier point that the idea generation sub-process of elaboration appears inseparable from implicit idea evaluation (Puccio & Cabra, 2012), Study 3 has already collected data that could contribute to the investigation of this issue. Study 3 coded every single idea, and every single elaboration upon it on the three quality bases of originality, feasibility and instrumentality. Did participants tend to elaborate upon highly feasible ideas? Previous research would suggest this to be the case (Paulus, 2015). Alternatively, is instrumentality a stronger draw for participants’ involvement via elaboration? The existing data from Study 3 may shed some light upon such questions. Sadly missing from the current data are the participant voices on their judgement of ideas.
and their motivation to elaborate, or not, upon them. Again, video elicitation (Kennelly, 2015; Suwa & Tversky, 1997) on newly collected data would remedy this.

Using the data from Study 3, reciprocity in elaborative dialogue could be investigated. Drawing on a large body of previous studies, Grove (1991) states that reciprocity is a well-known key characteristic of dyads. Dyadic reciprocity, coupled with improvised enrichment (Hewing, 2013) were the driving thoughts behind my expectation that low PF visual anchors would lead to long chains of elaborative dialogue. I may, however, have misplaced my expectation in a continuous exchange over a single initial idea. Within a “joint problem space” (Roschelle & Teasley, 1995, p. 69), participants have the opportunity to reciprocate elaboration upon their initial ideas by elaborating upon any idea that their partner initially offers. In this way elaborative dialog may prove to play a less functional, more relational role than what I had expected. The data from Study 3 can easily be re-examined to detect any pattern of reciprocal elaboration initiation.

Interviews can be a highly efficient manner by which to collect data that is relatively easily triangulated with other sources. The course of this research allowed me to make contact with a number of creativity facilitators and knowledge management specialists. Many of these expressed enthusiasm for walking meetings to generate ideas. Indeed, research indicates that simply oxygenating the brain via exercise can improve creative performance (Blanchette, Ramocki, O’del, & Casey, 2005). However, actual use of walking meetings for ideation appears to be far lower than their awareness level. Exploratory interviews on the topic of barriers to walking meetings and other ideation techniques could prove useful; and be a valuable lead into an informed participant observation study on barriers to ideation techniques.

The body of knowledge workers mentioned above are ‘typical’ office workers. They are co-located with their colleagues, and in the employ of knowledge-intensive organisations. In order to explore the visual impact on human-computer interaction (HCI) in “digital ba” (McGrath, 2015b, p. 1), researchers could compare and contrast interviews with ‘typical’ office workers and knowledge workers with a high level of dependence upon digital ba. For example, researchers aboard the International Space Station.

As noted above, integrative mixed methods analysis (Tashakkori & Teddie, 2008) is a robust approach which would well serve a number of fields. One area in particular that could benefit from this research is that of minority perspectives. Prior research shows that group members may be
reluctant to share ideas which differ from the majority group perspective (Nemeth & Nemeth-Brown, 2003). Other research shows exactly how beneficial functionally-diverse viewpoints (Hulsheger, Anderson & Salgado, 2009), conflict (Nemeth & Ormiston, 2007; Nemeth, Personnaz, Personnaz & Goncalo, 2004), idea-focused negative evaluations (Troyer & Younigreen, 2009) and minority viewpoints (De Dreu & West, 2001; Nemeth, 1986) are to ideation processes. It would be fascinating to investigate the incremental emergence of minority viewpoints. For example – does initial constructive critique of a majority perspective idea (Hewing, 2013) facilitate the full expression of a minority perspective? Does the visual notation of critical elaborative dialogue support this? Video elicitation of participants’ own behavior in combination with quantitative analysis thereof has the potential to offer interesting insights into the emergent voicing of minority perspectives.

“Presence disparity” (Tang, Boyle & Greenberg, 2005, p. 194) is another interesting area within which to use the same video elicitation methodology to research computer-mediated communication for ideation. Presence disparity is a phenomena of mixed presence groupware – the digital linkage of a remote group member or members with a physically co-present group. The introduction of a third visual interaction surface, which is equally present for both physically and virtually present group members is worthy of investigation. The long-term effects of presence disparity and mechanisms by which to overcome it would lend themselves to ethnographic methods (O’Reilly, 2012).

Ethnographic participant observation exploration of document creation from inception to delivery is likely to prove insightful. Such research would be in the tradition of Henderson (1995), but each researcher would be empowered to bring his or her own knowledge into the intersubjective account. Just as Henderson (1995) did. Image and video elicitation methods would prove invaluable in such an account.

Ethnography is a methodology strongly influenced by inter-subjectivity. Reflexivity is becoming increasingly vital in this method. Reflexivity is also important during the design and implementation of a multi-year research project such as the current set of studies. For this reason, I offer some personal reflections upon my role in the research process below.
7.6 Personal Reflections

Reflexivity is a broad, proliferating term. In particular, researchers using qualitative methods are increasing expected to “do a bit of reflectivity” (Bryman, 2008, p. 99). So what do I mean by the word “reflection”?

I recently discussed reflection with an ethnographer, who gave me a comprehensive yet surprisingly pragmatic working definition of reflexivity. According to renowned ethnographic methods expert Karen O’Reilly, “Reflexivity is our own role in everything we do” (O’Reilly, 2015b). In full terms, this is a processual approach that encourages researchers to describe how their own personal lens upon the world, including the unit of analysis evolved - and how it has impacted the study at hand. The point of reflection is an attempt at a transparent view into what I bring to the intersubjective study of the phenomena at hand. Below I will reflectively disclose the development of my perspective on ideation, visualisation and research into them.

The professional background I bring to this set of studies has two major components: marketing and the teaching of English as a second language (ESL). The first of these is extremely broad (McKenna, 1990), but I have an academic interest in services marketing and work experience in matrix-based global engineering organisations. This work experience includes recent work in innovation management. From this perspective, I can appreciate the critical role fuzzy front end ideation plays in an organisation’s strategic direction. As well as the expenses and difficulties involved with intelligently assembling experts. I am intrinsically motivated to study ideation. I have also seen ideas struggling to survive the whirlwinds of organisations’ internal politics. I see the multitudes of ideas which emerge from ideation sessions and into organisations’ project planning processes as akin to embryonic fish which must survive the ravages of the ocean before themselves becoming high impact giants. This is part of the reason, dyads interest me – my implicit view is that an idea conceived by two complementary skillsets will also be championed by two complementary skillsets.

As an ESL teacher I focused upon ‘business English’. By default I thus spent a great deal of time facilitating central European managers in complex knowledge sharing situations. Modern ESL tuition focuses on task-based learning, wherein the teacher essentially furnishes students with the necessary language skills before assigning them a collaborative knowledge sharing task. In this environment I quickly learnt the critical role of group dynamics. Dyads and dyad combination became useful tools by which I could influence student interactions. I thus brought experience with dyad combination into
my research on group ideation. Once I learnt that evaluation apprehension is one of the major detractors from group ideation, I instinctively thought back to my positive experiences giving voice to timid language students via dyad-based organisation. Thus Study 1 was born. Conducting Study 1 enabled me to learn a great deal about what helps and what hinders ideation.

Besides task facilitation, ESL teaching involves the frontal teaching of abstract grammatical structures. For example, tenses such as the present and future perfect. During my time as an ESL teacher I discovered that visual timelines were the most effective way by which to teach tenses, and I developed illustrative timelines for each tense. These timelines were not merely presented, they each had an unfolding dramaturgy. They were visual storytelling, and they would capture engagement and convey knowledge without fail. From these teaching experiences I learnt to value visualisation as a powerful tool.

As a group facilitator, it is self-evident to me that visualisation is useful. Therefore, comparative research into scenarios wherein visualisation is used or not did not overly interest me. My interest lies in drilling down into the fine granularities of what makes which aspects of visualisation work. Once Study 1 had allowed me to learn what drives ideation, I began to investigate how visualisation could foster those drivers. Laboratory experiments are ideal for investigating such pinpoint research questions. Thus Study 2 and Study 3 were born.

Beyond my professional background, my personal background influences the lens through which I view the world. In my case, I am a visualisation and creativity researcher married to an advertising agency’s visual communications consultant. Needless to say, during the course of the present set of studies I monitored processes and patterns within our interactions whilst mulling over the literature and forming hypotheses. It was such considerations that led me the strength of dyads (Study 1), and the value of cognitive closure delay (Study 2). Like many life partners, my wife and I could be termed a “creative pair” (Wolf Shenk, 2014, p. 68) – at least in the ‘small c’ everyday creativity sense (Gardner, 1993). The account above traces the development of the subjective view I bring to social science.

The reader will remember my surprise at finding that low PF does not lead to long elaborative chains. This finding begins to make sense within the designing/interpreting/drawing framework of Do & Gross (1996). Do & Gross view design, note – not ideation alone – “as a cognitive activity that involves attention, perception, memory and processing through the act of drawing.”
(Do & Gross, 1996, p. 2). While the participants of Study 3 did not draw, they interacted via visuals alone, and the cognitive elements of attention, perception, memory and processing all played major roles. Processing has been dealt with in depth during Study 3 itself. Cognitive load on working memory is reduced by visualisation (Eppler & Mengis, 2004); and search processes in semantic memory is a central unifying theme of this work. These are all strengths, however this set of studies has not paid attention to the subject of attention.

The majority of this body of research has dealt with the perception of completion, or PF, within dyadic interaction. Upon reflection, attention has been a blind spot of this study. I had taken it for granted because of the short length of time the study required participants to focus, as well as the inherent advantages of dyads and visualisation for engaging and holding attention. For example, dyads have only communication channel to maintain between the two individuals (Grove, 1991) and visual representations draw and hold focus (Eppler, 2004). A key component of ideation modality is the level of competing demands upon attention created. Goldenberg, Larson & Wiley (2013) find that cumulative, list-like notation modalities, such as that used in Study 3, lower the number of ideas participants generate. These researchers reason that when previous ideas remain visually available, cognitive fixation becomes an issue. Likewise motivation to produce more ideas lowers. However, these matters were consistent across conditions in Study 3, and there were no significant differences in ideational fluency between any conditions. It was a mistake not to explicitly examine attention, however it seems that my initial assumptions on its limited impact were warranted.

These studies test hypotheses, and a reflection upon the nature of hypothesis testing is therefore called for. Whether stated or unstated, quantitative researchers carry hypotheses into their studies. In my own case, going into Study 3 I expected low PF visual anchors to not only result in increased incidence of participants initiating elaboration, but also continuing elaboration for a longer period. I foresaw lower PF visual anchors leading to significantly longer chains of elaborative dialogue (Hogan, Pressley & Nastasi, 1999) and deliberate debate (Hewing, 2013). Study 2 and the literature built this expectation within me. The coding process disproved this intuition. However, by their very nature instincts are difficult to displace – and I now need to make sense of what I still cannot help but perceive as a surprising anomaly (Weick, 1995). As this sensemaking of the results continued, an article was published in which Paulus states that “Whenever people share ideas in a group context, they can be influenced by both the content and the rate of ideation” (Paulus, 2015, p. 44). During Study 3, the sudden appearance of partner entries within the shared space were just as likely to distract or
induce competitive response as they were to stimulate new thoughts or elaborative responses.

On the topic of statistical analysis, I can transparently say that I expected the post-hoc power test to find Study 3 to be underpowered by sample size. I expected the Study 3 findings to be of use for exploratory purposes only, and was ready to advise a large scale follow-up study on Amazon Mechanical Turk. Sacrifices in sample quality and laboratory conditions would have been necessary, but PF is a subject which lends itself to online studies.

As a final set of reflexive remarks, I take a critical view of the scope of this set of studies. All research invites critical thinking and criticism. A critic of this set of studies may firstly point to the larger scale, more pressing problems of our time. Namely, our species is rapidly destroying our own habitat (Darimont, Fox, Bryan & Reimchen, 2015; Deutsch, Ferrel, Seibel, Pörtner, & Huey, 2015) and this is leading to massive conflicts between increasingly divided populations (Crank & Jacoby, 2015). This set of studies posits visually-supported dyad combination as a tool to help to find solutions to these high impact problems.

Having now presented “myself as a research technique” (O’Reilly, 2015a); I hope the reader now has retrospective insight into this set of studies.

7.7 Concluding Remarks

Bearing in mind that “The social world is incredibly complex, and all you can do is put in your little part of the jigsaw puzzle” (O’Reilly, 2015b), this set of studies concludes that low PF increases the incidence of elaboration behaviour amongst central European middle and upper level managers during dyadic ideation. An ideation task dyad with low PF visual support provides optimal preparation for dyad combination, which in turn lowers evaluation apprehension. This combination of factors benefits creativity.

From this set of studies managers can deduce that low PF is useful in collaborative and co-creation contexts. A key managerial implication is that the appropriate application of the museum or workshop effect can aid the accomplishment of communications objectives.
Beyond its practical implications, this body of research progresses theorising on groups, ideative and collaborative sketching processes. By introducing planes of social impact into the theory of social impact (Latané, 1981) this set of studies has a potentially wide effect in social psychological literature. The spatial-hybrid theory of sketching (Fish & Scrivener, 1990) and the DPCM (Nijstad et al., 2010) are far narrower fields. Therefore the discovery of the workshop and museum effects may be more keenly felt by active theorisers in this field. Time will tell how these contributors are interpreted and integrated into these theorising processes.

What this set of studies has shown is that group creativity is a socio-material interaction. When ideating together as a dyad we are influenced by low and high PF lines. Low PF lines invite modification (the workshop effect), while high PF lines repel modification (the museum effect). Dyads using low PF line-based visual supports will thus build more original ideas together than those with high PF visual supports. The pairwise creation of original ideas is the best possible preparation for exchanging ideas with another dyad. I invite the reader to bear these findings in mind when he or she turns away from this document, and begins to engage in ideation as part of his or her daily activities. These findings have the capacity to help you ‘outcreate’ the competing factors in your life.
7.8 References


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8 Curriculum Vitae

Personal Information

Name: Lawrence McGrath
Date of Birth: February 4, 1980
Place of Birth: Henderson, New Zealand

Education

01/2013 – 03/2016
University of St. Gallen
Conferral of a Doctorate (PhD in Organization Studies and Cultural Theory)
Certificate of Advanced Studies in University Didactics

07/2008 – 11/2011
Monash University
Masters degree in Marketing

03/2006 – 05/2006
University of Cambridge
Postgraduate Certificate in English Language Teaching to Adults

02/2003 – 11/2003
University of Adelaide
Postgraduate Diploma in Viticulture

02/1998 – 06/2001
University of Canterbury
Bachelor of Arts

11/1997
University entrance exam pass A
Work Experience

01/2013 – 03/2016
University of St. Gallen
Research Assistant at the Institute of Media and Communications Management

–
08/2012 – 12/2012
Georg Fischer Automotive, Schaffhausen
Temporary Internship in Innovation Management

–
05/2012 – 07/2012
Seleso, Cham
Exploratory Business Development Manager

–
08/2011– 04/2012
Siemens Building Technologies, Zug
Temporary Internship in Vertical Marketing Management

–
07/2010 – 01/2011
Madagascar Fauna Group, Toamasina
Temporary Marketing Consultant

–
01/2008 – 08/2010
Inlingua Language School, Bern
Head of TOEFL Department and Taskforce Leader for Online Learning

–
Bénédict Schule, St. Gallen
English Language Teacher

–
08/2004 – 01/2006
Ochsentorkel Weinbau, Thal
Vineyard Supervisor and Apprentice Winemaker

–
06/2001 – 09/2007
New Zealand Grapevines, Cambridge
Manager