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CHAPTER TEN

SHIFTING BETWEEN MODES OF THOUGHT: A DOMAIN-GENERAL CREATIVE THINKING SKILL?

ANDREW PRINGLE, PAUL T. SOWDEN, CARYS DEELEY & SARIKA SHARMA

Abstract

In this chapter we argue that shifting between different modes of thought, termed ‘mode shifting’ for short, is a fundamental cognitive skill underlying human creative thinking across different domains. We introduce empirical evidence revealing a relationship between mode shifting and creativity. Findings also show a relationship between mode shifting, as assessed by the mode shifting index (MSI), and creativity across five different domains, as assessed by the Kaufman domains of creativity scale (K-DOCS), suggesting that mode shifting is important for creativity across different domains. However, findings demonstrate that the relationship between mode shifting and creativity hinges on the component of mode shifting (metacognitive awareness of shifting or shifting competence), with certain components more important in some domains than others. In sum, mode shifting has domain-specific in addition to domain-general elements. We conclude the chapter by discussing the implications of our findings for creativity training and educational practice.

Keywords: mode shifting, creative cognition, domain specificity, metacognition, creativity training

1. Defining creativity

Creativity is a multifaceted construct (Ward & Kolomyts, 2010; Kaufman, 2009). We use Plucker, Beghetto & Dow’s (2004) definition which captures this quality defining creativity as “the interaction among aptitude, process and environment by which an individual or group produces a perceptible product that is both novel and useful as defined within a social context”. Aptitude reflects ability and affective influences and can be shaped by experience and learning. Processes reflect activities, such as creative problem solv-
ing, which when engaged in may lead to creative outcomes. The environment refers to the present context an individual or group is operating in (Plucker, Beghetto & Dow, 2004). This definition of creativity applies across all domains. For example to be deemed creative, both a design for a new smartphone and an artwork must be novel and useful, where we can further define useful as being specified, valuable, meaningful, relevant or worthwhile (Plucker & Beghetto, 2004). Evidently a novel artwork may be useful because experiencing it induces a meaningful experience in the beholder while a novel smartphone design may be useful because it increases the value of the experience, for example containing a more sophisticated camera than competitor models. The key point is that novelty and usefulness are components of any outcome, an idea or product, across any domain and these are both necessary components imbuing it with the quality of being creative (Cropley & Kaufman, 2012).

2. Definition of the different modes of thought and mode shifting

The conceptualisation of two fundamental modes, types or stages of thinking is a key component of many models of creativity (see Sowden, Pringle & Gabora, 2015 for a review of these models). Here, we draw specifically on a subset of these models (Gabora, 2010; Gabora & Ranjan, 2013; Howard-Jones, 2002; Kaufman, 2011; Vartanian, 2009) that closely agree on the characteristics of the two modes of thinking. In these models the two modes are differentiated based on their attentional characteristics. Similar to Gabora (2010), we use the label ‘associative’ to describe a mode of thought characterised by defocused attention and ‘analytic’ to describe a mode of thought characterised by focused attention. Models of creativity also emphasise the importance of shifting between the two different modes of thinking during the creative process (see Sowden, Pringle & Gabora, 2015 for a review). Parallels have been drawn between associative and divergent thinking and analytic and convergent thinking (Gabora, 2010; Martindale, 1999). However it has been argued that divergent thinking, also termed ideation, involves an element of analysis in the form of evaluations of previously generated ideas (Runco, 2010). Further, the process of insight described by Mednick (1962) as an associative process involves convergence on a single idea or solution, which also requires analysis and evaluation. Hence simple mappings between associative thinking and divergent thinking and between analytic thinking and convergent thinking are not possible (see Sowden, Pringle & Gabora, 2015 for an elaboration of these arguments but see also Tanner & Reisman, 2014 for alternative conceptualisations). Associative and analytic modes of thinking are involved in both divergent and convergent thought. Shifting may occur in either direction between associative and analytic modes, for example shifting from analytic to associative thinking may enable one to overcome
being ‘stuck in a rut’ while shifts from associative to analytic thinking enable the evaluation of previously generated novel insights (Gabora & Ranjan, 2013). Thus, associative and analytic thinking are interwoven and both must be harnessed to effectively generate and evaluate in order to produce creative ideas or products.

In terms of Plucker, Beghetto & Dow’s (2004) definition of creativity, mode shifting can be defined as a process humans engage in that may lead to a creative outcome. Gabora & Ranjan (2013) view mode shifting as a process that all humans are capable of performing but others (Howard-Jones, 2002) have also proposed that there exist individual differences in the ability to shift between different modes of thought. These proposals are mutually compatible and we view mode shifting as both a process and an aptitude on which people differ. A final important point about mode shifting is that it may be influenced by the environment/context in which a person is operating. Gabora & Ranjan (2013) term shifting ‘contextual focus’ and describe it as the capacity to modulate the focus of attention to match the demands of the current situation. Shifting is conceptualised as occurring in response to changes in the nature of a task one is working on or the situation one is in. To illustrate, the nature of a problem requiring a creative solution may at first be ill defined but becomes progressively better defined as the problem solver works on it (Vartanian, 2009). During the stage when the problem is ill defined one may rely more on the associative mode to think laterally about how to approach the problem. Later in the task, once an approach has been decided on, one may rely more on the analytic mode to determine how to implement it (Gabora & Ranjan, 2013). Additionally, this may be a non-linear process with problem solvers going “back to the drawing board” and re-engaging the associative mode to search for a new way of approaching the problem if they discover, using the analytic mode that their initial strategy was ineffective and is leading towards a dead end. Ill-defined ‘creative’ problems may therefore engage mode shifting to a greater extent than ‘non creative’ well-defined problems which have one correct solution with a logical deductive procedure (Schraw, Dunkle & Bendixen, 1995), underpinned by an analytic mode of thought, guaranteed to reach that solution.

In sum, mode shifting appears to be a fundamental component of creative thinking and, like creativity, is multifaceted being an interaction between one’s aptitude in carrying out shifts between different modes of thought, the process of shifting and the environment within which one is operating.

3. Is mode shifting a domain-general or domain specific creative thinking skill?

Novelty and usefulness lie at the core of definitions of creativity, definitions that apply across domains from the arts to the sciences (Plucker & Beghetto, 2004). We have presented the case in the previous section of this
chapter in support of mode shifting as a fundamental thinking skill that enables humans to produce novel ideas that are also useful. On the face of it, mode shifting would appear to be a domain-general thinking skill, important for creativity across domains. The notion that mode-shifting could be a domain-general creative thinking skill leads us to one of the core debates in creativity research and to the heart of what it means to ‘be creative’ (Baer & Kaufman, 2005). This debate concerns the extent to which there are common elements, for example the same cognitive processes, underlying creativity in different domains, termed the domain-general position, or whether creativity in one domain such as design is completely different to creativity in another such as poetry (Baer & Kaufman, 2005). The latter position is termed the domain-specific view. In other words, is creativity the same thing across multiple domains or are we just applying the same term “creativity” to the products of processes, abilities and environments that in reality differ widely across domains? Is there a creative equivalent of the g-factor in intelligence (Barbot & Tinio, 2015) or does creative ability in one domain represent a highly specialized suite of knowledge and skills that can’t easily be transferred in order to be creative in another? This is not simply a debate of theoretical importance it also has practical implications for the design of creativity training programs and educational practice (Baer, 1996; 1997; 1998).

3.1 A bridge between domain specific and domain general views of creativity: the Amusement Park Theoretical (APT) Model of Creativity

A helpful response to this debate was proposed by Baer & Kaufman (2005) in the form of their Amusement Park Theoretical model of creativity (APT). The APT draws upon the metaphor of an amusement park to bring together both domain-general and domain-specific views of creativity in a hybrid model. The reasoning behind the amusement park metaphor is to highlight how domain-general and domain specific factors are linked together. For example, initial requirements required for creativity across all domains are likened to the basic requirements needed to visit any amusement park, for example having a ticket for the park. The general thematic areas in the APT model are likened to deciding what amusement park to visit, for example a water park or a zoo (Baer & Kaufman, 2005). The APT model presents a hierarchical view of creativity, going from domain-general at the highest level to sequentially more domain specific as you move down the hierarchy. At the top of the hierarchy is a set of initial requirements required in order to be creative across all domains. Initial requirements are a basic level of intelligence, motivation and the right environment to express one’s creativity (Baer & Kaufman, 2005). The next level down the hierarchy is the general thematic area in which one can be creative, for example within the arts and science. Within each of these general thematic areas are more specific
domains such as dance, music (for the arts) and for example biology, geology and computer science (for the sciences) (Baer & Kaufman, 2005; Kaufman, 2009). Within each domain there are micro-domains that consist of the specific tasks one does in a domain, for example studying fruit flies may be a task that helps one develop creative insights in one of biology’s micro-domains but may be of little use in others (Baer & Kaufman, 2005). The level of micro-domains is at the bottom of the hierarchy and represents highly specialized domain-specific expertise.

The question then is at what level does mode shifting sit in the APT hierarchy? On the face of it mode shifting would appear to be important across all domains, and if so would sit at the level of initial requirements. However the role of mode shifting and creativity across different thematic areas or domains has yet to be explored. Previous work has suggested a relationship between mode shifting and creativity but has only relied on domain-general measures of creative potential (Vartanian, 2009; Vartanian, Martindale & Kwiatowskis, 2007; Dorfman, Martindale, Gassimova & Vartanian, 2008). As such, this did not allow for the relationship between mode shifting and creativity across different thematic areas or domains to be examined.

4. The present work

The empirical work presented in this chapter focuses on examining if mode shifting is associated with creativity across different thematic areas/domains. We used the Kaufman Domains of Creativity Scale (K-DOCs) (Kaufman, 2012) as a measure of creativity across domains and the mode shifting index (MSI) (Pringle & Sowden, under review) as a measure of mode shifting. A sample of participants (N = 56) aged between 16 and 56 years of age (M =29, SD =11) completed both the K-DOCs and the MSI and a series of other task based measures (see below) on-site at the University of Surrey in the UK. Regression analyses were run to examine the relationship between mode shifting and creativity across different domains.

4.1 Mode shifting index (MSI)

The MSI is a self-report measure based on a conceptual framework of mode shifting which proposes mode shifting has two components (Pringle & Sowden, under review). The first component is shifting competence. This reflects the effectiveness of the operation of a shifting mechanism that shifts the balance of thinking by regulating the intensity of use of both the associative and analytic modes such that one may be more active than the other, or both may be equally active (or inactive). The second component is metacognitive awareness. This includes one’s awareness of the individual modes of thinking, and of the shifting process itself (Sowden, Pringle & Gabora, 2015), for example, monitoring when one is shifting or not and one’s rate of shifting.
during a task, and thus awareness of how effective one is at shifting. The MSI has previously demonstrated validity by showing that participants studying or working in architecture, an occupation that might be expected to require shifting in order to devise creative solutions (Cross, 2011; Dorst & Cross, 2011), reported greater metacognitive awareness of shifting compared to two control groups, from medicine and other professions (Pringle & Sowden, under review). It is also worth noting that in the aforementioned study all groups (architecture, medicine & other professionals) reported levels of metacognitive awareness of shifting and shifting competence that differed from the minimum possible values. These findings suggest that mode shifting is at least to some extent evidenced across different domains. Finally, the MSI has also been shown to be capable of capturing differences in mode shifting expected as a function of the environment/context in which a person is operating (Gabora & Ranjan, 2013). Specifically, architects reported greater mode shifting in their professional role compared to within their everyday life (Pringle & Sowden, under review).

4.2 Kaufman Domains of Creativity Scale (K-DOCs)

The K-DOCs is a self-report measure of self-perceived creativity across five broad domains; self-everyday, scholarly, performance, mechanical/scientific and artistic (Kaufman, 2012). These broad domains appear to lie somewhere between the general thematic areas and specific domains of the APT model. The important point for our purposes is the K-DOCs allows us to examine if the relationship between mode shifting and creativity is similar or differs across a diverse set of domains.

The K-DOCs asks participants to report how creative they rate themselves at performing a variety of different acts such as ‘helping other people cope with a difficult situation’ and ‘figuring out how to fix a buggy computer’. There are 50 acts in total that fall into the five broad domains of creativity measured. The measure asks participants to indicate how creative they think that they are in comparison to people of approximately the same age and life experience as them. For given acts that participants have not performed, they are asked to estimate their creative potential based on their performance on similar tasks. Participants are asked to indicate responses to each act on a five point scale, with 1 indicating they are much less creative and 5 indicating they are much more creative in comparison to their peers of approximately the same age and life experience. Creativity is scored by summing the scores of all acts that refer to the same domain giving five separate domain scores for creativity.
4.3 Assessing the validity of the self-report measures of creativity and mode shifting in the present sample

To complement the K-DOCs and MSI, we included a brief measure of divergent thinking in the form of the Product Improvement test from the Torrance tests of creative thinking (Torrance, 1974), a consensual assessment of the functional creativity of designs (Cropley & Kaufman, 2012) produced on the disposable coffee cup design task (Jansson & Smith, 1991; Chrysikou & Weisberg, 2005) and a measure of set-breaking (Gasper, 2003). The presence of relationships between K-DOCs domains and task based measures from the coffee cup design task, product improvement test and mental set task would indicate that, within our sample, K-DOCs domain scores are capturing one’s actual creative performance and real mode shifting behaviour and not merely one’s self-perception of creativity (Kaufman, 2012) or mode shifting. The reasons for expecting positive relationships between certain K-DOCs domains and task-based measures of creativity and mode shifting are explained for each task-based measure in turn.

4.3.1. Product improvement test

The product improvement test enabled us to assess if the scores for creativity on the K-DOCs dimensions correlated with divergent thinking, as divergent thinking is a measure of creative potential. Further, there is good evidence that divergent thinking ability is related to actual creative performance. For instance, the Torrance tests of creativity thinking (TTCT) (Torrance, 1974), of which the product improvement test is one component, demonstrated that divergent thinking was a strong predictor of later creative achievement (Plucker, 1999). Hence indices of divergent thinking performance from the product improvement test will enable an assessment of the validity of the K-DOCs domain measures.

Furthermore, the generation of ideas and judgements and evaluations of them are fundamental to divergent thinking tasks (Runco, 2010). Specifically, the product improvement test requires individuals to generate novel ways of changing an existing stuffed toy elephant so that children will have more fun playing with it. The instructions and scoring criteria specify that responses must be focused on things that could conceivably make the toy more fun for children to play with and do not instead fulfil different purposes, such as making the toy do your homework (Torrance, 1974). Since this task requires the generation of ideas which also must have utility in fulfilling the purpose of making the toy more fun to play with, it would appear to require the use of both associative and analytic modes of thought. Hence product improvement test scores would also be expected to capture individual differences in mode shifting. Evidence for a relationship between product improvement test
scores and MSI measures would support the validity of the MSI as a valid measure of mode shifting.

There are three measures of divergent thinking on the product improvement test: fluency, originality and flexibility. The total fluency score is calculated by adding up all appropriate responses. The total score for originality consists of the total number of responses that are distinct from a set of frequently generated responses listed in the test manual. Also listed in the manual are different categories that responses fall into. For example suggestions for adding bells and adding a squeaker would both fall into the same category of ‘adding things that means the toy will make a noise’. The suggestion to give it a removable trunk would fall into a different category. The score for flexibility consists of the total number of different categories that participant’s responses fall into.

4.3.2. Coffee cup design task

The reason for including the coffee cup design task was to assess if scores on the K-DOCS dimensions correlated with the functional creativity of designs produced on the task. Functional creativity is a measure of the creativity of a product, in this case a design, which takes account of both the design’s novelty and usefulness (Cropley & Kaufman, 2012). It therefore was a measure of actual creative performance against which we could assess the validity of K-DOCS domain scores. Further, its emphasis on measuring both novelty and usefulness means that it may also tap mode shifting.

For this task participants were presented with a brief asking them to solve a problem concerning flaws with a disposable coffee cup and, in the process, come up with their own designs for disposable coffee cups. Participants were presented with a brief together with a set of constraints that designs must adhere to and also a set of criteria previously used by Silvia et al. (2008) to emphasize ways that they could make the designs more creative.

Functional creativity was assessed using a consensual assessment of the creativity of disposable coffee cup designs (Cropley & Kaufman, 2012). Using the revised creative solution diagnosis scale, designs were rated by three independent raters and a single score for functional creativity for each rater obtained from this scale (Cropley & Kaufman, 2012). Cronbach’s alpha showed a moderate level of consistency of ratings of functional creativity across raters ($\alpha = .68$), above the required threshold (Amabile, Conti, Coon, Lazenby & Herron, 1996). Participants often produced more than one design for a disposable coffee cup. For each participant we obtained a single score for functional creativity by taking the mean of his or her two most creative designs (See Silvia et al. 2008 for a similar approach).
4.3.3. Mental set task

The mental set task is used to measure set-breaking (Gasper, 2003) and was included in order to further validate if the MSI captures real shifting behaviour. Specifically, strong evidence for the validity of the shifting competence component of the MSI is currently lacking (Pringle & Sowden, under review). The set-breaking task would appear to tap how effectively one’s shifting mechanism operates. It has been argued that the mental set task taps a key facet of creativity, namely one’s ability to flexibly generate a novel and appropriate alternate strategy when an established ‘mental set’ strategy has been shown to fail (Gasper, 2003). The mental set task comprises a series of 12 problems. For the first six problems there is only one strategy that can be used to solve the problem. Prior to working on the series of problems participants are presented with an exemplar showing them how to solve the problems using a specific strategy. This exemplar and the first six problems are designed to prime participants into using this strategy with the aim of ensuring they get stuck in a set way of approaching the problems; termed the mental set strategy. Two subsequent problems, numbered seven and eight, can be solved by either the mental set strategy or an alternative strategy, which participants have to discover for themselves. The key aspect of the task for our purposes appears on problem number nine, which cannot be solved by the mental set strategy and instead can only be solved by an alternative strategy. The change from following a rule-based analytic strategy, the mental set strategy, to the need to broaden one’s attentional focus to discover a novel problem solving strategy suggests a shift from analytic to associative thinking is required. Thus, this task appears to tap the competence with which one can shift the balance of thinking away from an established analytic strategy to an associative mindset conducive to discovering a new approach. The need to identify when the rule-based strategy has failed may also require metacognitive awareness of shifting (Pringle & Sowden, under review).

4.4. Measures of intelligence, inhibition and working memory

Finally, we also included measures of intelligence, inhibition and working memory. These were included to examine how key cognitive abilities are associated with different components of mode shifting and creativity across different domains. The APT model of creativity categorises intelligence as an initial requirement (Baer & Kaufman, 2005) hence we would expect it to be important and required for creativity across domains. However, previous work has demonstrated that beyond a certain level of intelligence there is no relationship between intelligence and creativity (Runco, 2010). Since our sample consists of university students we may therefore find no association between intelligence and creativity in the present sample. Further, research has suggested a positive relationship between inhibition and creativity.
(Carson, Peterson & Higgins, 2003) and between working memory and divergent thinking (Takuechi et al. 2011). The APT however leaves unspecified as to where working memory and inhibition might fit within the hierarchy of the model. Intelligence, inhibition and working memory were measured using the matrix-reasoning subtest from the Wechsler Abbreviated Scale of Intelligence (WASI) (Wechsler, 1999), the Stroop task (Stroop, 1935) and the Automated Reading span (ARSPAN) task (Unsworth, Heitz, Schrock & Engle, 2005) respectively.

### 4.5. Hypotheses

In this section we state the series of hypotheses we tested through regression analyses. Prior to listing each hypothesis we explain the reasoning behind the prediction, referring to prior theory and research.

#### 4.5.1. Examining the relationship between mode shifting and creativity across different domains

The Amusement Park theoretical model of creativity suggests that some abilities may be more important to success in some creative domains while other abilities may be more important to success in others (Baer & Kaufman, 2005). While mode shifting would appear to be important across domains for the reasons we argued earlier, certain components of mode shifting may indeed be more important in some domains than others. A tentative rationale for hypotheses was therefore proposed based on differences in the types of abilities that would appear to be important in performing creative acts in different domains.

We predicted that within the mechanical/scientific domain, where established methods of operating would appear deeply entrenched, a strong shift between modes may be required to break away from an entrenched analytic mode of thinking to enter an associate mode conducive to discovering new approaches. For example, items on the mechanical/scientific scale include “writing a computer program” and “helping to carry out or design a scientific experiment” that would appear to require an extended sequence of logical step-by-step activities involving analytic thinking. Specifically, “writing a computer program” presumably draws on a step-by-step sequence of logical coding rules, whilst “helping to carry out or design a scientific experiment”, on following a set sequence of rules to establish that the experiment has the required rigour. To produce creative solutions for these activities may therefore require a strong shift from an entrenched analytic sequence of thinking to an associative mode conducive to leaving the ‘well-worn path’ to discover a new approach. This line of reasoning suggests that the extent to which one is able to shift, that is shifting competence, will predict scores on the K-DOCs mechanical/scientific scale. The hypothesis is summarised as follows:
H1: Shifting competence will positively predict creativity scores on the K-DOCs mechanical/scientific scale.

It is less clear how metacognitive awareness of shifting might be related to mechanical/scientific creativity. It could however be important to be aware of when the analytic mode of thinking is not working. For example when a rule based strategy for computer programming is not working, engaging the associative mode to generate a workaround may help one to reach a solution. Greater metacognitive awareness of shifting should help one to identify the need to shift in situations like this and hence lead to more creative solutions in the mechanical/scientific domain. The hypothesis is summarised as follows:

H2: Metacognitive awareness of shifting will positively predict creativity scores on the K-DOCs mechanical/scientific scale.

Within the domain of artistic creativity, metacognition may be important to monitor the degree to which one’s current mode of thinking is functioning correctly so as an optimal point is reached between idea generation and evaluation (Basadur, 1995). For example, in the context of artistic practice it would seem important for one to actively monitor the global progress of an artwork (e.g. a drawing) one is working on and to be aware of which areas of the artwork are going better than others (Fayena-Tawil, Kozbelt & Sitaras, 2011). Applying one’s metacognition in this way could enable one to adjust the balance between associative and analytic thinking to be more analytic if there are problems in the global progress of the artwork or problems in certain areas of it are identified. There is also some evidence supporting the importance of metacognition in the artistic domain. Fayena-Tawil, Kozbelt & Sitaras (2011) conducted a study examining the thinking processes of artists and non-artists as they created original drawings, finding that artists evidenced more metacognition concerning monitoring the emerging progress of drawings than non-artists. Greater metacognitive awareness of shifting may have helped the artists in this study maintain an optimal balance between the two different modes of thinking with this being important to producing a creative end product. The hypothesis is summarised as follows:

H3: Metacognitive awareness of shifting will positively predict creativity scores on the K-DOCs artistic scale.

The capacity to shift may still aid the process of actually conducting shifts between different modes of thinking during the creative process in the artistic domain. As such it was tentatively predicted that:
**H4: Shifting competence will positively predict creativity scores on the K-DOCs artistic scale.**

It was not clear how mode shifting would be associated with creativity in K-DOCs domains other than mechanical/scientific and artistic. The reason for this is that there is no prior research investigating the relationship between mode shifting and domain specific measures of creativity in performance, self/everyday or scholarly domains. Hence no specific predictions were made for performance, self/everyday or scholarly creativity.

The extent to which relationships between mode shifting on the MSI and creativity on the K-DOCs domains differ across professional and everyday contexts depends on whether people do the same activities, as captured by the K-DOCs items, at study or work as they do in their non-study/work time. For example, people studying or working in certain fields that have work specific activities requiring mode shifting, for example designing scientific experiments (Cross, 2011; Dorst & Cross, 2011), may display greater mode shifting in their professional context, that is at study or at work, than they do in their everyday context, that is during their non-study/work time. Previous research has already shown that those studying or working in architecture display greater metacognitive awareness of shifting in their professional context, where mode shifting would appear to be particularly important (Lawson, 1997), compared to their everyday context (Pringle & Sowden, under review). However, the direction of the difference in mode shifting between professional and everyday contexts is difficult to predict because we do not have data concerning the extent to which participants engaged in activities (e.g. designing a scientific experiment) in any of the K-DOCs domains in their everyday compared to their professional context. As such we propose the following two non-directional hypotheses:

**H5: The relationship between metacognitive awareness of shifting and K-DOCs creativity in each domain will vary as a function of the context in which mode shifting is measured.**

**H6: The relationship between shifting competence and K-DOCs creativity in each domain will vary as a function of the context in which mode shifting is measured.**

### 4.5.2. Examining the validity of the K-DOCs domains as measures of creativity in the current sample

There is some existing evidence that supports the validity of the five broad K-DOCs domains. Specifically, scores on the five K-DOCs domains have evidenced a profile of correlations with personality factors consistent with prior research examining the relationship between personality and crea-
tivity with domain specific measures of creativity. To summarise, work by Kaufman (2012) showed that, mirroring work by King, Walker, & Broyles (1996), McCrae, (1987) and Silvia, Kaufman, & Pretz (2009), openness positively correlated with all K-DOCs domains other than mechanical/scientific creativity. Consistent with prior research by Kaufman, Cole, & Baer (2009) and Silvia, Kaufman, & Pretz (2009), K-DOCs performance creativity was positively correlated with extraversion (Kaufman, 2012). Finally, similar to Feist (1993) and Silvia, Kaufman, Reiter-Palmon, & Wigert (2011), K-DOCs mechanical/scientific creativity was negatively correlated with agreeableness and like Silvia, Kaufman, & Pretz (2009) was also positively correlated with emotional stability.

This body of evidence suggests the K-DOCs domains are valid measures. However, there is a lack of prior research examining the relationship between K-DOCs domain scores and actual creative performance. While there was a lack of prior research on which to base our predictions we examined the alignment between measures of task based creativity and the K-DOCs items comprising K-DOCs domains in order to make tentative predictions. As argued earlier, the product improvement test requires one to generate novel ideas, that is ways of changing an existing stuffed toy elephant, and ensuring that these ideas also have utility, so that children will have more fun playing with it. The coffee cup design task requires one to generate novel designs for a disposable coffee cup that have utility by way of meeting a set of constraints that designs are required to adhere to.

The creative behaviours captured by certain domains of the K-DOCs would appear similar to the activities one must perform to achieve creative performance on the product improvement test and coffee cup design task. We tentatively predicted relationships between K-DOCs mechanical/scientific, artistic and scholarly domains with the two task based measures of creative performance for the following reasons.

The K-DOCs mechanical/scientific scale includes items that, like the coffee cup design task, tap design ability such as “helping to carry out or design a scientific experiment” and “building something mechanical (like a robot)”. Like the product improvement test the mechanical/scientific scale appears to tap one’s ability to both produce something novel that is also useful, specifically a “scientific experiment” or a “computer program”. As such we predicted that:

\[ H7: \text{K-DOCs mechanical/scientific domain scores will positively predict functional creativity on the coffee cup design task} \]

\[ H8: \text{K-DOCs mechanical/scientific domain scores will positively predict divergent thinking as indexed by product improvement measures} \]

The K-DOCs artistic scale includes items that tap one’s creativity in producing an artwork, for example “drawing a picture of something I’ve never
actually seen (like an alien)‖ and “sketching a person or object”. The coffee cup design task requires people to draw novel designs for disposable coffee cups on paper so both would appear to tap a similar creative drawing ability to that measured by the K-DOCs artistic scale. The product improvement test requires one to simply list changes one would make to a toy elephant in writing as opposed to drawing those changes. However, research has shown that university students with majors in the fine and performing arts score higher on divergent thinking than non-arts majors (Silvia et al., 2008). Hence we would expect a relationship between the K-DOCs artistic scale and divergent thinking ability. The following predictions were made:

**H9:** K-DOCs artistic domain scores will positively predict functional creativity on the coffee cup design task.

**H10:** K-DOCs artistic domain scores will positively predict divergent thinking as indexed by product improvement measures

Kaufman (2012) proposes that the scholarly dimension of the K-DOCs involves “creative analysis” (p. 300). The concept of “creative analysis” is embodied by K-DOCs items that form the scholarly scale such as “figuring out how to integrate critiques and suggestions while revising a work”. This item taps one’s ability to both analyse and generate ideas and appears similar to the product improvement test instruction to change an existing stuffed toy elephant so it is more fun for children to play with and the coffee cup design task instruction to solve a problem concerning flaws with a disposable coffee cup and, in the process, come up with your own creative designs for disposable coffee cups. As such we predicted that:

**H11:** K-DOCs scholarly domain scores will positively predict functional creativity on the coffee cup design task

**H12:** K-DOCs scholarly domain scores will positively predict divergent thinking as indexed by product improvement measures

4.5.3. Examining the validity of the MSI as a measure of mode shifting in the current sample

We explained earlier the rationale, from a conceptual standpoint, of expecting set breaking to be positively associated with MSI shifting competence and metacognitive awareness of shifting. There is however no previous work that has examined the relationship between mode shifting and set breaking. There is evidence of correlations between skill transfer errors, which resemble the failure to break mental set on Lunchins (1942) mental set problems, and a latent measure of attentional disengagement formed from measures of
attentional switching and inhibition (Woltz, Gardner & Gyll, 2000). These findings lend some evidence to suggest that the mental set task involves attentional flexibility, which, as argued earlier, appears related to mode shifting. There were two measures of set breaking, set breaking before and set breaking after the set-breaking problem was presented. Gasper (2003) only proposed the latter to be a measure of creative thinking. However, conceptually speaking, both measures would appear to tap mode shifting and there is no reason to expect that the relationships between components of mode shifting will differ across everyday and professional contexts. As such, we made the following predictions:

**H13: Metacognitive awareness of shifting will positively predict set breaking both before and after the set-breaking problem is presented**

**H14: Shifting competence will positively predict set breaking both before and after the set-breaking problem is presented**

Finally, since both functional creativity on the coffee cup design task and divergent thinking on the product improvement test would appear to involve mode shifting, we also made the following predictions. Again, there is no reason to expect that the relationships between components of mode shifting will differ across everyday and professional contexts:

**H15: Metacognitive awareness of shifting will positively predict the functional creativity of designs on the coffee cup design task**

**H16: Shifting competence will positively predict the functional creativity of designs on the coffee cup design task**

**H17: Metacognitive awareness of shifting will positively predict divergent thinking on the product improvement test**

**H18: Shifting competence will positively predict divergent thinking on the product improvement test**

5. Results

Linear regressions were performed to investigate if there were linear relationships between different measures. Linear regressions were only performed between measures that preliminary bivariate correlations revealed were correlated. Marginally significant regressions were those with $p$ value’s of <.10 but >.05 where the power of tests was < .8.
5.1. Examining the relationship between mode shifting and creativity across different domains

We ran a set of linear regressions to explore whether the four MSI measures predicted each of the five K-DOCs domains. Linear regressions are reported in Table 1.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Outcome</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>p-value</th>
<th>R²</th>
<th>Adjusted R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>(constant)</td>
<td>K-DOCs mechanical/scientific</td>
<td>-94.71</td>
<td>35.67</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP Competence</td>
<td>scientific creativity</td>
<td>6.76</td>
<td>2.01</td>
<td>.42**</td>
<td>.001</td>
<td>.18</td>
<td>.16</td>
</tr>
<tr>
<td>(constant)</td>
<td>K-DOCs scholarly</td>
<td>-4.36</td>
<td>25.40</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP Competence</td>
<td>creativity</td>
<td>2.44</td>
<td>1.43</td>
<td>.33</td>
<td>.09</td>
<td>.05</td>
<td>.04</td>
</tr>
<tr>
<td>(constant)</td>
<td>K-DOCs performance</td>
<td>6.97</td>
<td>7.58</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP Awareness</td>
<td>creativity</td>
<td>.72</td>
<td>29</td>
<td>.33*</td>
<td>.02</td>
<td>.11</td>
<td>.09</td>
</tr>
<tr>
<td>(constant)</td>
<td>K-DOCs performance</td>
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<td>6.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE Awareness</td>
<td>creativity</td>
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<td>23</td>
<td>.36*</td>
<td>.01</td>
<td>.13</td>
<td>.11</td>
</tr>
<tr>
<td>(constant)</td>
<td>K-DOCs artistic</td>
<td>11.91</td>
<td>6.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP Awareness</td>
<td>creativity</td>
<td>.55</td>
<td>23</td>
<td>.32*</td>
<td>.02</td>
<td>.10</td>
<td>.09</td>
</tr>
<tr>
<td>(constant)</td>
<td>K-DOCs artistic</td>
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<td>4.90</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE Awareness</td>
<td>creativity</td>
<td>.45</td>
<td>19</td>
<td>.32*</td>
<td>.02</td>
<td>.10</td>
<td>.09</td>
</tr>
<tr>
<td>(constant)</td>
<td>K-DOCs self</td>
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<td>4.40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE competence</td>
<td>everyday creativity</td>
<td>.48</td>
<td>25</td>
<td>.26</td>
<td>.06</td>
<td>.07</td>
<td>.05</td>
</tr>
</tbody>
</table>

**p < .01, *p < .05**

*N = 54

Table 1: Results of the linear regressions with MSI measures as predictor variables and K-DOCs domains as outcomes

The linear regression with shifting competence in a professional context as the predictor variable and K-DOCs mechanical/scientific creativity as the outcome variable revealed that K-DOCs mechanical/scientific creativity was significantly predicted by SP competence ($F (1, 52) = 11.35, p = .001$). The unstandardized B and standardized Beta are significantly different from zero ($t = 3.37, p = .001$). $R^2$ indicates that 18% of the variance in K-DOCs Mechanical/Scientific creativity was explained by SP competence. A second linear regression with shifting competence in a professional context as the predictor variable and K-DOCs scholarly creativity as the outcome variable
revealed that SP competence was a marginally significant predictor of K-DOCs scholarly creativity ($F(1, 52) = 2.91, p = .09$). The unstandardized B and standardized Beta are marginally significantly different from zero ($t = 1.71, p = .09$). $R^2$ indicates that 5% of the variance in K-DOCs scholarly creativity was explained by SP competence.

A linear regression with metacognitive awareness of shifting in a professional context as the predictor variable and K-DOCs performance creativity as the outcome variable revealed that K-DOCs Performance creativity was significantly predicted by SP awareness ($F(1, 52) = 6.24, p = .02$). The unstandardized B and standardized Beta are significantly different from zero ($t = 2.50, p = .02$). $R^2$ indicates that 11% of the variance in K-DOCs Performance creativity was explained by SP awareness. As was the case in the professional context, K-DOCs performance creativity was also significantly predicted by metacognitive awareness of shifting in the everyday context ($F(1, 52) = 7.55, p = .01$). The unstandardized B and standardized Beta are significantly different from zero ($t = 2.75, p = .01$). $R^2$ indicates that 13% of the variance in K-DOCs Performance creativity was explained by SE awareness.

A linear regression with metacognitive awareness of shifting in a professional context as the predictor variable and K-DOCs artistic creativity as the outcome variable revealed that K-DOCs artistic creativity was significantly predicted by SP awareness ($F(1, 52) = 5.89, p = .02$). The unstandardized B and standardized Beta are significantly different from zero ($t = 2.43, p = .02$). $R^2$ indicates that 10% of the variance in K-DOCs performance creativity was explained by SP awareness. As was the case in the professional context, K-DOCs artistic creativity was also significantly predicted by metacognitive awareness of shifting in the everyday context ($F(1, 52) = 5.89, p = .02$). The unstandardized B and standardized Beta are significantly different from zero ($t = 2.43, p = .02$). $R^2$ indicates that 10% of the variance in K-DOCs performance creativity was explained by SE awareness.

A linear regression with shifting competence in an everyday context as the predictor variable and K-DOCs self/everyday creativity as the outcome variable revealed that SE competence was a marginally significant predictor of K-DOCs self/everyday creativity ($F(1, 52) = 3.73, p = .06$). The unstandardized B and standardized Beta are marginally significantly different from zero ($t = 1.93, p = .06$). $R^2$ indicates that 7% of the variance in K-DOCs performance creativity was explained by SE competence.

Considered as a whole, these findings demonstrate that there is a relationship between mode shifting and creativity and that this relationship holds across different domains. Scores on K-DOCs mechanical/scientific creativity were predicted by shifting competence in a professional context. Scores on K-DOCs performance creativity were predicted by metacognitive awareness of shifting reported in both professional and everyday contexts. Similarly, scores on K-DOCs artistic creativity were also predicted by metacognitive awareness of shifting reported in both professional and everyday contexts. Scores on K-DOCs self/everyday creativity were predicted by shifting com-
petence in an everyday context and scores on K-DOCs scholarly creativity were predicted by shifting competence in a professional context, albeit these two findings were only marginally significant. All relationships were positive, with greater metacognitive awareness of shifting or greater shifting competence associated with higher creativity.

It is important to note that different components of mode shifting were associated with creativity in different domains. Namely, shifting competence in a professional context predicted K-DOCs mechanical/scientific creativity and, to a lesser extent, scholarly creativity. Shifting competence in an everyday context predicted K-DOCs self/everyday creativity. Metacognitive awareness of shifting in both professional and everyday contexts predicted creativity in both K-DOCs performance and artistic domains. These findings are discussed further in the discussion section.

5.2. Examining the validity of the K-DOCs domains as measures of creativity in the current sample

It was important to establish the validity of K-DOCs scores as measures of actual creativity in our sample by examining the relationship between participant’s K-DOCs domain scores and task based measures of creativity. Linear regressions were run to examine the relationship between K-DOCs domain scores and task based measures of creativity from the product improvement task (Torrance, 1974) and the disposable coffee cup design task (Jansson & Smith, 1991; Chrysikou & Weisberg, 2005) scored using a consensual assessment of the functional creativity of coffee cup designs (Cropley & Kaufman, 2012). K-DOCs domain scores were entered as the predictor variables and task based measures of creativity as the outcomes in linear regressions. Linear regressions are reported in table 2 below.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Outcome</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>p-value</th>
<th>R²</th>
<th>Adjusted R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>(constant)</td>
<td></td>
<td>2.11</td>
<td>.39</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K-DOCs mechanical/scientific</td>
<td>Product improvement originality</td>
<td>.03</td>
<td>.01</td>
<td>.28*</td>
<td>.04</td>
<td>.08</td>
<td>.06</td>
</tr>
<tr>
<td>(constant)</td>
<td></td>
<td>1.37</td>
<td>.51</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K-DOCs artistic creativity</td>
<td>Product improvement originality</td>
<td>.06</td>
<td>.02</td>
<td>.39**</td>
<td>.004</td>
<td>.15</td>
<td>.14</td>
</tr>
<tr>
<td>(constant)</td>
<td></td>
<td>5.47</td>
<td>4.55</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K-DOCs artistic creativity</td>
<td>Product improvement fluency</td>
<td>.34</td>
<td>.17</td>
<td>.27*</td>
<td>.05</td>
<td>.07</td>
<td>.05</td>
</tr>
<tr>
<td>(constant)</td>
<td></td>
<td>2.05</td>
<td>.52</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K-DOCs scholarly creativity</td>
<td>Coffee cup design</td>
<td>.02</td>
<td>.01</td>
<td>.25</td>
<td>.07</td>
<td>.06</td>
<td>.04</td>
</tr>
</tbody>
</table>

Table 2: Results of linear regressions with K-DOCs domain scores as predictor variables and task based measures of creativity as outcomes
A linear regression with K-DOCs mechanical/scientific creativity as the predictor variable and product improvement originality as the outcome variable revealed that product improvement originality was significantly predicted by K-DOCs mechanical/scientific creativity ($F (1, 52) = 4.48, p = .04$). The unstandardized B and standardized Beta are significantly different from zero ($t = 2.12, p = .04$). $R^2$ indicates that 8% of the variance in product improvement originality was explained by K-DOCs mechanical/scientific creativity.

A linear regression with K-DOCs artistic creativity as the predictor variable and product improvement originality as the outcome variable revealed that product improvement originality was significantly predicted by K-DOCs artistic creativity ($F (1, 52) = 9.29, p = .004$). The unstandardized B and standardized Beta are significantly different from zero ($t = 3.05, p = .004$). $R^2$ indicates that 15% of the variance in product improvement originality was explained by K-DOCs artistic creativity. Similarly, a linear regression with K-DOCs artistic creativity as the predictor variable and product improvement fluency as the outcome variable revealed that product improvement fluency was significantly predicted by K-DOCs artistic creativity ($F (1, 52) = 3.97, p = .05$). The unstandardized B and standardized Beta are significantly different from zero ($t = 1.99, p = .05$). $R^2$ indicates that 7% of the variance in product improvement fluency was explained by K-DOCs artistic creativity. Finally, a linear regression with K-DOCs scholarly creativity as the predictor variable and functional creativity on the coffee cup design task as the outcome variable revealed that K-DOCs scholarly creativity was a marginally significant predictor of functional creativity ($F (1, 52) = 3.38, p = .07$). The unstandardized B and standardized Beta are significantly different from zero ($t = 1.84, p = .07$). $R^2$ indicates that 6% of the variance in functional creativity was explained by K-DOCs scholarly creativity.

Regressions revealed positive associations for three out of five K-DOCs domains with scores on measures of creativity. Creativity reported within the K-DOCs mechanical/scientific domain was a significant predictor of product improvement originality. Creativity reported within the K-DOCs artistic domain was a significant predictor of both product improvement originality and fluency scores. K-DOCs scholarly creativity was a marginally significant predictor of the functional creativity of designs produced on the coffee cup design task. There were no significant relationships between task-based measures of creativity and K-DOCs self/everyday or K-DOCs performance creativity. In sum, these findings demonstrate some evidence for the validity of the K-DOCs artistic, mechanical/scientific and, to a lesser extent, scholarly domains as measures of actual creative performance.

5.3. Examining the validity of the MSI as a measure of mode shifting in the current sample
Previous research has provided evidence that the MSI is a valid measure of one’s metacognitive awareness of mode shifting (Pringle & Sowden, under review). As stated previously, evidence for the validity of the shifting competence component of mode shifting requires further assessment. In order to address this, we examined whether self-reported shifting competence was associated with a task-based measure of shifting; the mental set task (Gasper, 2003). Regressions were run to examine the relationship between one’s tendency to break set on the mental set task and self-reported shifting on the MSI. Only a subset (N = 33) of the full sample was included in these analyses. The reason for this was that only 33 participants had established the mental set in the first place. In order to ensure that participants’ had switched strategy and, as we argued earlier, had shifted to a new mode of thought it was crucial that we ensured they were following the rule based mental set strategy in the first place.

A series of Logistic regressions were performed to determine if mode shifting reported on the four MSI components predicted task based mode shifting as indexed by the two measures of set breaking on the mental set task; breaking set before and after the set breaking problem was presented. Logistic regressions were performed instead of linear regressions as scatterplots suggested that scores on both of the measures of breaking set were not continuous and there was some evidence of homoscedacity. Regressions are presented in table 3.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Outcome</th>
<th>Model</th>
<th>95% CI for Odds ratio</th>
<th>p-value</th>
<th>Wald test</th>
</tr>
</thead>
<tbody>
<tr>
<td>(constant)</td>
<td>breaking set after the set</td>
<td>-39.99</td>
<td>5.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP competence</td>
<td>breaking problem</td>
<td>2.26</td>
<td>5.12*</td>
<td>.02</td>
<td>9.54</td>
</tr>
<tr>
<td>(constant)</td>
<td>breaking set after the set</td>
<td>-2.28</td>
<td>1.13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE awareness</td>
<td>breaking problem</td>
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<td>1.23</td>
<td>.27</td>
<td>1.10</td>
</tr>
<tr>
<td>(constant)</td>
<td>breaking set before the set</td>
<td>5.57</td>
<td>2.61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP awareness</td>
<td>breaking problem</td>
<td>-2.25</td>
<td>3.24</td>
<td>.07</td>
<td>.78</td>
</tr>
<tr>
<td>(constant)</td>
<td>breaking set before the set</td>
<td>3.47</td>
<td>3.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE awareness</td>
<td>breaking problem</td>
<td>-1.16</td>
<td>2.37</td>
<td>.08</td>
<td>.85</td>
</tr>
</tbody>
</table>

N=33
*p < .05

Table 3: Results of logistic regressions with MSI scores as predictor variables and whether set was or was not broken (before or after the set breaking problem) as the dichotomous outcome variable. The p-values reported are those for the Wald test.

A first set of logistic regressions were performed with participants divided to form a dichotomous measure of those who had broken set after the set
breaking item and those who had not broken set after the set breaking item had been delivered. This outcome variable was entered into two separate logistic regressions, one with SP competence as predictor and the other with SE awareness as a predictor.

A test of the full model with SP competence against a constant only model was statistically significant, χ² (1, N =33) = 8.13, p = .004; nagalkerke R² = .29, indicating SP competence did successfully distinguish between those evidencing no instances of set breaking after the set breaking item and those evidencing at least one instance of set breaking after the set breaking item. Prediction success was mixed with 82.4% of the group who demonstrated at least one instance of set breaking being correctly predicted but only 50% of the group demonstrating no instances of set breaking correctly predicted, for an overall success rate of 68%. Table 3 shows the regression coefficient, Wald statistic, odds ratio and its 95% confidence interval. According to the Wald criterion, shifting competence in a professional context predicted set breaking group (z= 5.12, p=.02). A large odds ratio of 9.54 indicated that a one unit increase in the predictor, SP competence, resulted in just over a 9-fold increase in the odds of being a member of the group who demonstrated at least one instance of set breaking after the set breaking item.

A test of the full model with SE awareness against a constant only model failed to reach statistical significance, χ² (1, N =33) = 1.30, p = .25; nagalkerke R² = .05, indicating SE awareness did not successfully distinguish between those evidencing no instances of set breaking after the set breaking item and those evidencing at least one instance of set breaking after the set breaking item. Prediction success was poor with 58.8% of the group who demonstrated at least one instance of set breaking being correctly predicted and only 50% of the group demonstrating no instances of set breaking correctly predicted, for an overall success rate of 54.5%. The regression coefficient, Wald statistic, odds ratio and its 95% confidence interval are shown in table 3. According to the Wald criterion, metacognitive awareness of shifting in an everyday context failed to predict set breaking group (z= 1.23, p=.27).

A second set of logistic regressions were performed with participants now divided to form a dichotomous measure of those who had broken set before the set breaking item and those who had not broken set before the set breaking item had been delivered. This outcome variable was entered into two separate logistic regressions, one with SP awareness as predictor and the other with SE awareness as a predictor.

A test of the full model with SP awareness against a constant only model was statistically significant, χ² (1, N =33) = 4.01, p = .05; nagalkerke R² = .16, indicating SP awareness did successfully distinguish between those evidencing no set instances of set breaking before the set breaking item and those evidencing at least one instance of set breaking before the set breaking item. Prediction success was poor with 90.1% of the group who demonstrated no instances of set breaking being correctly predicted but only 9.1% of the group demonstrating at least one instance of set breaking correctly predicted,
for an overall success rate of 63.6%. The regression coefficient, Wald statistic, odds ratio and its 95% confidence interval are shown in table 3. According to the Wald criterion, metacognitive awareness of shifting in a professional context was a marginally significant predictor of set breaking group ($z = 3.25, p = .07$). A small odds ratio of .78 indicated that a one unit increase in the predictor, SP awareness, resulted in a 22% increase in the odds of being a member of the group who demonstrated no instances of set breaking before the set-breaking problem.

A test of the full model with SE awareness against a constant only model was marginally significant, $\chi^2 (1, N = 33) = 3.57, p = .06$; Nagelkerke $R^2 = .14$, suggesting that SE awareness did successfully distinguish between those evidencing no set instances of set breaking and those evidencing at least one instance of set breaking before the set-breaking problem. Prediction success was poor with 90.9% of the group who demonstrated no instances of set breaking being correctly predicted but only 18.2% of the group demonstrating at least one instance of set breaking correctly predicted, for an overall success rate of 66.7%. The regression coefficient, Wald statistic, odds ratio and its 95% confidence interval are shown in table 3. According to the Wald criterion, metacognitive awareness of shifting in an everyday context was a marginally significant predictor of set breaking group ($z = 3.10, p = .08$). A small odds ratio of .85 indicated that a one unit increase in the predictor, SE awareness, resulted in a 15% increase in the odds of being a member of the group who demonstrated no instances of set breaking before the set-breaking problem.

The analyses with logistic regressions demonstrated that there is only a positive relationship between shifting competence in a professional context and the odds of set breaking after the set-breaking problem was presented; that is on problem numbers 10, 11 and 12 when only an alternative to the mental set strategy can be used to solve the problem. Conversely, the logistic regressions with SP awareness and SE awareness suggested a negative relationship between metacognitive awareness of shifting and set breaking before the set-breaking problem was presented; that is on problems seven and eight when either the mental set or an alternative strategy can be used to solve the problem. The findings with metacognitive awareness of shifting were however only marginally significant. As such, findings only provide strong support for the hypothesis that shifting competence in a professional context is positively associated with the tendency to break set after the set-breaking item.

A final set of linear regressions were performed to examine if MSI components of shifting predicted divergent thinking on the product improvement test. The results of these regressions are displayed in table 4. We did not run linear regressions to examine the relationship between MSI component scores and functional creativity on the coffee cup design task because bivariate correlations failed to reveal any significant relationship between functional creativity and MSI components.
Table 4: Results of linear regressions with MSI scores as predictor variables and product improvement measures as outcome variables

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Outcome</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>p-value</th>
<th>( R^2 )</th>
<th>Adjusted ( R^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>(constant)</td>
<td>Product improvement</td>
<td>.69</td>
<td>.88</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP awareness</td>
<td>originality</td>
<td>.09</td>
<td>.03</td>
<td>.33*</td>
<td>.02</td>
<td>.11</td>
<td>.09</td>
</tr>
<tr>
<td>(constant)</td>
<td>Product improvement</td>
<td>.69</td>
<td>.22</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP awareness</td>
<td>fluency</td>
<td>.02</td>
<td>.01</td>
<td>.25</td>
<td>.07</td>
<td>.06</td>
<td>.04</td>
</tr>
</tbody>
</table>

**p<.01, p<.05

\( N=54 \)

The linear regression with metacognitive awareness of shifting in a professional context as the predictor variable and product improvement originality as the outcome variable revealed that product improvement originality was significantly predicted by SP awareness (\( F(1, 52) = 6.34, p = .02 \)). The regression coefficient and its standard error, standardized beta and the values of \( R^2 \) and adjusted \( R^2 \) are shown in table 4. The unstandardized B and standardized Beta are significantly different from zero (\( t = 2.52, p = .02 \)). \( R^2 \) indicates that 11% of the variance in Product improvement originality was explained by SP awareness.

The linear regression with metacognitive awareness of shifting in a professional context as the predictor variable and fluency as the outcome variable revealed that SP awareness was a marginally significant predictor of product improvement fluency (\( F(1, 52) = 3.41, p = .07 \)). Table 4 shows the regression coefficient and its standard error, standardized beta and the values of \( R^2 \) and adjusted \( R^2 \). The unstandardized B and standardized Beta are marginally significantly different from zero (\( t = 3.10, p = .07 \)). \( R^2 \) indicates that 6% of the variance in Product improvement fluency was explained by SP awareness. SP competence failed to significantly predict Product improvement originality (\( F(1, 52) = 2.82, p = .10 \)).

In summary, there was support for the prediction that metacognitive awareness of shifting would positively predict product improvement originality and, to a lesser extent, fluency scores. This was a context specific effect, found only for metacognitive awareness of shifting in a professional not within an everyday context. We failed to find support for the prediction that there would be a positive relationship between shifting competence and divergent thinking on the product improvement test or for the hypothesized positive relationship between MSI components and functional creativity.
5.4. Latent abilities/tendencies that overlap between creativity and mode shifting across different domains

The analyses conducted on the data up to this point have only examined relationships between pairs of measures in order to test hypothesized relationships between mode shifting and creativity or between the K-DOCs, MSI and task based measures of creativity and mode shifting respectively. A different but complementary approach is to conduct exploratory analyses of how performance on different measures of mode shifting (from the MSI and mental set task) and creativity (from the K-DOCs, product improvement test and the coffee cup design task) together with scores on the additional measures of IQ, working memory and inhibition cluster together. An advantage of exploring which variables cluster together is that this approach is free of a priori assumptions concerning the nature of the relationships expected. It thus complements the previous analysis using regressions where we tested a priori hypotheses and specifically, helps us understand the latent abilities/tendencies that overlap between creativity and mode shifting across different domains.

Two different forms of analyses were performed in order to examine how scores on different measures cluster together. In light of the present study’s relatively small sample size a regularized exploratory factor analysis (REFA) was run to examine which measures load on to the same factors. This has been recommended as an alternative to principal components analysis with small sample sizes similar to those in the present study (Jung & Lee, 2011). A hierarchical cluster analysis was also performed to examine which measures cluster together. If a similar structure is revealed across these two different methods then that would strengthen the argument that measures that cluster together are tapping similar latent abilities/tendencies.

The REFA was run in MATLAB using code developed by Jung & Lee (2011). Running REFA based on this code resulted in six factors being extracted based on the Kaiser criterion. The regularization scheme used for the REFA was based on the anti-image assumption since it was not clear that unique variances were constant across items (S.Jung, personal communication, November 28, 2013; Jung & Lee, 2011; Konecna, Weiss, Lhota & Wallner, 2012). These factors were subjected to an oblique (geomin) rotation. In accordance with the recommendations of Jung & Lee (2011) loadings equal to and above .35 were defined as salient loadings. These are displayed in table 5. For measures loading on multiple factors we based our interpretation only on the factor on which the measure loaded highest.
Metacognitive awareness in both everyday and professional contexts, shifting competence in an everyday context, K-DOCs performance and artistic creativity loaded onto factor one, suggesting that these measures tap similar latent abilities. Metacognitive awareness in both everyday and professional contexts were the highest loading components on this factor so it was labelled ‘metacognitive awareness of shifting involved in performance and artistic creativity’. Unsurprisingly, the three product improvement test measures loaded onto factor two so this factor was simply labelled ‘product improvement creativity’. Factor three showed that the same latent abilities underlie shifting competence in the professional context, mechanical/scientific creativity, proportion of times breaking set after the set breaking item and working memory as measured by the RSPAN total correct measure. All items loaded to a similarly high degree on this factor so it was termed ‘shifting competence in a professional context, working memory and set breaking after the set breaking item related to mechanical/scientific creativity’. No MSI measures of mode shifting loaded onto factor four but it did show that similar latent abilities underlie self/everyday, scholarly and the functional creativity of designs. The highest loading items on this factor were scholarly and self/everyday creativity and hence it was labelled ‘the overlap between scholarly and self/everyday creativity related to functional creativity’. Unsurprisingly factor five demonstrated that similar latent abilities underlie set breaking before and after the set breaking item. This factor was thus labelled ‘set breaking’. Finally, no MSI measures of mode shifting loaded onto factor six but it showed that similar latent abilities underlie inhibition and intelligence. The
highest loading item on factor six was inhibition so this factor was labelled ‘inhibition and intelligence’.

A hierarchical cluster analysis was performed with measures as cases and the participants as variables. Scores on each measure were z-scored to overcome scaling differences between variables and the method of complete linkage, also known as furthest neighbour, was employed. The use of complete linkage avoided degenerating solutions being produced (C. Fife-Schaw, personal communication, June 2013). It also can be used when clusters are of different sizes as was clearly the case here (Everitt, Landau, Leese & Stahl, 2011). The dendrogram based on complete linkage is shown in figure 1 below.

![Dendrogram using Complete Linkage](image)

*Figure 1: Cluster analysis of the 16 measures. The proposed “cut” of the dendrogram is indicated by the dashed line.*

As can be seen from table 5 and figure 1, both the REFA and cluster analyses revealed six factors/clusters of measures. A similar factor/cluster structure was revealed using the two different methods. Specifically, the REFA revealed that metacognitive awareness of shifting in both a professional and everyday context, shifting competence in an everyday context and K-DOCS artistic and performance creativity all loaded onto one factor; factor one in table 5. A cluster with the exact same measures was also revealed by the cluster analysis. The REFA also revealed a factor, factor number three in
table 5, with salient loadings for shifting competence in a professional context, K-DOCs mechanical creativity, working memory, as indexed by the RSPAN total correct measure, and the proportion of times participants broke set after the set breaking item on the mental set task. The cluster analysis revealed a cluster with the same set of measures minus the measure of the proportion of times participants broke set after the set breaking item on the mental set task.

We were primarily interested in the two factors/clusters mentioned above because they contained our primary measures of interest, MSI mode shifting and K-DOCs creativity domain scores, and because they were also similar across REFA and cluster analyses. However, we also briefly mention the other factors/clusters that were found. The REFA and cluster analyses both revealed a factor/cluster with K-DOCs self/everyday creativity, scholarly creativity and the functional creativity of designs from the coffee cup design task. The REFA but not the cluster analysis revealed that intelligence, as measured by WASI matrix reasoning T scores, was also a part of this grouping. Both the REFA and cluster analyses revealed a factor/cluster with the three different product improvement scores. The REFA revealed that metacognitive awareness of shifting in an everyday context was also part of this grouping. The final cluster revealed by both analyses included intelligence and inhibition. The REFA also revealed that K-DOCs artistic and performance creativity was also part of this grouping.

Returning to the two factors/clusters that we were primarily interested in, it was interesting to note that creativity in the K-DOCs domains of art and performance and three components of the MSI (metacognitive awareness of shifting in both a professional and everyday context, shifting competence in an everyday context) loaded onto one factor/cluster while creativity in the K-DOCs mechanical/scientific domain and MSI shifting competence in a professional context, together with working memory, loaded onto another. These findings complement those obtained from the analyses of correlations and regressions. Specifically, they suggest that the latent abilities/tendencies involved in metacognitive awareness of shifting in both professional and everyday contexts and shifting competence in the everyday context overlap with those required to be creative in artistic and performance domains. In contrast, the latent abilities/tendencies involved in shifting competence in the professional context and also working memory overlap with those required to be creative in the mechanical/scientific domain.

6. Discussion

6.1. Summary of the key findings

We found evidence to support the hypothesis that there is a positive relationship between mode shifting and creativity. These findings are in accordance with those found in prior research on creativity and mode shifting that
employed domain-general measures of creativity (Vartanian, 2009; Vartanian, Martindale & Kwiatowksi, 2007; Dorfman, Martindale, Gassimova & Vartanian, 2008). Further, the current findings are the first we know of that demonstrate a positive relationship between mode shifting and creativity across different domains. Specifically, relationships between mode shifting and creativity were evidenced in the domains of mechanical/scientific, performance and artistic creativity as measured by the Kaufman domains of creativity scale (K-DOCs). There was also some evidence of a relationship between mode shifting and creativity in the scholarly and self/everyday domains, albeit the evidence for these relationships was weaker.

Importantly, findings revealed that the relationship between mode shifting and creativity within each domain hinged on the component of mode shifting being measured by the Mode Shifting Index (MSI). Different components of mode shifting were associated with creativity in different domains. Metacognitive awareness of shifting was positively associated with K-DOCs creativity in performance and artistic domains. In contrast, shifting competence was positively associated with K-DOCs creativity in mechanical/scientific, scholarly and self/everyday domains. In some cases these relationships were also dependent on the context in which mode shifting was reported. Specifically, only shifting competence in one’s professional context was associated with creativity in mechanical/scientific and scholarly domains and only shifting competence in one’s everyday context was associated with self/everyday creativity. In contrast, metacognitive awareness of shifting in both one’s professional and everyday context was associated with K-DOCs artistic and performance creativity. The REFA and cluster analyses revealed that similar latent abilities underlie working memory, shifting competence in one’s professional context and K-DOCs mechanical/scientific creativity.

6.2. Are the K-DOCs and MSI valid measures of creativity and mode shifting respectively?

Three out of the five K-DOCs domains that we expected to be valid measures of actual creative performance did indeed demonstrate evidence of validity. Specifically, creativity in the mechanical/scientific domain was positively associated with the originality of solutions generated on the product improvement divergent thinking task, creativity in the artistic domain was positively associated with both product improvement originality and fluency and scholarly creativity was positively associated with the functional creativity of designs produced on the coffee cup design task, albeit this last association was less strong. In sum, artistic, mechanical/scientific and, to a lesser extent, scholarly domains of the K-DOCs demonstrate validity as measures of actual creative performance on the measures used in the present study.

The Mode Shifting Index (MSI) also demonstrated validity as a measure of mode shifting. Specifically, shifting competence was positively associated
with the odds of breaking set after the set-breaking problem was presented. However, the positive association between shifting competence and set breaking only held true for shifting competence reported in the professional and not the everyday context. Further, there was no relationship between shifting competence and set breaking before the set-breaking problem was presented. In direct contrast to our predictions, the metacognitive awareness component of the MSI actually demonstrated a negative relationship with set breaking before the set-breaking problem, albeit this effect was relatively weak. Metacognitive awareness of shifting did demonstrate a positive relationship with divergent thinking on the product improvement task. This finding supports our prediction that divergent thinking involves mode shifting, and is another source of evidence for the validity of the MSI as a measure of mode shifting. This was a context specific effect, found only for metacognitive awareness of shifting in a professional and not within an everyday context. We failed to find any support for the hypothesised relationship between shifting competence and divergent thinking on the product improvement test. We also failed to find any support for our prediction that MSI scores would index the mode shifting we expected to be required on the coffee cup design task, with functional creativity on this task unrelated to any MSI mode shifting components.

In sum, MSI shifting competence in a professional context did demonstrate validity as a measure of real life mode shifting and there was indirect evidence, by way of the positive relationship with product improvement divergent thinking, that metacognitive awareness of shifting in a professional context was also a valid measure of mode shifting. These findings build on previous work demonstrating the MSI to be a valid measure (Pringle & Sowden, under review) and in particular strengthen the case for the validity of the shifting competence component.

6.3. Is mode shifting a domain-general or domain specific creative thinking skill?

As we argued in section 3, from a theoretical standpoint mode shifting would appear to be a domain-general thinking skill, important for creativity across domains. Our findings showing that there is at least some relationship between at least one component of mode shifting and creativity in all five K-DOCS domains appears to provide support for the position that mode shifting is a domain general creative thinking skill. However, when you examine the relationship between creativity and mode shifting at the more fine-grained level of the individual MSI components, a more complex picture emerges. The relationships between MSI components of mode shifting and creativity in different K-DOCS domains are summarised in figure 2.
Metacognitive awareness of shifting, simply termed ‘shifting awareness’ in figure 2, is the only component associated with creativity in artistic and performance domains and shifting competence is the only component associated with creativity in mechanical/scientific and scholarly domains. These findings suggest a divide between the arts and the sciences, with metacognitive awareness more important for creativity in the former and shifting competence more important for creativity in the latter. Of course the individual K-DOCs items for scholarly creativity would appear to encompass activities in not just the sciences but also in other academic areas such as the humanities and other industries such as journalism.

The distinction between the arts and the sciences is however interesting as it may help us to understand why different components of shifting were associated with creativity in different domains. Specifically, in the sciences there would appear to be a need to shift from an established way of doing things, supported by the analytic mode of thinking, to a more associative mode to discover a novel solution to a problem. For example, Items on the

![Figure 2: A conceptual diagram of the relationship between the four components of mode shifting measured by the MSI and the five domains of creativity measured by the K-DOCs. The solid arrows represent significant linear regressions between the measures. The dashed arrows represent marginally significant linear regressions between the measures.](image-url)
mechanical/scientific domain of the K-DOCs such as ‘writing a computer program’ may involve following a series of established steps to write the programming code but at points, one has to break away from these entrenched ways of working to develop novel strategies such as a workaround to overcome problems that one has never encountered before. Shifting competence may capture how good one is at breaking away from an established method to adopt a novel strategy to solve an impasse. This is exactly what the measure of set-breaking after the set breaking problem on the mental set task measures. On this task the set-breaking problem induces the impasse and the participant is required to generate a novel workaround. It makes sense then that the ability to generate novel solutions after this impasse, as measured by set breaking after the set-breaking item, was related to both shifting competence and mechanical/scientific creativity. The ability to break away from an entrenched established way of working might require a strong shift. This strong shift may tap the effectiveness with which one’s shifting mechanism, as indexed by shifting competence, can alter the balance of thinking to be more associative.

In contrast, in the arts people may be less entrenched at any time in one mode of thinking or another and, as such, one’s competence in shifting out of one entrenched mode of thought and into another may be less important. Previous findings showing that artists demonstrated more metacognition in monitoring the emerging progress of their drawings than non-artists (Fayena-Tawil, Kozbelt & Sitaras, 2011) are consistent with ours that show a positive relationship between metacognitive awareness of shifting and artistic creativity. Metacognitive awareness of shifting may be more important than shifting competence in the arts and used to monitor and make subtle adjustments in order to keep an optimal balance between the use of the two modes of thought.

Whether or not mode shifting is conceived as a domain-general or domain-specific creative thinking skill depends on how broadly mode shifting itself is conceived. Considered as one single entity, mode shifting appears important for creativity across all domains. However when viewed as a series of distinct inter-related components, the relationship between mode shifting and creativity appears more domain specific, with a differentiation between the skills required in the arts versus the sciences.

6.4. Theoretical implications of taking a domain-general or domain-specific view of mode shifting

The present findings shed light on where mode shifting fits in the hierarchy of the amusement park theoretical (APT) model of creativity. Mode shifting appears to fit best in the APT model at the level of the general thematic areas of the arts and science, with metacognitive awareness of shifting in the arts area and shifting competence in the science area. There are a num-
number of reasons why this distinction is important. Firstly, future empirical studies that aim to examine the relationship between mode shifting and creativity should focus on choosing measures most likely to capture mode shifting in the study’s creative domain of interest. Measures that tap one’s competence shifting would seem better suited to capturing mode shifting that impacts on creativity in science while measures that tap one’s metacognitive awareness of mode shifting would seem better suited to capturing mode shifting that impacts on creativity in the arts. If one takes a domain-general view of mode shifting then one may end up unknowingly selecting the wrong measures, for example measures of shifting competence, which on the basis of the present findings would fail to show a relationship with creativity in the artistic domain. Furthermore, research using neuroscientific methods to study mode shifting may gain clearer results by measuring mode shifting at the more fine-grained level of its individual components. A similar point has previously been made by Dietrich (2004) with respect to the neuroscientific study of divergent thinking.

Finally, it is also important to highlight that the context in which the MSI component of shifting competence was measured in, professional or everyday, impacted on whether a relationship between mode shifting and creativity was found. The APT model of creativity doesn’t currently account for the importance of context. The related construct of environment is listed as an initial requirement, that is one must be operating in an environment conducive to creativity to be able to express it (Baer & Kaufman, 2005). However, our findings demonstrate that context should be included further down the hierarchical model, interacting with the shifting competence component of mode shifting.

Clearly, research such as that reported in the present work which disentangles the different processes involved in mode shifting and creativity, together with the impact of context, may help us better understand why mode shifting benefits creativity in different domains (Baer & Kaufman, 2005).

6.5. Practical implications of taking a domain-general or domain-specific view of mode shifting

The most obvious areas that present findings appear to have implications for is in creativity training and educational practice. It has previously been argued that “creativity training programs tend to assume (either implicitly or explicitly) that creativity is a general skill or set of skills that can be applied in any domain to help solve any problem more creatively” (p. 159, Baer & Kaufman, 2005). However this approach is ineffective with evidence that creativity training on one task often fails to transfer to other tasks, even within the same domain (Baer, 1996). It has previously been argued that teaching strategies could be designed giving students practice at shifting between the different modes of thought so they can learn how to freely shift (Howard-
Jones, 2002). Taking a domain-specific view of mode shifting and closely matching the component of mode shifting with the activities required within a given domain should help one to develop an effective program that targets the specific component of mode shifting useful for creative thinking in the given domain. For example, practice at strengthening one’s shifting mechanism to allow it to perform a strong shift to a more associative mode from an entrenched analytic mode of thinking may be important for unlocking one’s creativity in the mechanical/scientific domain. In contrast, practice in applying one’s metacognitive awareness of shifting to better identify when it is best to adjust the balance between associative and analytic modes of thinking may be important for aiding one’s creativity in the artistic domain. In sum, taking a domain-specific view of mode shifting would appear beneficial for training people in creative thinking skills. Furthermore taking a domain-specific approach doesn’t preclude one from choosing a creative thinking skill that can benefit one’s creativity across different domains. Metacognitive awareness of shifting was associated with creativity in both artistic and performance domains, suggesting training one in this skill would benefit creativity in both.

6.6. Limitations and future research

It is important to note that the present findings only demonstrate a predictive relationship between mode shifting and creativity across different domains. Future research should go further and look for indicators of mode shifting during the creative process to examine how mode shifting impacts on the products produced at the end of that process within different domains. For example, researchers could employ think-aloud protocols or ERP’s to identify such indicators and examine mode shifting as the creative process unfolds (Sowden, Pringle & Gabora, 2015). While the majority of the effects found were in line with those predicted, it was surprising to find a lack of an association between MSI mode shifting components and functional creativity on the coffee cup design task. This was particularly surprising given previous findings have shown elevated mode shifting in a group studying/working in the design discipline of architecture (Pringle & Sowden, under review). It could simply be that the measure of functional creativity didn’t tap design creativity in this case; it may instead better capture “creative analysis” or self/everyday creativity as demonstrated by its association with scholarly creativity and also self-everyday creativity in the factor analysis. Future research is needed to examine if measures of mode shifting are associated with genuine design creativity. The findings showing similar latent abilities underlie working memory, shifting competence in one’s professional context and K-DOCs mechanical/scientific creativity suggests a role for working memory in mode shifting. It is at present unclear what this role is and further research is required in order to examine the role of working memory in the link between
shifting competence in one’s professional context and K-DOCs mechanical/scientific creativity.

6.7. Conclusions

The purpose of this chapter was to examine if shifting between modes of thought, termed ‘mode shifting’ for short, is a domain general thinking skill important for creativity across multiple domains. The findings of the present work do indeed demonstrate a relationship between mode shifting, as assessed by the mode shifting inventory (MSI) (Pringle & Sowden, under review) and creativity across different domains, as assessed by the Kaufman domains of creativity scale (K-DOCs). However, when the relationship between creativity and mode shifting was examined at the more fine-grained level of the individual MSI components, a more complex picture emerged. Different components of mode shifting were associated with creativity in different domains, with shifting competence associated with mechanical/scientific creativity and metacognitive awareness of shifting associated with artistic and performance creativity. We argue that mode shifting fits into the amusement park theoretical model of creativity at the level of the general thematic areas, with a distinction between the component of mode shifting more important in science, that is shifting competence, and the component of mode shifting more important in the arts, metacognitive awareness of shifting. This distinction is important both for informing future research examining the relationship between mode shifting and creativity and for the design of creativity training programs, that should focus on fostering the operation of the specific component of mode shifting important for creativity in a given domain.

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Correspondence
Dr. Andrew Pringle
University College Dublin
Ireland
Email: andrew.pringle@ucd.ie

Dr. Paul T. Sowden
University of Surrey
United Kingdom
Email: p.sowden@surrey.ac.uk

Carys Deeley
University of Surrey
United Kingdom

Sarika Sharma
University of Reading
United Kingdom

Authors’ Brief Bios
Andrew Pringle is a post-doctoral researcher in cognitive psychology at the Insight Centre for Data Analytics, University College Dublin. His research examines the psychological processes underpinning creative thought, with his PhD thesis in this area. He is also interested and researches the potential of games as a tool to examine cognition and behaviour.
Paul Sowden is Head of the Department of Psychological Sciences at the University of Surrey and Director of the ILLUME Creativity Research Network. His research explores the cognitive and affective mechanisms underlying creative thinking and methods of intervening to enhance the creative process.

Carys Deeley is a final year undergraduate student studying for a degree in Psychology at the University of Surrey.

Sarika Sharma is a final year undergraduate student studying for a degree in Psychology at the University of Reading.
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