CREATIVITY AND EMBODIED FLUID MOVEMENTS

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Abstract

There is an increasing body of evidence suggesting that the embodiment of certain movements can stimulate creative idea formation. Embodied Creativity suggests that embodying particular movements, often fluid, free movements can improve creative thinking over the embodiment of non-fluid movements. In the first of two experiments participants were required to navigate a character through a bespoke virtual environment while (a) following a fluid, free flowing pathway, (b) a non-fluid pathway, or (c) a straight, linear pathway. Movements were performed on a flat, horizontal axial plane. Participants completed a series of Divergent thinking tasks *(Torrence Test of Creative Thinking, TTCT; Torrence, 1974)* and a series of Convergent thinking tasks *(Remote Associations Test, RAT; Mednick, 1962).*

The first experiment results suggest a contradiction with previous findings, displaying an increase in creativity scores for participants embodying both fluid and non-fluid movements when compared to the straight pathway. It was discussed that aspects of the virtual pathway design may explain the result. Though the first experiment showed support for the idea that individuals can embody movements when immersed within virtual environments. In a similar yet revised second experiment, participants embodied fluid, non-fluid and linear movements through an altered virtual pathway. The movements were performed on a variable vertical axis, participants embodied up and down fluid and non-fluid movements. The results indicated increased divergent thinking scores for those completing both a fluid pathway and a linear free moving straight pathway over a non-fluid pathway in line with previous research (Slepian & Ambady, 2012; Leung et al., 2012). Results were discussed in terms of virtual environments, axis and embodied metaphors.

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Chapter 1 - Introduction

1.0 - History and Definitions of Creativity

Chapter one seeks to firstly illustrate definitions of creativity, whilst addressing the issues with these definitions which cause problems when researching creative thinking. Secondly looking at the ways in which research has utilised certain cognitive tasks to measure creative thinking – for example, the *Torrence Test of Creative Thinking* (TTCT; Torrence, 1974) and the *Remote Associations test* (RAT; Mednick, 1962). Moving onto the stimulation of creative thinking through a variety of methods such as incubation. Consequently this chapter intends to provide the principles needed for following discussions.

Researchers in the field propose that creativity is the foundation of current human existence, that creativity is an essential attribute in the development of culture, science, economy and society (Fink, Benedek, Grabner, Staudt & Neubauer, 2007; Gibson, Folley & Park 2009; Dietrich & Kanso 2010) and is becoming ever more important in the rapidly evolving world of science, technology and business (Jauk, Benedek & Neubauer, 2012). Not only this, a level of creativity is needed to overcome the simplest of day to day problems that may arise and undoubtedly the ability to think creatively is an extremely important aspect of everyday life. It is therefore something which science has aimed to study. Since Guildford's (1950) address stating the need for an increase in creativity research, it has become a popular and emerging research area. Though creativity is usually associated with paintings, musical composition and other works of the arts, research in this domain focusses on creative problem solving. Problem solving, over creativity in the arts leads to a more objective study of creative thought. Creative problem solving has many varying aspects, such as insight and incubation. One important developing area is in relation to the embodiment of certain movements and how this effects the way in which creative cognitive processing takes place.

Though perhaps due to the all-encompassing nature of creativity, deciding upon a rational definition, and a subsequent scientific explanation is something which research is finding quite problematic. An early idea expresses how creativity is seen as paradoxical mystery (Boden, 1994), a phenomenon that may well never be explained in terms of scientific theory due to its illusive nature. Though as Boden continues to discuss, its existence should be explained like all other cognitive phenomena. Conventional definitions of creativity may involve 'the use of a creator's imagination to envisage novel ideas'. That the novel idea somehow, and somewhat mysteriously appears to the creator, "the concept is ethereal and elusive" (Fisher, 2004). Here lies one of the main difficulties when researching creative thought, that definitions, and commonly held beliefs, pose that creative ideas are imagined, that they appear from thin air, they are magical. That musicians and artists are creative geniuses, that they possess the ability to conjure these new ideas. Creativity is something that is easily observed but difficult to measure, an artist painting a new canvas, a musician writing a song or even a mathematician solving a problem. These examples are perhaps the evidence that the concept of creativity exists, and that anyone may have the ability to be creative. Yet at the current point, one encompassing explanation for the specific set of cognitive and biological processes involved in creative idea production has to be found. Thus creativity unnecessarily continues to be a mystery.

Creativity is regarded as an aspect of human cognition which should, and can be explained. Although elusive it is still an apparent concept which can be observed. Creativity is an aspect of normal human intelligence and cognition and thus something which can be targeted and scrutinised (Boden, 2009). That when an original idea is formed there is a series of cognitive and physiological processes which have taken place for this idea to come to fruition. For this to take place the definition of creativity has been addressed, rather than the creative product being 'imagined'. The novel idea is instead a product of several previous ideas.

Creativity is therefore the ability to piece together these pre-existing ideas, transcending traditional, long-established concepts to conceive new, original ideas. It is important then to understand the diverse array of antecedents which effect the creation of novel ideas. To understand the processes which take place, and how manipulating certain external variables may change the way, or the successfulness of creative production. This will aid knowledge toward a comprehensive explanation of creativity.

"All progress and innovation depend on our ability to change existing thinking patterns, break with the present and build something new" (Dietrich and Kanso, 2010). That an individual's creative tendencies may mean they have the ability to change their established thoughts, to alter what is currently known about an object and construct something which is novel by combining or modifying once old ideas. Similarly creativity has been explained as the aptitude to combine two or more ideas that would not normally go together to produce something original (Mihov, Denzler & Forster, 2010). Though for a product to be deemed creative, the object must be unique, of high quality and applicable to the situation (Sternberg, Lubart, Kaufman & Pretz, 2005). Importantly, in accordance with this definition, the creative product must have an application, or a use, and thus should have the quality to be fit for purpose. A product of a creative thought is not creative unless it can be utilised in the proposed situation. Something that is both novel and worthwhile (Sternberg & Kaufman, 2011).

Evidently creativity is a relatively complex phenomenon, creative moments are diverse and spontaneous. More than that creative moments are elusive, which makes the study of these moments very difficult from a scientific point of view. This said, it is still possible to do so, and many researchers, using a variety of different research methods have tried to encapsulate and understand the mystery of creativity.

1.1 - Measurements of Creative Thinking

Research into creative thinking has focused upon divergent and convergent thinking as constructs for assessment (Guildford, 1950). Divergent thinking as the capacity for an individual to provide multiple original answers to an open ended question. Convergent thinking being the ability of an individual to present an answer to a question requiring one answer.

Breaking creativity down into these more observable attributes has allowed research to flourish. The majority of research into creative thinking utilises Guildford's ideas surrounding convergent and divergent thinking. The notion of creativity is seen within research as a type of problem solving, that individuals are required to solve problems by thinking in creative ways; either solving divergent problems or convergent problems similar to what occurs in day to day life though in a less structured way. Researching in this manner, rather than looking at aspects of creativity such as in the arts or music, allows for the ability to operationalise the study of creativity.

Deciding upon a feasible definition for creativity is not the only struggle when undertaking research, often creativity is spontaneous and complex (Zeng, Proctor & Salvendy, 2011) therefore capturing and measuring these moments of creative thinking can also be difficult. Thus researchers have attempted to streamline the ways in which creative thinking is measured, by attempting to create tests and tasks which can be applied to a variety of situations through allowing researchers to compare like for like. Perhaps due to the complexity of creativity there are at least 255 tests attempting to assess creative ability (Torrence & Goff, 1989).

Divergent thinking tasks give individuals the ability to think creatively but in a fairly structured, measurable way that is in line with the common definitions of creativity. Guildford (1967) introduced several divergent thinking tasks. Developing the alternative uses test, a staple in creativity research based on the principles of divergent thinking. Requiring individuals to name as many unusual or alternative uses for a brick, a newspaper or other objects. The principles of divergent thinking were expanded on by Torrence (1974) in the development of the Torrence Test of Creative Thinking (TTCT). The TTCT is a more established version of Guildford's ideas, encapsulating aspects of divergent thinking, whilst adapting Guildford's tasks to make them more suitable for research. Torrence also provided researches with ways to measure participant's responses to these divergent thinking tasks. Proposing that divergent tasks can be rated on four scales, for fluency, the number of meaningful responses. For flexibility, the number of differing categories that the ideas fall into. For originality, essentially the most important scale and associated with the rarity and novelty of the answers presented. Finally elaboration, the depth to which the individual explains the answer given, or how many answers they provide to the question.

Treffinger (1985) found that the TTCT was fairly reliable, and good for investigating individual and groups differences, however the TTCT may struggle when trying to assess individuals. The main criticism of the TTCT is that the visual aspects of the test needed updating such as the drawings and pictures, and also that some of the concepts and ideas needed changing to bring them in line with modern culture (Cooper, 1991).

Convergent thinking tasks require only one correct answer, and little divergent thinking, though they are still a useful measure of creativity because they test individual's propensity to use associative hierarchy's. Mednick's (1962) remote associations test (RAT) is one of the most common convergent thinking tasks used in research and requires individuals to find the last word in a string of four distantly related words. For example Cream, Skate, Water, the answer would be Ice. Convergent thinking tasks have been employed to research insight as an element of creativity, this being insight. Creative insight has been coined the 'aha' moment (Barren & Harrington 1981, Shobe, Ross & Fleck 2009, Kounios & Beeman 2009) because of its instantaneous appearance when trying to solve a problem, similar to Archimedes' Eureka! Moment, there is a sudden, spontaneous flash, and the answer becomes clear when before it was not.

Perhaps the main issue with simplifying creativity into convergent and divergent thinking is the risk of being reductionist. As discussed above, creativity is a highly diverse topic which may require a more all-encompassing test to research overall creative ability. A criticism may be then that rather than focussing on creative capabilities of an individual, the tasks may actually be measuring aptitude to think divergently and convergantly. Therefore not assessing creativity at all but two separate constructs. Thus steps have been taken to attempt to increase the reliability and validity of divergent and convergent thinking tasks (Silvia et al., 2008). The issue with convergent and divergent thinking tasks is that what they are measuring could be another concept of human cognition. That the tasks themselves may be reliable, but targeting at the wrong behaviour. Researchers may have fundamentally different definitions of creativity from task to task. These tasks may be unintentionally measuring aspects such as motivation and personality (Cropley, 2000). This said, the reduction of creativity into problem solving tasks allows for researchers to investigate in a structured way, whilst still maintaining the key aspects of creativity.

The cognitive neuroscience aspects of creativity focus on hemispherical differences, brain locations and brain states, research also utilises divergent and convergent thinking tasks. EEG recordings have been a vital tool in the hunt for the location, triggers and brain processes surrounding creative thinking, which in turn can be utilised to further the understanding of creative moments.

Insight moments have been linked to a specific series of cortical processes known as the brain blink (Kounios et al., 2006). Prior to solving an insight problem brain activity has been shown to slow down, this pause is followed by a spark of activity when the answer is formulated (Kounios et al., 2006; Kounios & Beeman, 2009), however this is not always the case for the temporo-parietal junction which alpha power often increases. Potentially emphasising the importance of this area of the brain within creative moments. These findings go hand in hand with a plethora of work showing a relationship between creative thinking and a drop in brain activity subsequently followed by a burst of activity (Danko, Starchenko, & Bechtereva 2003, Jung-Beeman et al. 2004 & Kounious et al. 2008).

Fink et al. (2009) showed that during original idea development tasks participants showed an alpha synchronisation in the frontal lobe, and also the parietal lobe. The left hemisphere was dominant when it came to task performance. It was summarised that rather than cortical idling, the brain processes observed were genuinely down to cognitive activation when completing creativity tasks. Interestingly an increase in alpha activity at the parietal lobe was observed, this is similar to Fink and Neubauer (2006) who found that on originality based tasks alpha synchronicity occurred at this site which is often linked with bodily senses and touch. Jauk, Benedek and Neubauer (2012) looked for differences in EEG recordings between participants who completed a divergent thinking task and those who completed the same task but in a convergent way. The results showed that those who completed the divergent thinking task exhibited higher alpha power at similar sites to those in previous experiment. Establishing the notion that both the frontal and parietal lobes play in creative thought though differ over convergent and divergent tasks.

Dietrich and Kanso (2010) provide a review showing a range of research attempting to explain a localisation or hemispheric specificity of creativity using brain related methods. Though unlike the agreement regarding the 'brain blink', there is very little to agree upon in regards to creativity as a whole from physiological point of view. In fact, very few of the authors are in agreement. This may because researchers have used many differing divergent thinking tasks, also these are then compared with control groups which may differ from study to study which makes it very different to compare studies as like for like. This point is illustrated by Arden, Chavez, Grazioplene and Jung (2010) who in a review of 45 studies found there to be very little consistency from one article to next. There have been as many different methods used as studies. Discussing that a reform needs to take place in creativity research to unify research methods so studies can be compared on a level basis. This is unacceptable within this area, as there are several well established, standardised tests which may be used when undertaking research. Therefore subsequent research should utilise these standardised tests, rather than devising their own.

Research utilising brain imaging techniques such as the EEG and fMRI have struggled to draw any major, concrete conclusions regarding any aspect of creative thinking. There is a large amount of uncertainty and many authors are in dispute. Essentially the area is a minefield, though there are some interesting results from individual studies there is generally a lack of cohesion. This, as highlighted earlier could be due to a problem with research method differences across studies. It has emerged that research should focus on one research method to allow for comparisons. Such as using one type of divergent thinking test, and one for convergent thinking. Though what has been found using brain related methods is applicable to the current study, there is one finding that stands out. That during certain tasks activation in several areas, between the frontal and parietal lobes, occurs just before the creative response takes place.

1.2 - Stimulating Creative Thinking

A developing, important subsection within creativity research has taken to improving creativity in various ways. To try and either develop the way in which people produce novel ideas or attempt to overcome fixed states of thinking to help to develop new ideas. This seems more pertinent in terms of understanding creativity, and being able to use knowledge to improve the creation of ideas within economics, technology and society over researchers using brain imaging techniques to simply journal what takes place during a creative moment. Several studies have provided techniques for improving creativity, for example, changes in intrinsic motivation can improve creativity within organisations (Amabile, 1997). Behavioural mimicry as a social cue increased divergent and convergent thinking (Ashton-James, Van Baaren & Chartrand, 2007). Fink, Grabner, Gebauer and Reishofer (2010) showed that cognitive stimulation in the form of idea sharing enhanced participants originality in a divergent thinking test, that participants allowed to share ideas then provide more originality in there subsequent creative thinking. This, hand in hand with several other pieces of work highlight the ways in which creative thinking can be improved by altering specific factors in relation to a person.

This is important in terms of creativity, as creative thinking is often linked to minority groups, often with higher intelligence (Jauk, Benedek, Dunst & Neubauer 2013), certain unique personality attributes (Eysenck, 1993), or specific genetic profiles (Kuszewski, 2009). Indicating that to be creative, an individual must have very specific attributes. However research showing general improvements in creative thinking amongst groups of people highlights how, essentially anyone can think creatively. The step for research is to strive for a uniform answer toward promoting creative thinking, as currently research is showing many differing areas in which creative thinking has been stimulated. There may well be one specific factor which more efficiently allows individuals to think more creatively, on the other hand it may well be due to several factors all playing a part.

Incubation has also been shown to stimulate creative thinking, incubation is a moment of inspiration when a problem is solved when not directly concentrating on that particular topic (Baird et al., 2012). Thoughts are focussed elsewhere and suddenly the answer appears. Similarly to insight (Seifert, Meyer, Davidson, Patalano & Yaniv, 1994), opportunistic assimilation has been described as one explanation for incubation effects (Sio & Ormerod, 2015). In particular incubation is useful at overcoming functional mental fixedness, a state in which the individual loses the ability to think or solve the specific problem. They are limited in their approach to an idea, in that they are incapable of thinking about it in another way. Smith and Blankenship (1991) argued that incubation gave problem solvers time to forget that they were stuck on a problem, allowing them to become less inhibited by their thoughts of the incorrect answer and focus upon being creative in finding the correct answer.

Koppel and Storm (2014) displayed that a twenty-two minute incubation periods allowed participants to overcome memory inhibition and successfully solve previously unsolvable remote associations. Studies like this indicate a specific process which is taking place. That leaving an unsolvable problem for a varying length of time and focussing on something other than the problem can stimulate a positive response to the question. The act of redirecting conscious thought processing towards another target triggers subconscious thought process to focus on the previously unsolvable task. Creative problem solving has also been stimulated with incubation effects (Gilhooley, Georgiou, Sirota & Paphiti-Galeano, 2015). On an alternative uses task participants who were allowed an incubation period with a distractor task and an incubation period with suppression performed better on the task than the control groups.

Demonstrating how incubation effects can stimulate not only insight type problems, but those which involve divergent, creative type thinking. However incubation is perhaps not the most practical way of stimulating creativity thought, as it requires movement of cognitive resources away from the problem for several minutes. In a real world situation, creative problem solving is often needed urgently where incubation would be normally an impractical solution. Therefore more convenient solutions are needed for this problem. A method which could stimulate creativity very quickly, the individual could utilise a technique that would act like incubation though over a shorter period of time.

Chapter 2 - Embodied Creativity

2.0 - History, Debates & Definitions within Embodied Cognition

Chapter two will focus on the principles of embodied cognition, and how this has recently been associated with creative thinking. This chapter will firstly provide the background theory within the area of embodied cognition and then provide research which has been undertaken looking at the way certain physically embodied actions can affect cognition. Moving onto how creativity and embodied cognition ideas have been associated, and the notion that embodying fluid movements can stimulate creative thinking.

Evidently research has shown how creative problem solving can be stimulated and improved using a variety of techniques, methods and stimuli. In a similar light the emerging domain of Embodied Creativity has utilised divergent and convergent thinking tasks to develop a concept that links sensorimotor states and high level social cognition. Under the wide ranging scope of embodied cognition, Embodied Creativity posits that interaction between the mind, body and the world in specific ways can influence originality in thinking and problem solving. Proposing that specific actions taken place in the real world by the individual can stimulate the creative process, allowing those individuals performing the action to gain an advantage in creative problem solving ability in comparison to a group with a differing embodied stimuli.

The core principles of embodied creativity lie within embodied cognition, initially therefore it is important to briefly explain definitions and a background to embodied cognition before moving onto how embodiment has been shown to improve creativity thinking. Embodied cognition, in a movement away from cognitivist principles, emphasises the role that the environment and the physical body takes in cognitive processes. Embodied cognition then, diminishes the importance of internal, diagram based theories such as memory to focus on how the external world and the embodiment of certain actions can effect cognition. Aspects of both the brain and the body work in collaboration during cognitive processing, the brain needs the sensory and motor systems to think. The characteristics of the inputs into these systems subsequently shapes the internal processes involved. Embodied cognition therefore posits itself in contrast with what may be called the disembodied cognition hypothesis (Mahon & Caramazza, 2008).

Embodied cognition can be linked to the philosophy of mind debate. One of the first noted theories surrounding the mind body debate perhaps came from Plato (Silverman, 2013) who discussed the Theory of Forms, similar to the idea of a soul in that the body is a temporary house for the form to reside. That mind and matter are fundamentally different and once the matter had aged and died the soul would move on, the soul is immortal and essentially imprisoned within the body until the matter decays. Perhaps slightly farfetched, however Plato was proposing an idea which remained virtually unchanged for two millennium. Rene Descartes extended the ideas surrounding the mind and body debate, proposing that via a gland in the brain the 'mind' again, similar to the 'soul' or 'form' was used to control both the brain and the body. This explanation became known as Cartesian dualism. That the mind cannot exist beyond the body, though the body is unable to process thought. Though this viewpoint is hazy and fails to provide substantial reasoning behind the belief that the mind and body are separate entities functioning for one specific cause.

Though this viewpoint is fairly similar in some respects to standard theories of cognition. For example working memory (Baddeley & Hitch, 1974) in which the processes involved are largely abstract from the body and the environment. Possibly the most pragmatic view then is the idea that the mind and body work together to complete cognitive processes, that external influences in the real world have effect on the mind and body, and the mind and body influence the world. Embodied cognition can be seen as a proposed alternative to cognitive psychology, moving away from the idea of problem solving as input and output, using symbols and computation, though most importantly overcoming the idea that cognition is an entirely internal process (Cowart, 2004).

The term embodied perhaps came from Varela, Thompson, and Rosch (1991), who also proposed *'enaction'* or the "growing conviction that cognition is not the representation of a pre-given world by a pre-given mind but is rather the enactment of a world and a mind on the basis of a history of the variety of actions that a being in the world performs" Varela et al. (1991, p9). As Anderson (2003) discusses, most real world thinking actually takes place in a specific, often complex setting, and frequently involves the management of external, environmental objects. Thus a theory which takes these aspects into account holds unquestionably more relevance.

An example of this is within Vision, vision cannot simply be explained using an inner model, it is something which is active and intelligent, solely based on what is taking place within the external environment (Clark, 1999). This is a logical explanation, that the mind is situated in a setting with an almost constant stimuli from external agents. Thus cognition is attained from stimuli from the external world, and inner cognitive diagrams may struggle to explain.

The main debatable issue is that embodied cognition struggles to settle upon one feasible definition. There are often several interpretations and ideas regarding embodied phenomena, sometimes three explanations (Shapiro, 2007) or even six views (Wilson, 2002) stemming from embodied research. For each researcher there may be a different explanation for embodied occurrences (Adams, 2010).

Embodiment has also been connected with language processing (Feldman & Narayanan, 2004) and metaphor (Gibbs, 2006). That certain words and phrases are associated with an embodied simulation of the action. For example, action words relating to the leg, such as kick have been shown to activate areas corresponding to moving the leg in a kicking motion (Hauk, Johnsrude & Pulvermüller, 2004). This is similar to action related sentences, which have been shown to stimulate hand and feet when the sentences refers to that specific body area. Essentially for an individual to hear or speak a verb the action is internalised similarly to actually performing the movement. Potentially this association originates in early language development, that as a child action related language may be taught whilst displaying the specific action. Thus associations between the action and the word develop early within the child. This may also be explained through mirror neurons (Fogassi & Ferrari, 2007), that the individual observes the action taking place and the language is then associated through observation and performance of the action. Therefore words and metaphor are imperative within embodiment movement, that metaphor and embodied experience of the action illustrated with the metaphor are fundamentally connected (Gibbs, Lima & Francozo, 2003).

With careful consideration regarding embodied cognition the stance for the current research is that some cognitive processing takes place with agents beyond the brain and mind alone, that external bodily factors and experiences contribute to the inner world. The belief that actions beyond the body are the sole reasoning behind the way cognitive processing takes place. That without the body's senses such as sight, touch and hearing the mind would essentially have no purpose. The main ideas within embodied cognition then are that cognition is situated within an external environment, and that this environment plays a part in cognitive processing (Wilson, 2002).

2.1 - Examples of Studies within Embodied Cognition

Though often embodied cognition is discussed from a philosophical point of view, there are several pieces of empirical research which have aimed, and often succeeded in highlighting the connections between mind and body within cognitive processing. Displaying the way specific actions grounded in a certain physical movement or bodily behaviour can change an individual's thinking patterns. That movements can alter pre-existing thought processes without the knowledge of the individual.

Often these studies look to a common metaphor, or well-known saying to research. One such study (Miles, Nind & Macrae, 2010) believed that mental time travel, or the act of thinking in the past at memories or into the future was dictated by sensorimotor states, in that these mental ideas are embodied. Investigating the notion that the past is behind us, and the future in front. Participants in condition A were required to imagine what their life experiences had been like in the past 4 years. Participants in experiment B were required to imagine what their life experiences would be like in the next 4 years, in the future. Participants were attached to a motion sensor to measure the distance and direction of movement when providing answers, were allowed to move when answering the imagery question.

The results showed a link between body movement and brain activity, that retrospective thought was tied to backwards movement, and prospective thought tied to forward movement. That thinking ahead creates forward movements, and thinking back creates backwards movements. The researchers propose future research surrounding more in depth distance measurements, for example looking back further in time may produce a larger movement. However as the study only used twenty participants, a study replicating the current one with a larger sample would maybe a more meaningful initial next step for the research area.

Weight has been something embodied cognition researchers have looked at, that holding or carrying heavier objects has several important effects on the way cognitive processes take place furthering the link between mind and body. For example, Proffitt (2006) who found that participants wearing heavier backpacks judged distances to be further and the severity of hill climbs to be steeper than those with lighter backpacks. Jostmann, Lakens and Schubert (2009) proposes that weight can be embodied in a signification of importance. In a series of four studies research found that participants holding a heavy clipboard, over a lighter clipboard were more likely to increase judgements of monetary value, regard fair decision making as more important and agree more with strong arguments. Links to creativity can be seen in their third experiment, where Jostmann et al. (2009) discuss how cognitive elaboration can increase when holding a heavier clipboard. However the clarity of this argument is fairly low, as the tests undertaken when holding the clipboard have very little to do with elaboration and rather are related to judgements. This said the study is pertinent in terms of showing how the bodily experience of weight is grounded within cognitive processing.

Slepian, Ambady, Weisbuch, Bastian and Pauker (2014) looked at how embodying fluid movements can lead to differing social categorisations. That tracing a fluid line, as opposed to a non-fluid line allowed participants to show more concern for social inequalities, to stereotype less and to be less strict in terms of social categorisation. On the whole, tracing the fluid line made participants softer and somewhat more caring in their approach to social factors over non-fluid line tracers. A similar result was found in a prior study, participants were more likely to categorise a sexual ambiguous face as male if they were squeezing a hard ball over a group of participants who were squeezing a soft ball. Showing that hard and soft, likened to, and with similar properties to fluid and non-fluid can influence social categorisation (Rule, Rosen, Slepian & Ambady, 2011).

A further study displayed that when two sets of participants viewed a clip that caused disgust, the set of participants who were required to wash their hands, compared to a set of participants with 'dirty' hands ranked social judgements differently (Schnall, Benton & Harvey, 2008). The cleanlier set of participant's ranked moral judgments with less severity than those who had not washed their hands. Researchers aim to link increased physical purity, clean hands, with mental cleanliness and positive thinking. Davis et al. (2012) linked this result to a law situation in which the jury is allowed to leave for a bathroom break before a verdict is made; it was discussed that jurors may be influenced inadvertently by their own hand washing behaviour. Those those who wash their hands may judge the defendant in a more lenient way. A similar phenomenon has been found (Lee & Schwarz, 2011), they discuss that not only cleaning the body of containments, and washing hands can act as a cleaning of the mind. This is compared to the cleaning of a slate, and the study found that participants who cleaned their hands with an antiseptic wipe were less likely to do good by volunteering to help, an action taken by the researchers to mean the participants were feeling less guilt.

Ackerman, Nocera and Bargh (2010) investigated touch, and discuss in a series of six experiments how touching or holding certain objects can cause several effects. Holding heavy or light clipboards, solving puzzle with rough or smooth textures or touching hard or soft objects unintentionally altered judgements surrounding people and conditions. The experiments showed several main effects, heavier clipboards, like in previous studies showed a higher importance for job candidates, social interactions seemed more awkward when holding rough objects, and holding hard objects made negotiations more ridged.

The sensation of warmth has been shown to effect judgements (Williams & Bargh, 2008), and without the participants awareness it was found that those who held a cup of hot coffee versus those holding a cup of iced displayed a higher level of trust towards a target person. The target person was judged as more personable to the participants holding the warm coffee which indicates that embodying the feeling of warmth then allows the participants to feel warmth towards a stranger. This study highlights again how embodying basic sensations cause numerous interesting effects.

It is evident then that embodying certain sensations, movements or feelings effect the way in which an individual thinks and behaves. By grounding an embodied action or movement an individual's cognitive processing of emotion, decision-making or other attributes can be changed. Embodying certain actions has been shown on several occasions, and across varying domains to effect cognition (Shapiro, 2007). The issue is however, explaining how and why embodying certain movements or actions can alter cognitive processing. That as illustrated prior, a plethora of evidence showing aspects of embodiment influencing cognition.

2.2 - Emergence of Embodied Creative Thinking

The scope of embodied cognition is far reaching, touching upon many different aspects of human cognition. Research has recently moved toward linking embodied cognition and creativity, that embodying certain movements and actions can stimulate creative thinking. However, a critical analysis by Stancui (2015) displays the lack of research in the embodied creativity research area, indicating that this 'underdeveloped subject' should be a focus for researchers. Affirming that embodied creativity is not only useful in understanding the creative process, but on shaping creativity itself. Stancui only highlights two empirical research papers that have published in the area, both of which are discussed later.

However, there have actually been several other appropriate research articles, overlooked by Stancui that are useful within this area. Such as Chu and Kita (2011) who showed that amongst other things problem solving was improved in a condition which encouraged the use of fluid hand gestures. Also Werner and Rabb (2015) who showed that priming participants with certain body movements increased their problem solving ability. Playing Tetris, a problem solving game, was made easier by performing the movements in the real world, using physical representations rather than processing in the head alone (Kirsh & Maglio, 1992). A study which was followed up by listing several ways in which embodying physical representations can help to improve problem solving (Kirsh, 2010), such as providing a structure that can serve as an object of thought, allowing us to "think the unthinkable" (Kirsh, 2010, p1).

In relation to creative Insight, research has been fairly underwhelming on the whole, though Thomas and Lleras (2009) found that problem-solving success was improved in a condition which allowed participants to swing their arms in a fluid motion. In comparison to a condition in which the participants were allowed to stretch their arms out straight. There are several issues with Thomas & Lleras work, firstly the problem participants were attempting to solve was Maier's (1931) two string problem in which two strings must be tied together though they are too short to walk and reach. Thus a pendulum must be created using a given object to swing the string to the correct side of the room. Clearly allowing participants to swing their arms is more of a clue to the problems answer than anything that can substantially link bodily movements and higher cognitive processing. Secondly Thomas and Lleras link the solving of the answers to insight, when referring to definitions of insight this is an incorrect label. There are no measures for insight within the experiment and insight moments are more or less unobservable without the EEG (Kounios & Beeman 2009) or participant's verbal discourse.

One of the more prevalent studies in the area of embodied cognition (Stancui, 2015) was by Leung et al. (2012). Focussing on five commonplace creativity metaphors, and whether these have any influence upon creative thinking themselves. In one of three experiments, participants who were asked to swing their arms, over participants who were asked to stand still provided more creative ideas when asked to present them in front of a panel. The second experiment of their research required one group of participants to both eccentrically and ingeniously answer remote association tasks from within a cardboard box – testing the 'thinking outside of the box' metaphor. Interestingly participants who were physically outside the box answered more correct RAT triads than those inside the box. Asking participants to answer questions from within a box may perhaps have certain obvious external variables.

Still testing the outside of the box metaphor, researchers asked participants to walk around a room in either a fixed, rectangular manner, in an unrestricted fashion, or to simply sit down. Scores on two divergent thinking tasks showed that participants in the free-walking condition scored higher for originality than the fixed path, or the sitting condition. Though scores on fluency and flexibility did not differ. In a third experiment Leung et al. (2012) developed the finding that free-movement can aid creativity thinking by mapping a virtual level in Second-Life that required participant's to either walk freely or along a fixed path for three minutes before answering a divergent thinking task regarding gift ideas. Interestingly participants who walked freely scored higher originality scores than those on the fixed path highlighting how free bodily movements can increase creative output. Although an interesting result, the effect sizes for a few of the experiments were fairly small. Nevertheless, walking in a free- way, whether physically or virtually, has been shown to improve creative thinking. That there is something within the action of free movement that increases the propensity of an individual to think creatively in comparison to an individual on a fixed path.

A noteworthy outcome in the area, that embodied fluid movements can aid in the production of creative ideas. Not only this, and possibly more importantly, is that embodiment does not need to be physical; it appears that it can be virtual. An individual merely has to experience the given embodied action in a three dimensional world for the effect to take place. The action does not need to take place in the real world, it can all be done digitally yet the response, in terms of creative output still increases.

The notion that embodied movement effects are still present within virtual worlds is interesting as prior to this research the understanding was that embodiment was a physical construct only. That an individual had to physically experience the stimulation for it to effect cognition. This finding displays how maybe there are structures within the mind and body to allow for virtual embodiment.

Though this brings about an important argument, soft embodiment versus hard embodiment, essentially whether a human mind can function adequately in a virtual body other than its own. That a virtual body can appear to an individual as their own, and any form of stimulation on the virtual body is internalised as it would if it was on their physical body. Any virtual embodied movements feel real. Soft embodiment referring to the embodiment of certain movement or actions within a virtual world, and hard embodiment being the standard embodiment found in previous studies such as the heavy versus light clipboard experiment. Referring to Leung et al. (2012) this would appear to be the case, free movement within the virtual world causes the same effects that free movement in the real world does; an increase in creative thought.

This is similar to in Botvinick and Cohen's (1998) experiment, in which participants were required to focus on a rubber dummy left arm being stroked by a paint brush from behind a screen that their own arm was covered by, therefore the dummy arm appeared to be their own. Participants reported 'feeling' the brush stroking the artificial arm, indicating that although the arm was clearly not theirs, they had sensed the touch. Therefore the participants mind had mistakenly believed the arm to be their own.

"Senses are the portals to the mind" (Biocca, 1997), so for an individual to feel the sense of touch on an arm that was not their own is very interesting and visibly highlights how embodiment may be 'soft', that an individual can feel immersed in the sense of another body, and that the mind is almost deceived into false feelings from an alien body. An experiment by Ehrsson (2007) showed how the sense of being located within the brain can be completely altered by moving a participants perceptions externally. Participants wore head-mounted displays connected to cameras that created the illusion of looking upon yourself from another person's perspective. Participants affirmed to the notion of and out of body experience. Interestingly relating back to the brain studies, researchers found that the temporo-parietal area had some connotations with creativity, this area is also linked to body ownership and out of body experiences. Thus there is a possibility that activation within this area may have links to both embodiment and creative thinking.

Embodiment in a virtual sense is orthodox within the domain of first person gaming, the camera is set within the head of the character. The user experiences the virtual world through the eyes of the character, creating a feeling of immersion and embodiment. Essentially once an individual feels comfortable with controlling a character, their own body becomes but a tool to control their virtual self. Any physical attributes that may be holding a person back in the physical world are forgotten, and the user essentially becomes one with a virtual body other than their own. Kilteni, Groten and Slater (2012) express a 'sense of embodiment' as the feeling that emerges when the actions of a secondary body are processed in the same way as that of one's own biological body. Proposing that the mind has the ability to perceive another body, perhaps virtual, as its own. That despite not being physically connected, the mind still reacts to virtual audio and visual sensory stimuli from a first person outlook as if it was happening in the physical world. If so this has important connotations in cognitive tasks, as it has been found that individuals who were in control of a virtual casually dressed dark-skinned body performed a significantly higher number of moves when it came to a drumming task than did those controlling a formally dressed light-skinned body (Kilteni, Bergstrom & Slater, 2013). Participants on the whole reported a strong ownership over their virtual body. Within a virtual world this is often referred to as Presence. Presence is the immersed feelings people often get whilst in virtual environments, such as fear virtual cliffs when there is nothing to fear. There are several factors which can effect level of presence, such as participant involvement and environment realness (Schubert, Friedman & Regenbrecht, 1999).

Noting participant involvement and environmental realness as the key factors for virtual embodiment is relatively inadequate. Unquestionably they are imperative aspects to consider when attempting to immerse an individual within an embodied virtual setting. Though the differences between real embodiment and virtual embodiment are vast, total immersion is regarded as purely 'techno-fantasy' (Farrow & Iacovides, 2013). That the idea someone can be fully immersed within a virtual world, with no comprehension of the real world is for now unrealistic. However this is a current aim for the video game industry, to develop games with complete sensory immersion. It is something which is not currently obtainable, also somewhat undesirable. For now the most appropriate way to attempt to make individuals feel immersed and embodied is through suitable game design, drawing individuals in (Jennett et al., 2008). If levels are similar to those found in the real world this may allow players to feel ‘at home’, it is therefore imperative that textures used are suitable, things such as doors and windows are comparable to real life and most importantly for the current study that characters move in the same way as humans.

There is a succinct difference however between embodiment and immersion. Though it is possible for an individual to participant in a game and feel both embodied (sense of embodiment) and immersed (presence). It is also possible for an individual to be embodied and not immersed, and immersed but not embodied when gaming. For instance, since the introduction of Nintendo Wii (2006) type games, followed by PS Move (2010) and Xbox Kinect (2010) individuals have been participating in embodied games, requiring physical bodily movement to drive virtual character movements. For example, moving the Wii remote to strike a golf ball. This is different to being immersed, the individual performs the action to move the virtual character to strike the golf ball, however there is a chance the person will not be immersed sufficiently to believe the character they are controlling is themselves. It is again therefore imperative that participants are comfortable with the controls (McGloin, Farrar & Krcmar, 2013; McGloin, Farrar & Fishlock, 2015), feel a relation in terms of body structure with the character and appreciate the textures used within the design. It may be then that soft embodiment within virtual worlds is a valid mechanism of the human mind. Though from a philosophical view point the feeling that the mind and body can be separated, and the mind can then function normally whilst in control of a foreign body is perhaps a further argument. For the current study, soft embodiment will be taken as a potential attribute of human cognition.

Moving away from virtual embodiment, Slepian and Ambady (2012) link free flowing, fluid movement to an increase in creative thinking. The researchers liken creativity to the movement of fluids. In contrast to structured analytical thought, creativity is said to be ‘liquid’. That when thinking creatively, people think in a smooth and flexible way, not in a concrete way, but problems can be solved by again, ‘thinking outside of the box’. In a series of experiments the researchers apply the emerging concept that fluid motion embodied in sensorimotor systems can stimulate creative thinking.

They explored this idea by asking participants to trace one of two lines, a line which was curved and fluid, and a line which was sharp and jagged. The lines the participants were required to trace were visibly different, the fluid line was very free-flowing, and relatively easy to trace in terms of time and thought. Whereas the jagged line took more effort to trace due to its non-fluid, jagged nature. Post to tracing the line participants were asked to complete a divergent thinking unusual uses task. The task was from Guildford (1967), and required the participants to name as many unusual uses for a newspaper as they could, they had one minute to think of as many ideas as they could. Also participants completed a mood questionnaire, specifically no differences were found indicating mood was similar across condition. Responses were independently rated and scores for participants who traced the fluid line scored higher for originality (statistical rarity of answers) and fluency (number of answers). Showing that participant's following a fluid, free flowing line gain an increased capability to think creatively in comparison to a non-fluid, less free-flowing line. However the researchers only chose 2 of Guildford's measurement scales to compare, it may have been interesting to see if there were any differences in terms of elaboration (depth of answers) and flexibility (amount of categories answers fall into). Perhaps the non-fluid path provided a greater number of answers, even though the answers were less creative. It would have also been affable for the researchers to use a few more of Guildford's creativity tests, to provide a bigger picture in terms of the differences between fluid and non-fluid lines. The use of only one test increases the risk of a type 1 error.

In a second experiment it was found that participants who traced fluid lines scored a greater amount of correct answers on Remote association triads than participants who traced the non-fluid line. This being convergent thinking rather than divergent thinking in the first experiment, this is useful as relating to Guildford, convergent and divergent thinking make up creative thinking. Therefore showing that participants who traced fluid lines scored better on convergent thinking and divergent thinking. Participants who trace the fluid line are more creative. Furthermore there was no difference between participant's scores on math problems, illustrating how fluid movement only aides in creativity related problems and does not change the way in which individual's solve more analytical problems.

In a further experiment, and what initially seems like a movement away from creativity the Slepian and Ambady looked at cognitive flexibility. This is justified in that to be creative there needs to be a level of rule breaking, thinking about an object in an uncharacteristic way, and utilising pre-existing thoughts to develop new ideas. This could again be linked to the 'thinking outside of the box' metaphor common throughout creativity research, and to the researcher's divergent thinking first experiment. It was proposed that fluidity in movement would improve the flexibility of thought processes. The results from this experiment showed that in comparison to non-fluid line tracers flexibility of thought was improved in the fluid movement condition. Though with all the experiments undertaken by Slepian and Ambady, their conclusions may have been stronger if there was a third control condition by which comparisons could be made against. Although they found differences between fluid and non-fluid line tracing on all their experiences, this could be due to the non-fluid line decreasing creativity scores rather than the fluid-line increasing creativity scores. For a real world application it would be useful to understand if in fact fluid movement does increase creative thinking. If Slepian and Ambady could conclude that fluid movement causes an increase in the predisposition to think creatively then these ideas could be adapted and applied to those who are in need.

Although Slepian and Ambady's research has highlighted a very interesting phenomenon, in that tracing a fluid line can improve an individual's tendency to think creatively. Findings across the board display how tracing a fluid line improves cognitive flexibility, convergent thinking and divergent thinking over a non-fluid line. Displaying an overarching judgement that fluidity, either fluid or non-fluid has implications in regard to creative problem solving. However, similar to Leung et al, Slepian and Ambady provide little explanation to why this phenomenon exists, posing that 'bodily movement can influence cognitive processing, with fluid movement leading to fluid thinking'.

The field of embodied creativity is emergent, and the link between fluidity and creative thinking has only been reported upon twice. So evidently an explanation for this phenomenon is unlikely to be found momentarily. However it would be useful for researchers to provide some possible explanations, and in turn provide a focus for future research. Highlighting problems with their current study so those trying to further the knowledge in the area have a basis. As fluid motion has been shown to improve creativity both virtually and physically embodied in comparison to a non-fluid condition, it would be useful to have some form of explanation for this in terms of a discussion. Though rather than providing an insight at an explanation of the occurrence, Slepian and Ambady fail to provide any clarification, and reinstate their experimental findings.

Therefore this provides the reasoning for the current piece of research. Researchers such as Slepian and Ambady (2012) and Leung et al. (2012) have revealed an interesting aspect of creative thinking and problem solving. As discussed previously, papers within this area of creativity show that fluid, free motion as opposed to non-fluid movement appear to stimulate creativity within problem solving tasks. That when individuals are required to perform movements which invoke fluid, free flowing actions, this, in a way currently unbeknownst to researchers allows the ability to think more convergent, divergent, originally and essentially more creatively when compared to a non-fluid movement condition. Though the predominant issue with the scarce amount of research into the current area is that they fail to provide any real explanations for the phenomena they are observing.

Though explaining such a new finding is undeniably a difficult task, and merely discovering the finding is commendable. The current research will encapsulate ideas from both of the two prominent original works, using notions surrounding soft embodiment within virtual worlds and fluid versus non-fluid embodiment to attempt to broaden the understanding within the field. Aiming to investigate further the finding that fluid movements in a virtual environment promote creative thinking in comparison to a non-fluid group. The rationale for the current research also relates to the need for further data within the area (Stancui, 2015), also looking toward more evidence for virtual embodiment, fluid movement and insight. Consequently several research aims, questions and hypothesis have been developed.

The current study aims to investigate by what means embodying fluid motion; moving along a curved, smooth path, increases the originality of an individual's creative ideas on a divergent thinking task, when compared to a non-fluid jagged path and a straight path. Also to examine whether fluid movement increases insight moments in the way it improves creative thinking, does fluid motion increase the chance creative insight. Furthermore these embodied actions will be undertaken within a virtual setting to investigate further the implications of embodied virtual actions on creativity scores.

In regards to the studies aims several hypothesis have been established;

1. Participants who are primed with following a curved, fluid virtual pathway will score higher than those primed with following the non-fluid and straight paths on open ended divergent thinking tasks.
2. Participants who are primed with following a curved, fluid virtual pathway will score higher than those primed with following the non-fluid and straight paths on convergent thinking remote association's tasks.
3. Participants who are primed with following a straight path will differ significantly from the fluid and non-fluid tasks. In regard to the means, the straight path scores will fall in-between the scores for fluid and non-fluid on both convergent and divergent thinking tasks.
4. There will be a significant difference between scores for participants on the fluid path and the non-fluid path across divergent and convergent tasks.
5. There will be a significant difference in self-reported insight on the remote association's tasks across the three virtual pathways.

Chapter 3 - Experiment 1

3.0 - Method

Participants- A self-selecting sample of 78 participants were used, there were 23 males *(Age, M= 19.91, S.D= .397)* and the range of age was 18 to 24. There were 55 females *(Age, M= 20.73, S.D= .869)* and the range of age was 18 to 47. The students were in either their first our second year of university studying a Psychology based course. Participants volunteered to participate via the University of Huddersfield SONA experiment participation software. Participants were awarded credits towards their course for undertaking the experiment.

Design- An independent samples design was used to measure differences in the creativity scores for participants on 3 pathways. There was one independent variable, Path, with 3 levels; a fluid, curved path, a non-fluid jagged path and a straight control path (see Figure 1). The dependent variables were scores on a series of creativity questions taken from Torrence's test of Creative thinking, and Mednick's remote associations test (RAT). Scores for Torrence's test were subjectively marked by 3 independent judges unaware of condition. Marks out of ten were scored for Fluency, Flexibility, Originality and Elaboration. An example of a high and low scoring answer was provided for clarity. Scores on the RAT's are marked out of 5, one mark for each correct answer.

Apparatus and Materials- The experiment used 2 Windows PC computers with Steam installed and therefore capable of running the Source engine through the Hammer editor. The PC's were powerful enough to run the game through a 24"monitor at a Full HD resolution of 1920 x 1080p whilst maintaining an above 60 Frames per second (FPS) frame rate for smooth, for lag-free gameplay which allowed the participant to be sufficiently immersed.

The experiment aimed to look at whether the change of path, between a curved path, a jagged path and a straight control condition would allow participants to be more creative in their answers on solving a series of creative problem solving tasks. The pathways were bespoke to this experiment, and thus were created using the readily available and free to use 3D video game engine; Source. Developed and made available for free bundled with a Source engine game by the Valve Software Corporation through Steam, their internet based digital games distribution service. The Source engine uses a software editing client known as Hammer to allow users to build a game level from the bottom up, starting with an open blank space and adding blocks, textures and entities to create an environment. The textures were taken from the Valve game Half Life 2, these were of an office block style. The textures used were a brick/stone texture for the walls, a rubber floor texture and a ceiling texture. A door and door frame texture was used to simulate a door that participants were required to walk through. The graphics quality of the Source engine was deemed high enough that participants would feel involved.

The overarching idea for the level design was to create a space where participants could freely control their character through one of three virtual pathways leading to a virtual room where they would be presented with a creativity problem state that they would be required to solve. Referring to Slepian and Ambady (2012) who developed two sets of lines for participants to trace to stimulate fluid or non-fluid movements. Two conditions (see Figure. 1) were initially developed, one in which participants would progress down a curved, fluid and winding pathway and a second condition which required participants to move in a more non-fluid, jagged motion. A third path, which was taken as a control, was a straight path. This, due to limitations from Hammer was created in a separate map file.

Figure 1; Centre, top down wireframe view of the two experimental pathways, Left and right shows the 3D textured view from the participants perspective.

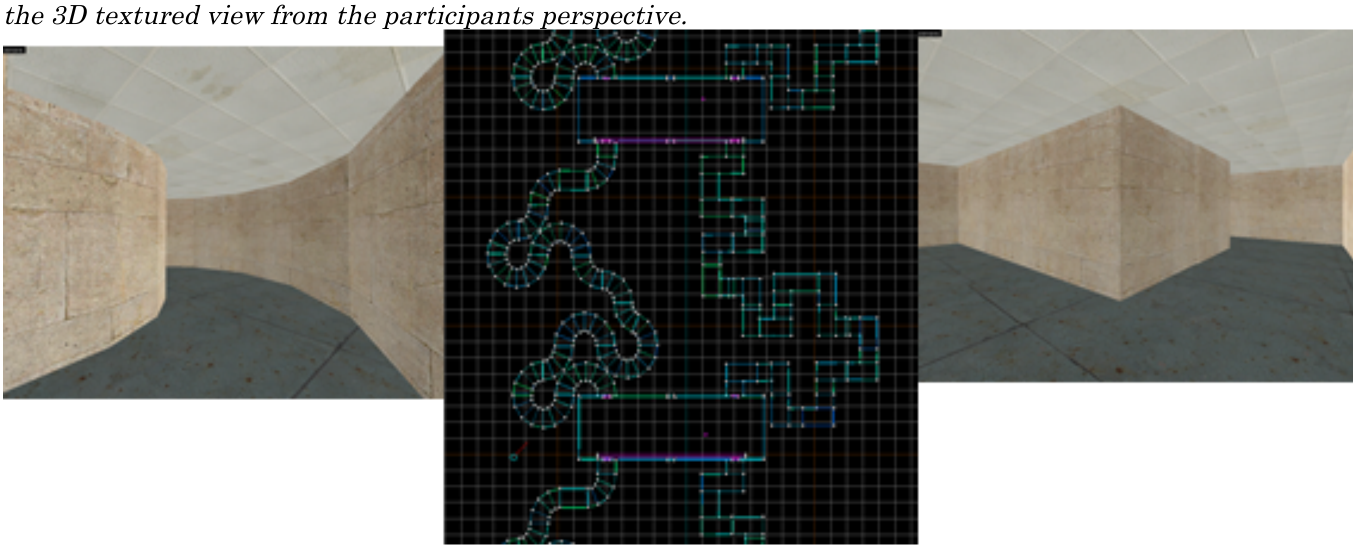

Figure 1 highlights how the map design has been controlled for the number of turns and time taken. Each path makes 20 turns and due to a controlled walking pace takes the participant no longer than 45 seconds to complete 1 path. Participants complete 7 paths in total.

A task sheet containing four Divergent thinking tasks from Torrance's test of creative thinking based of Guildford's work. Two unusual or alternative uses, one asking participants to list as many unusual uses for a brick, and then a newspaper. An Impossibilities task requiring participants to list as many impossibilities as they can. Finally an improvements task, requiring participants to list as many useful, educational or fun improvements to a child's toy. Also three Convergent thinking tasks from Mednick's Remote associations test, the task sheet and other experiment related documents can be seen in Appendix 1.

Ethics – The study was granted full ethical approval from the School Research Ethics Panel (SREP), to BPS standards. The study contained mild deception that the participants believed the study was focussed on navigation through a virtual world, which essentially it was, though the focus on creative thinking in relation to this was not disclosed until they had finished. Though participants were fully debriefed after and this was not viewed to be an issue. Any questions participants may have had surrounding the study were answer in full.

Procedure- The study was ostensibly on the ways in which participants navigate themselves and solve problems within virtual environments. So participants were informed that they would be completing a video game to assess the way they navigate and solve tasks within virtual environments. Participants were presented with a sheet of instructions regarding the controlling of the character, most had previous experience with video games and felt competent at controlling the character. The few that were unsure were given ample time to practice within a section of the virtual map. When participants indicated that were confident to control the character they began the experiment. Participants were to navigate themselves through a door and down their assigned pathway (Fluid, Non-fluid, Straight) until they would reach a room. At this point the game would advise them to stop, and refer them to a task on the response sheet which they would need to complete. The task sheet advised participants to how long they had to complete each task, this was around 1 minute per task. On the convergent thinking tasks, participants were asked to respond as quickly as possible. The concept of Insight was explained to the participant and they were asked to place a tick in a box next to their response if they had solved the remote association's task via insight. Once one task is completed the participant would walk through the next door and follow along their next pathway until they reached another room. This cycle would continue until all 7 tasks had been completed.

3.1 - Results

Divergent Thinking Tasks

Responses to the divergent thinking questions in tasks 1, 3, 5 and 7 were scored on Torrence's (1974) scales for Fluency, Flexibility, Originality and Elaboration and marked out of ten for each scale. The sum of these 4 scales was taken to give a total divergent thinking score on each task giving a total score out of forty.

Task 1 & 7 – Unusual Uses Task – Descriptive Statistics

Task 1 and 7 required participants to think of as many novel unusual uses for a certain stimuli as they could. The tasks were identical in structure though the stimuli was changed from task 1 to 7 from participants having to find unusual uses for a Brick to a Newspaper.

Table 1; shows the Total Means (M) and Standard deviations (SD) (2.d.p) for Task 1 and Task 7 Unusual Uses across Path.

	M(SD) Fluid	*M(SD) Non-Fluid*	*M(SD) Straight*
N	27	25	26
Task 1	14.93(4.64)	13.72(3.41)	10.69(3.72)
Task 7	13.41(5.67)	12.72(3.39)	9.65(5.73)

Table 1 shows the Mean and Standard Deviations for the combined score of Fluency, Flexibility, Originality and Elaboration on the 2 unusual uses tasks. On the first task participants who completed the Fluid path scored the highest means *(M = 14.93, SD = 4.64)* followed closely by the Non-Fluid condition *(M=13.73, SD = 3.41)*. The straight path scores were considerably lower *(M= 10.69, SD = 3.72)* than either the Fluid or Non-Fluid paths. The degree of spread from the mean was fairly high, yet similar across condition. These mean scores correspond with scores from the Fluency and Originality scales, Fluid and Non-Fluid paths scored higher on average on Fluency *($_{Fluid.}$, M= 4.37, SD = 1.84 $_{Non\ Fluid.}$, M= 4.48, SD =1.47)* and Originality *($_{Fluid.}$, M= 4.42, SD = 1.90 $_{Non\ Fluid.}$, M= 3.64, SD =1.41)* than did the Straight path *($_{Fluency.}$, M=3.81, SD= 1.65. $_{Originality}$, M=2.92, SD= 1.62).*

Showing that participants on the fluid and non-fluid paths came up with a greater quantity of answers, not only that but these answers had greater creative qualities. Interestingly Fluid path participants scored higher originality scores than the non-fluid path, though the non-fluid path provided a greater abundance of answers given the fluency means. Similarly on the second unusual uses task participants who followed the Fluid path scored higher overall total means *(M=13.41, SD= 5.67)* than any other path. Though again the Non-Fluid condition was close *(M=12.72, SD=3.39)*, once more the participants in the straight condition scored markedly lower *(M=9.65, SD= 5.73)*. Like in task 1, participants who completed the fluid and non-fluid paths scored higher on originality *($_{Fluid.}$, M= 3.81, SD = 1.96 $_{Non\ Fluid.}$, M= 3.28, SD = 1.34)* and fluency *($_{Fluid.}$, M=4.22, SD = 2.00 $_{Non\ Fluid.}$, M=4.28, SD = 1.95)* than the straight path *($_{Fluency.}$, M=3.04, SD= 2.16. $_{Originality}$, M=2.46, SD= 1.81)*. In correspondence with task 1 fluid movers had higher originality than non-fluid. Though non-fluid scored higher on fluency.

<u>Task 1 & 7 – Unusual Uses Task – Inferential Statistics</u>

The population was found to be normally distributed after a Kolmogorov-Smirnov test of normality. A one way analysis of variance (ANOVA) showed that there was a significant difference in the total mean scores between the 3 paths on the first task $p = .001$, $(DF = (2,75)$ $F = 7.92$, $\eta^2 = .174)$ Levene's test showed that homogeneity of variance had not been violated $(F = 1.62, p > .05)$ so the Tukey post hoc test was chosen. This showed that the significant differences were between both the Fluid and Straight paths ($p = .001$) and the non-fluid path and the straight path ($p = .022$). However not between the Fluid path and the non- fluid path ($p = .521$). Showing that either condition involving a movement; whether fluid or non-fluid, yielded significantly higher total means than the straight path.

An ANOVA on the total mean scores for task 7 again showed significant variation among conditions, $p = .021$, ($F(2, 75) = 4.05$, $\eta^2 = .097$). The subsets were found to be homogenous after completing Levene's test $(F = 2.34, p > .05)$. A post hoc Tukey test showed that the fluid path differed significantly from the straight path at $(p = .024)$ however this time the non-fluid path did not differ from the straight path.

Task 3 – Impossibilities task- Descriptive Statistics

Task 3 involved participants simply listing as many unusual impossibilities as they can, things not physically achievable by a human. Such as the ability to fly with no aid, or walking on water.

Table 2; shows the Total Means (M) and Standard deviations (SD) for Task 3 impossibilities task across Path.

Task 3	*N*	*M (2.d.p)*	*SD (2.d.p)*
Fluid	27	14.19	4.52
Non-Fluid	25	14.36	4.97
Straight	26	15.12	4.25

Table 2 highlights the similarities between means and standard deviations on task 3. Though very similar across condition, noticeably the straight path is slightly higher *(M = 15.12, SD = 4.25*) than fluid *(M= 14.19, SD = 4.52)* and non-fluid *(M = 14.36, SD = 4.97).* Additionally, regarding the Elaboration scores for task 3 there appear to be further differences in the means. Again participants completing the straight path appear to provide more detail in their answers (*M= 3.54, SD= 1.82*) than the fluid *(M = 2.81, SD = 1.64)* and Non-fluid *(M = 2.04, SD= 1.31)*. Means appear to be fairly similar across the other scales so it appears elaboration is where the total mean difference comes from.

Task 3 – Impossibilities task- Inferential Statistics

The population was found to be normally distributed after a Kolmogorov-Smirnov test of normality. A one way ANOVA showed that there was no significant difference in the total mean scores between the 3 paths on the first task $p = .739$ $(DF = (2,75)$ $F = .304)$. Though a one way ANOVA for the elaboration scores showed that there was a significant difference across path $p = .006$ $(DF = (2, 75)$ $F = 5.55$ $\eta^2 = .185)$. Levene's test showed that homogeneity of variance had not been violated $(F = 3.12, p > .05)$ so a Tukey post hoc test was chosen. This showed that there was a significant difference between the fluid path and the straight path ($p = .004$) indicating that those on the straight path provided more detailed answers on a task asking to list impossibilities.

Task 5 – Improvements task- Descriptive Statistics

In task 5 participants were required to try and think of creative ways that a soft toy could be improved so that it was more useful, education or fun for children.

Table 3; shows the Total Means (M) and Standard deviations (SD) for Task 5 improvements task across Path.

Task 5	*N*	*M (2.d.p)*	*SD (2.d.p)*
Fluid	27	13.89	4.61
Non-Fluid	25	11.04	4.96
Straight	26	8.77	3.62

Table 3 shows a clear difference in the total mean scores for the improvements task. Again the fluid movement condition *(M = 13.89, SD = 4.61)* total mean scores are the highest than both the non-fluid *(M = 11.04, SD = 4.96)* and the straight *(M = 8.77, SD = 3.62)*. Standard deviations are again fairly high yet also similar across condition.

Task 5 – Improvements task- Inferential Statistics

Kolmogorov-Smirnoff showed the population was normally distributed. A one way ANOVA displayed a significant difference in the total mean scores between the 3 paths on the improvements task $p = .001$ $(DF = (2, 75)$ $F = .8.904$, $\eta^2 = .192)$. Levene's test revealed equal variances. After a Tukey post hoc test the differences were shown to be between the significantly higher for the fluid than the straight path ($p = .001$). Though not between the non-fluid and fluid ($p = .059$), or the non-fluid and straight ($p = .167$).

Remote Association Tasks

Task 2, 4 and 6 are solely based on the Remote Associations test (RAT) developed by Mednick, (1962), in each task participants were presented with 5 individuals RAT's to solve and were also asked to place a tick in the box if the answer was retrieved through an insight moment. Although three different tasks for the participants, they have been group together for the results to give a score out of 15. Participants are presented with a string of 3 seemingly unrelated clue words for which they must provide the fourth word which is linked to the 3 clue words. The answer is either correct or incorrect and participants were presented with 3 sets of 5 giving a total score out of 15.

Tasks 2, 4 & 6 - Remote Association Tasks – Descriptive Statistics

Table 4; shows the total Means (M) and Standard deviations (SD) for the remote associations tasks, out of 15.

RAT	*N*	*M (2.d.p)*	*SD (2.d.p)*
Fluid	27	8.44	3.04
Non-Fluid	25	7.48	2.58
Straight	26	5.38	2.08

Table 4 shows the Mean and Standard Deviations for the remote association's task. Participants on the straight path scored fewer correct answers *($M = 5.38$, $SD = 2.08$)* than the non-fluid path *($M = 7.48$, $SD = 2.58$)* and the fluid path *($M = 8.44$, $SD = 3.04$)*. Scores are fairly low, with the straight path achieving only 36% correct answers on average, moving to 50% for the non-fluid path and 56% on the fluid path. Participants on the fluid path scored 20% more correct answers than those participants who followed the straight path.

Tasks 2, 4 & 6 - Remote Association Tasks – Inferential Statistics

The Kolmogorov-Smirnoff test indicated a non-normally distributed sample, however upon visual inspection of the Q-Q plots it was determine normality could be assumed (*see appendix 2 for Q-Q Plots*). A one way ANOVA showed that there was a significant difference in the total mean scores between the 3 paths on the remote associations task $p = .001$ *($DF = (2,75)$ $F = .9.496$* $\eta^2 = .202$). Levene's test showed that homogeneity of variance had not been violated *($F = 1.595$, $p > .05$)* so the Tukey post hoc test was chosen. There was a significant difference between means scores from participants on the fluid path and the straight path *($p = .001$),* and the non-fluid path and the straight path *($p = .015$)* and no significant difference between the fluid path and the non-fluid path *($p= .381$).* Yet again highlighting how participants following either path that involved movements whether fluid or non-fluid scored higher on creativity tests.

Tasks 2, 4 & 6 - Remote Association Tasks (Insight) – Descriptive Statistics

To measure insight participants were asked to tick a box next to their answer to denote that they had solved the RAT using insight and to leave blank if they had to take time (more than a couple of seconds) to think about the answer.

Table 5; shows the total Means (M) and Standard deviations (SD) for the remote associations tasks, out of 15.

Insight	*N*	*M (2.d.p)*	*SD (2.d.p)*
Fluid	27	2.41	1.28
Non-Fluid	25	2.12	1.72
Straight	26	2.19	1.36

Means and standard deviations for Insight are pretty similar across condition. With fluid being slightly higher *(M = 2.41, SD = 1.28)* than both straight *(M = 2.19, SD = 1.36)* and non-fluid *(M = 2.12, SD = 1.72).* These scores are fairly low, and with a relatively high SD for the scores. That on average just over ten percent of the remote associations were completed using insight, and this was very similar regardless of pathway.

Tasks 2, 4 & 6 - Remote Association Tasks (Insight) – Inferential Statistics

Kolmogorov-Smirnoff showed the population was normally distributed. A one way ANOVA displayed no significant differences in the total mean scores between the 3 paths on the on self-reported insight on the remote associations tasks $p = .759$ $(DF = (2, 75)$ $F = 277$, $\eta^2 = .007)$.

3.2 - Discussion

The overall study and specifically the first experiment primarily aimed to highlight the variances in creative answers provided when participants are stimulated with either fluid, non-fluid or straight virtual movements. Fundamentally predicting that in line with previous works (Slepian & Ambady 2012; Leung et al. 2012) participants who were allowed to move freely, or trace a fluid line will score higher on creativity tests than those embodied with more non-fluid forms. Essentially that embodying a fluid type movement would enhance the creativity in the answers provided. The experimental conditions within the current study required participants to control a virtual character through a fluid, curved tunnel, embodying a fluid movement through means of soft-embodiment. If the participant was sufficiently immersed, and the level of presence was high enough, the individual would embody the virtual characters movements.

Briefly summarising the results from the first experiment displays generally, though with the exception of the Remote associations and the impossibilities task. That those participants who completed either experimental pathway, scored higher on the creativity tasks than those participants who completed the straight, control path. Essentially whether the participants followed a curvy, fluid path, or a jagged, non-fluid path would produce an increased ability to think creatively on the given tasks in comparison with the straight path. Movement in either direction other than the straight path increased creativity scores barring the impossibilities task where the straight scored higher. Creative problem solving was improved when movement of any kind was embodied. Fluid movements increased creativity scores over the straight pathway, and non-fluid movements also improved creativity scores over the straight pathway.

This set of results was not particularly expected, the finding does indicate that fluid movement, or non-fluid movement helps in creative thinking over a straight path condition. Though little difference was found between the fluid and non-fluid pathways as expected. As the current experiment was designed to look at the way in which fluid movement, as found by Leung et al. and Slepian and Ambady can improve problem solving in comparison to a non-fluid jagged path. That free flowing, fluid movement can improve creative answers. The first experiment seems to indicate that any kind of movement, in comparison to the straight path can improve creative thought. Therefore in regards to the research hypothesis stating that participants who are primed with following a curved, fluid virtual pathway will score higher on a divergent thinking task compared to those primed with following the non-fluid and straight paths must be rejected.

Though not necessarily in line with prior research, the result unquestionably indicates an array of interesting aspects of creative thinking. That either experimental path stimulated the ability to think creatively, embodied movement aided creative thinking. On the unusual uses tasks, for example; participants who completed the fluid path scored the highest, though participant's scores on the non-fluid path were very close, followed by the straight path which trailed by quite a margin on both tasks. Likewise on the improvements task, participants who walked a fluid or a non-fluid path scored higher overall scores than those on the straight path. This result is interesting, however this outcome was not anticipated. Thus rather than participants scoring higher having completed the fluid path as in previous research, participants scores were fairly similar between the non-fluid and fluid paths with the straight path scoring much lower. In fact, across all tasks there were no significant differences between the fluid and non-fluid conditions, though several between both the fluid and straight and the non-fluid and straight.

As researchers have struggled to provide any explanation for the notion that fluid, free movement stimulates creative thinking, the current set of results are fairly difficult to interpret and discuss. It may be accepted that the results from past research are valid, as in both studies differences between free, fluid movement and non-fluid were found on well- known reliable measures similar to the ones completed in the current study. Fluid movement produced higher creativity scores when compared to a non-fluid case. The current results are perhaps too strong to dismiss as an abnormality from previous research, also the indication that fluid and non-fluid movement increase creative problem solving over the straight path was shown here on all but one task. The current results will therefore be discussed as correct.

Therefore an interpretation for this set of results may be developed. Perhaps the most feasible explanation for these results may be in regard to path design and selection. Firstly, participants who completed the straight path were fundamentally following a straight passageway with very little input for around 45 seconds each pass. This is a fairly monotonous task, and perhaps not as stimulating in comparison to the other paths in which continuous movement and assessment is needed to keep the character moving in the correct direction. Proposing that straight path participants were uninterested by the time they reached the task room in which they were required to complete the creative problems. It is not that participants were bored when it came to answering the problems, as creativity has been shown to actually improve within boredom states by several researchers including Mann and Cadman (2014). Also they were actively controlling the character and were possible immersed within the virtual environment, it may be they were rather lacking the level of stimulation and concentration that came from undertaking the fluid and non-fluid pathways. That participants on the other paths, more than anything were more alert and activated when required to solve the creative problems. Thus it is more likely that straight path participants were under activated. That those participants in the paths requiring constant alterations to their characters movement direction were more focused and concentrated on both walking the path and subsequently when it came to answering the creativity problems.

The straight path scores were the lowest, perhaps a mixture of task specific demands and pathway design hindered participants on the straight path leading to subsequently lower creativity scores. This may well be an explanation for the differences between fluid, non-fluid and the straight path. Those participants on the straight path, by the time they reached the task room were not cognitively prepared, though those in either experimental condition were activated in preparation of the task. Therefore currently the hypothesis regarding the straight path cannot be accepted as the scores do not fall between the fluid and non-fluid conditions as predicted.

One step which could be taken in future with regard to this is the opportunity to ask participants briefly how they felt when they had completed a path. This may put any possible stray results in context and allow to describe the participant's feelings when completing the tasks. Possibly explain differences in scores between embodied movements. By addressing participants feelings toward the specific path may help to interpret the results, that the fluid and non-fluid pathways may have been more enjoyable or even demanding which may be the explanation for the result. Possibly a qualitative section within the task sheet were participants can reflect or their experience within the pathways and completing the tasks. This may help with building a picture surrounding the embodiment of various movement as well. This was something Slepian and Ambady included in their research so could been utilised within the current research, although they found no difference on a mood scale so it could be presumed that a similar finding would be obtained here. It may have been useful to include something similar on the current experiment.

To add to the unclear results, on the impossibilities task participants on the straight path scored the highest results, though the fluid and non-fluid paths are were fairly similar in terms of means. This further complicates the results, as it would have been expected that fluid and non-fluid pathways would obtain higher results as in previous trials. This result is either an anomaly, or possibly due to the relative complexity of the task. As in other tasks participants are provided with an item for which they are required to think of unusual uses or ways in which the item may be improved. However for the impossibilities task, participants are required to develop their own ideas with no starting point. This may well be more difficult for participants, though scores are fairly similar to those on the other tasks, if not slightly higher on average so this may not be the case. It may be that the task difficulty itself bypasses the embodiment from the pathways, essentially levelling the playing field. Possibly this may be that the answers provided for the impossibilities task are more original, for participants having no starting point to build their ideas from, encouraging participants to think in a less constructed way. So participants may have developed, across the board a wider range of answers that were deemed more creative, regardless of path. This would elevate the results and maybe nullify the lack of activation within the straight path which may have led to lower results in subsequent tasks.

The results for the straight pathway tie in with the third hypothesis, as it was predicted that the scores on the straight path would differ from the fluid and the non-fluid; which they did. However the hypothesis also states that the score would fall somewhere between the fluid and the non-fluid, though as there was no previous research to support this there was no certainty in this predication. The third hypothesis must be rejected as the scores on the straight path were significantly lower.

The second unpredicted result is that there was found to be little difference between the fluid and the non-fluid path. That unlike Slepian and Ambady (2012) and Leung et al. (2012) the fluid pathway scores were not significantly higher than the non-fluid pathway. Yet on all the tasks, barring the relative incongruity with the results on task three, the fluid path scored the highest. On all tasks the non-fluid path was very close in terms of scores and there was no significance in any of the differences highlighting how basically the fluid and the non-fluid path were very similar in terms of effect on participant's creative ability on the tasks. This can be linked to the first, second and fourth hypothesis. Hypothesis one states that participants who are primed with the fluid path will score higher than both the straight and the non-fluid paths on the divergent thinking tasks, hypothesis two predicts higher scores for fluid movers on the convergent thinking tasks over non-fluid and straight paths. Both these hypothesis can be accepted, as predicted participants on the fluid pathway scored higher means for originality, elaboration, flexibility and fluency showing a higher level of creative thinking on the divergent thinking tasks than those completing the straight path. Also for convergent thinking, on the Remote associations participants on the fluid path scored significantly higher than the straight. Priming with a fluid pathway was the most successful in terms of stimulating creating problem solving. The virtual embodiment of fluid movement helped creative thinking.

Although the mean scores show higher scores for the fluid path in comparison to the non-fluid path, there was found to be no significant difference between these two groups. Therefore the fourth hypothesis regarding a significant difference between fluid and non-fluid pathways cannot be accepted. This result is fairly abnormal in relation to prior works, as it has been documented that fluid movement should improve creative problem solving over the non-fluid path. Yet this was not the case therefore it can be assumed that the fluid and non-fluid paths are having a similar effect on the participants as the scores are roughly, though slightly higher in the fluid, equal. This result may well be due to pathway design, as the paths have elicited a similar response in terms of creativity scores. Thus there is a possible explanation for the result and referring to the aerial view of the map (figure 1) may make this clearer.

The paths are designed in a way that participants can actually move around within the path, from side to side. The pathways are relatively wide compared to the character so there is the ability to walk from one wall to the other. This it is believed, allowed participants in the non-fluid path to walk in a potentially fluid way by cutting corners rather than following the jagged edges and turning in a non-fluid way as anticipated. Consequently allowing people within the non-fluid condition to walk in a relatively fluid way. Perhaps not as fluid as in the fluid condition but not in a strict non-fluid way as required in this experiment to satisfy a non-fluid condition. A possible explanation why the fluid path scores were slightly higher than the non-fluid scores may be that the fluid path allowed for greater fluid movement, though cutting the corners on the non-fluid path created fluid movement though not to the extent of that in the fluid condition. As the participants eye is still observing a non-fluid pathway even thought their character is moving in a fluid manner. When designing the paths it was anticipated that participants would follow their path in the expected way, so for the fluid path the participants would walk in a curved manner, and for the non-fluid path participants would walk jagged. It is supposed then that non-fluid participants took the 'principle of least effort', by taking the path in which minimum effort is required to complete. Walking the non-fluid path in a more or less fluid way may well be the path of least resistance. Though it may well be that participants simply cut the corners because that was the simplest way to control the character through the map. In fact, using the mouse and keyboard it is fairly difficulty to walk in a non-fluid way, as any movement dictated by a mouse is fairly fluid.

However this is simply an assumption of what may have taken place during the experiment. Although well informed, the only empirical way to find out the way in which participants moved would be specifically track the participant's movements through the level. Then analyse their tracked movement pathways to assess whether the path has been completed in the correct manner. This is perhaps something which could be utilised within future research, one option would be to video a character walking down a pathway and present this to participants, though this would take all aspects of immersion, control and embodiment out the experiment and leave it meaningless. Perhaps the simplest, most appropriate method for a further experiment would be to alter the paths to force participants into completing the specified action.

In relation to insight the fifth hypothesis must be rejected. No significant differences were found. Although looking at the means there is a slight favour towards the fluid path indicates that there may be something within the results to suggest further research into the connotations of insight and fluid movement. However the current research did not investigate insight thoroughly enough. Merely asking participants to note down when they had completed a remote association with an insight moment was not satisfactory, although this is the way insight moments have been witnessed in previous research (Danko et al 2003, Kounios & Beeman 2009) Perhaps a more appropriate method for capturing insight would be through a version of think aloud protocol analysis

(Ericsson & Simon 1993). This would be applicable for both divergent and convergent thinking tasks. Participants would be required to think out loud, if an insight moment took place then it would be on the record, and the thoughts leading up to that moment could be scrutinised.

To clarify the findings, the current study has added to previous knowledge within the area. There are several important findings that can be taken out of this first experiment. Although initially appearing to be in contradiction to previous work highlighting increased creativity after a fluid condition. These ideas can be supported in some way, this research is the first to add a third condition, a type of a control condition. In which participants were required to walk in a straight line, so no effects from fluid or non-fluid movement pathways. This straight movement condition, in six out of seven tasks, scored markedly lower than either the fluid or the non-fluid conditions. Indicating that either the fluid and non-fluid movement scores were increased because of their pathways, or perhaps completing the straight path hindered the scores for those participants. Also regardless of significance, the fluid pathway scored the highest means on the majority of tasks, displaying again, that perhaps like Slepian and Ambady fluid movement promotes creative thinking. Though there were no differences between the fluid and non-fluid tasks this first experiment has provided several items of knowledge which can be utilised in the designing of a second experiment which may aid explaining the overall phenomena.

For future work changes must be made to the pathways to attempt to force the action of both fluid and non-fluid movement and bypass the potential issues. As noted above, perhaps the pathways created a similar embodied action thus explaining the similar results. Following these map changes a further experiment may find differences between the fluid and non-fluid pathways. Suggesting that there was a difference with the path design in experiment one, and an effect of pathway can be discussed. Though no significant differences such as in the current experiment would suggest that fluid or non-fluid promote creative thinking over linear movement. Therefore a second experiment to further investigate is imperative.

Chapter 4 - Experiment 2

4.0 - Method

Participants- A self-selecting sample of 47 participants was used, there were 9 males *(Age, M= 21.33, S.D= 2.06)* and the range of age was 18 to 25. There were 38 females *(Age, M= 20.63, S.D= 3.92)* and the range of age was 18 to 42. The students were in either their first or second year of university studying a Psychology based course and had not participated in the first experiment.

Design- The design was identical to that in experiment 1, an independent samples design was used to measure differences in the creativity scores for participants on the 3 pathways. There was one independent variable, Path, with 3 levels; a fluid, curved path, a non-fluid jagged path and a straight control path. Though it must be noted that these pathways differ on axis and in design to the pathways in the first experiment. The dependent variable was scores on a series of creativity questions taken from Torrence's test of Creative thinking, and Mednick's remote associations test as used in experiment one.

Apparatus and Materials- The apparatus and materials used in experiment 2 were very similar to that of the first experiment, bar a change to the game level design and the question sheet. Several questions which were included in the question sheet of experiment 1 were discarded as they were not used in the analysis during experiment 1 and were not deemed appropriate.

Ethics – The study was granted full ethical approval from the School Research Ethics Panel (SREP), to BPS standards. The study contained mild deception that the participants believed the study was focussed on navigation through a virtual world, which essentially it was, though the focus on creative thinking in relation to this was not disclosed until they had finished. Though participants were fully debriefed after and this was not viewed to be an issue. Any questions participants may have had surrounding the study were answer in full.

Procedure- Procedurally the second experiment was identical to the first, participants followed a given path, solved problems on the response sheet, and continued this until they had completed all 7 tasks. Due to the suspected issues with the map design in the first experiment, highlighted in the previous discussion, some corrections were made to attempt to correct concerns with the design of the first map. Experiment 1 simply required participants to walk along a pathway which deviated in direction on the x-axis, the pathway was flat. Initially this was expected to simulate either fluid or non-fluid movement but this may not have been the case. Therefore this was altered so participants were required to traverse up and down on the pathway. The fluid path was designed to simulate a wave line, with liquid, fluid movement up and down on the y-axis. This created a path that was unquestionably more fluid due to a constant, smooth up and down motion, and gave participants no opportunity to perform the movement action in the wrong way.

The main issue with the level design of the pathways in the first experiment was that participants were seemingly able to cut corners, or so is predicted. That those participants on the non-fluid path condition were able to walk through the path in a fluid type motion, by taking the apex of the corner rather than walking the path in a non-fluid way as was expected. Therefore, it is assumed, that the fluid and non-fluid pathways had the same effect on the participants which would explain the similar results between both experimental conditions regardless of the control.

Figure 2; shows a 3D textured view from the participants perspective within the pathways for the Straight path (left), Fluid path (centre) and the non-fluid path (right).

As figure 2 shows, participants walking down the fluid path moved in a smooth, liquid movement. There was no reservation about the strictness of the fluid-movement, as this movement was essentially forced. The participant, regardless of their input, followed the path in a fluid, liquid way. As the participant was only required to walk forward, the action of creating the fluid movement was out of their control, although it appeared to the participant that it was and they observed the embodied fluid movement. For the non-fluid path the improvement in path design was effective. As seen in figure 2, again the participant had no option but to control their character in non-fluid, jagged fashion. To overcome this, the path was changed to a series of steps, so participants were forced to jump from one step to the next. This provided greater discontinuation, as participates never had an opportunity to get into a fluid motion as they were interrupted with the need to jump to the next step. This was truly a non-fluid path. For the participants to successfully complete the path they had to jump their character up the series of steps, then down the other side (see figure 3). The steps were just high enough for the participants embodied character to climb, though the action was not easy to perform. The participant was required to jump a step, stop then progress onto the next step. This action was a clear stop/start, jagged movement. It is assumed then that changing the paths in this manner controlled for several variables. Firstly participants were unable to get lost, or confused to which direction they were going as happened in several occasions on the first experiment. Secondarily and more significantly, participants were forced to perform the actions that the study is interested in, so those on the fluid path moved in a fluid way, and those on the non-fluid path moved in a non-fluid way.

Figure 3; shows a side wireframe view for the fluid and non-fluid pathways, highlighting the matching height and drop for each path.

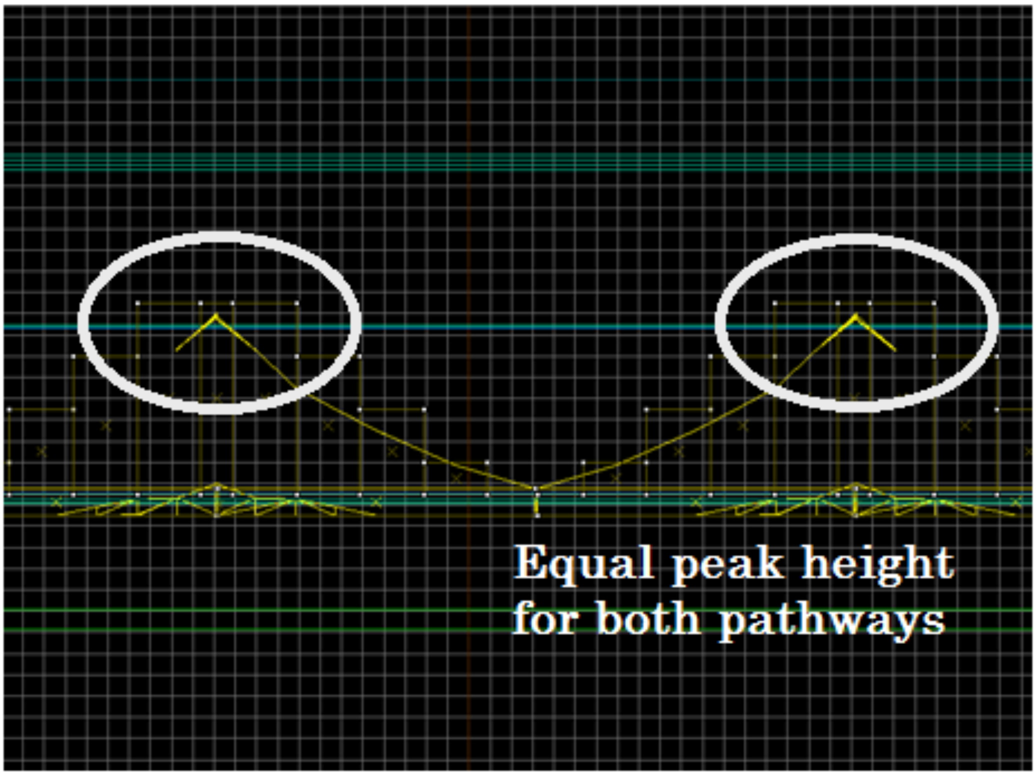

Figure 3 shows that both paths have the same peak height that the wave and the steps were identical thus the distance and time taken to complete was very similar same. Due to the nature of the paths now being straight lines, the straight path was included in the same map file. A series of teleport pads built into the map file allowed participants to simply follow their given path, then be jumped back to the start once they had completed the tasks. The textures used were the same neutral, office style textures used in experiment 1, and the straight path map remained unchanged though now included with the experimental paths. Participants were required to complete 12 individual climbs either up the stairs or along the fluid wave. It took 45 seconds for participants to complete one walk along a path, traversing the steps, wave or along the straight path.

4.1 - Results

Divergent Thinking Tasks

Task 1 & 7 – Unusual Uses Task – Descriptive Statistics

As in the first experiment Task 1 and Task 7 are alike so they have been grouped together, they are unusual or alternative uses.

Table 6; shows the Total Means (M) and Standard deviations (SD) (2.d.p) for Task 1 and Task 7 Unusual Uses across Path.

	M(SD) Fluid	*M(SD) Non-Fluid*	*M(SD) Straight*
N	19	17	11
Task 1	14.16(3.22)	15.47(2.65)	11.91(2.74)
Task 7	14.42(2.93)	11.71(2.02)	13.18(3.07)

Table 6 shows the Means and Standard Deviations for the combined score of Fluency, Flexibility, Originality and Elaboration on the 2 unusual uses tasks for the second experiment. On the first task participants who completed the non-Fluid path scored the highest means *(M = 15.47, SD = 2.65)* followed by the Non-Fluid condition *(M=14.16, SD = 3.22)*. Participants on the straight path scored the lowest *(M= 11.91, SD = 2.74)*.

Though on the second unusual uses task participants who followed the Fluid path scored far higher overall total means *(M=14.42, SD= 2.93)* than those on the non-fluid path *(M=11.71, SD=2.024)*. The straight path was around halfway between *(M=13.18, SD=3.027)*. This large differences coincides with a large difference on the originality scores, the means for the fluid and straight paths were reasonably high *(Fluid, M=3.53, SD=1.64, Straight, M=3.45, SD=1.44)*, though the non-fluid path was considerably lower *(M=2.12, SD=1.16)*.

Task 1 & 7 – Unusual Uses Task – Inferential Statistics

Shapiro-Wilk test indicated a normally distributed sample. A one way ANOVA showed that there was a significant difference in the total mean scores between the 3 paths on task 1, $p = .011$ $(DF = (2,46)$ $F = 4.992$, $\eta^2 = .185)$. Levene's test showed that homogeneity of variance had not been violated $(F = .772, p > .05)$ so the Tukey post hoc test was chosen. Using the Tukey test showed that scores on the first unusual uses task were significantly higher for participants completing the Non-fluid path than for participants on the straight path (p = .01). However no difference between the fluid and the straight paths (p = .43) and the non-fluid pathway and the fluid (p = .376).

For the second unusual uses task, the sample was normally distributed after a Shapiro-Wilk test. Analysis of variance highlighted a significant difference between the 3 paths, $p = .02$ *(DF = (2, 46)* $F = 4.668$, $\eta^2 = .175$). Levene's test showed that homogeneity of variance had not been violated ($F = 1.370$, $p > .05$) and a Tukey HSD indicated that overall creativity scores were significantly higher for those completing the fluid path over the non-fluid path (p = .010). The first time in either experiment a difference has been found between the non-fluid path and the fluid path. Indicating a difference in the level of creativity in the responses to this task between those participants who completed the fluid path and those who completed the non-fluid path. Though no differences were found between fluid and straight ($p = .443$).

Task 3 – Impossibilities task – Descriptive Statistics

For the third task participants were required to think of as many impossibilities as they could. The fluid group scored the highest overall mean scores *(M=12.32, SD = 4.00),* though the straight path was only slightly less (*M=12.09, SD = 2.87*) followed by the non-fluid path *(M=10.29, SD = 3.80).* Though the means appear to differ and the fluid and straight paths scored higher than the non-fluid path. A one way analysis of variance indicated no significant differences across path $p = .23$*(DF = (2, 46)* $F = 1.503$).

Task 5 – Improvements task- Descriptive Statistics

Table 7; shows the Total Means (M) and Standard deviations (SD) for Task 5 improvements task across Path.

Task 5	*N*	*M (2.d.p)*	*SD (2.d.p)*
Fluid	19	14.42	2.93
Non-Fluid	17	11.71	2.01
Straight	11	13.18	3.03

On the fifth task the participants in the fluid condition scored the highest means *(M=14.42, SD = 2.93),* with the non-fluid scoring the lowest *(M = 11.71, SD = 2.01)* and then the straight path scoring similarly high means with the fluid path *(M = 13.18, SD = 3.03).*

Task 5 – Improvements task- Inferential Statistics

A one way ANOVA showed that the difference in mean scores between the 3 groups were statistically significant, *p= .01 (DF = (2, 46) F = 6.632,* η^2 *= .232).* Tukey's HSD test showed participants on the fluid path again scored significantly higher means than those on the non-fluid path (p = .003). Though neither the fluid (p = *.74*) nor non-fluid (p = *.672*) group differed significantly from the straight path.

Remote Association Tasks

Tasks 2, 4 & 6 - Remote Association Tasks – Descriptive Statistics

The three sets of five remote associations tasks were grouped together to give one score out of fifteen.

Table 8; shows the total Means (M) and Standard deviations (SD) for the remote associations tasks, out of 15.

RAT	*N*	*M (2.d.p)*	*SD (2.d.p)*
Fluid	19	8.10	3.04
Non-Fluid	17	7.48	2.58
Straight	11	5.38	2.08

Referring to table 9, means for the combined remote associations tasks marked out of 15 appear slightly higher in the fluid condition *(M = 8.10, SD = 3.04)* than the non-fluid *(M = 7.48, SD = 2.58)* path participants. However those on the straight path *(M = 5.38, SD = 2.08)* scored on average more than 2 less correct answers than either of the experimental groups. A one way ANOVA indicated no significant differences between groups *p= .86 (DF = (2, 46) F = .153).*

Tasks 2, 4 & 6 - Remote Association Tasks (Insight) – Descriptive Statistics

Table 9; shows the total Means (M) and Standard deviations (SD) for the remote associations tasks insight, out of 15.

RAT	*N*	*M (2.d.p)*	*SD (2.d.p)*
Fluid	19	2.21	1.23
Non-Fluid	17	2.76	.83
Straight	11	2.91	1.14

Scores for Insight show that the straight pathway *(M = 2.91, SD = 1.14)* participants reported noticeably more correct remote associations solved via an insight moment than the fluid pathway *(M*

$= 2.21, SD = 1.23$) and the non-fluid pathway ($M = 2.76, SD = .83$). However a one way analysis of variance showed no significant differences across pathway $p = .165$ ($DF = (2, 46)$ $F = 1.878$, $\eta^2 = .079$)

4.2 - Discussion

The second experiment is a well-refined version of the first; even though the first added several key findings to the knowledge within the area there was one potential underlying flaw in the pathway design that required alteration. The first experiment showed that the straight path was found to be a poor promoter of creative thinking, and either the fluid or non-fluid pathway was shown to be more successful in promoting creative behaviours. However due to a suspected issue with the level design differences between the fluid and the non-fluid groups were not established as was the case in previous research. Therefore a second experiment was intended to re-examine the hypotheses from the first experiment using a different map structure in which the target conditions were scrutinised more suitably. The fluid pathway, as predicted in relation to previous findings would stimulate more fluid embodied movement, and the non-fluid pathway would stimulate non-fluid movement. The straight pathway remained unchanged.

The hypotheses for the second experiment remained the same as in the first in an attempt to both bolster the arguments from experiment one and also further investigate potential differences between the fluid and non-fluid pathways apparent within research. The first hypothesis states that participants primed with a fluid path will score higher than those primed with either a straight or non-fluid task. In relation to the acceptance of this hypothesis, this is not as clear-cut as in the first experiment. As on the first alternative uses task in which participants on the non-fluid task scored the highest mean scores, though this was not significantly higher than the fluid pathway the mean was still greater. In line with the hypothesis though, task five which was an improvements task and task seven unusual uses show results in support of the hypothesis. For the improvements task the fluid path scored the highest means beyond the straight and non-fluid pathways. Also on task seven the scores were greater than both the other conditions. The first hypothesis cannot be confidently accepted then, as only around half of the tasks showed an increase in creative thinking for those completing the fluid path.

On three of the four divergent thinking tasks no significant differences were found between the fluid and the straight pathway. From the first experiment, participant's scores on the straight pathway were markedly lower than those on the fluid or the non-fluid. It was discussed that any movement away from the linear allowed for greater creativity scores. However, after changing the pathway design in the second experiment the difference between the fluid and the straight pathway was non-significant. Therefore the change in pathway may explain the current lack of difference.

The first experiment required participants to move on one axis, a flat plane in which they had to make either fluid, non-fluid or straight movements to complete the path. This can be linked to Slepian and Ambady (2012) in which participants traced fluid and non-fluid lines. The lines were situated on a sheet of paper and therefore limited to one axial plane. After alterations to the pathways in the second experiment due to suspected issues with the fluid and non-fluid pathways, the participants were now required to embody movements on a different axis. Participants moved up and down for their respective movements. Participants in the first experiment were fixed to the x-axis, where as participants in the second experiments fluid and non-fluid conditions moved up and down on the y-axis. Essentially all three pathways were straight in the second experiment, the straight and fluid were very similar in that participants moved in a constant motion from starting the pathway to researching the first room. Both were fairly linear experiences for the participant. In contrast the non-fluid pathway required participants to jump from one step to the next eliciting a non-constant, jagged movement.

This may be the explanation for the indifference between the fluid and the straight pathways on scores on the divergent thinking tasks. The two pathways embodied very similar movements when compared to the non-fluid movement condition. Walking through the straight pathway could be regarded as fluid movement in comparison to the non-fluid pathway. The issue is potentially to do with the planes that the pathways have been based upon. As humans we travel through three-dimensions, however the current study is limited to either horizontal movement, or vertical movements. The axis by which movement is taking place has the capability to be an extraneous variable in the current study. A potential further experiment would utilise a roller-coaster type design within a virtual world. Allowing for embodied movements on the x, y and z axis.

The second hypothesis posits that 'Participants who are primed with following a curved, fluid virtual pathway will score higher than those primed with following the non-fluid and straight paths on a series of creativity convergent thinking remote association's tasks'. The remote association's convergent thinking task results went in a similar light to in the first experiment, fluid pathway participants scored the highest, followed by non-fluid and then the straight path. Again there were no significant differences across pathway on the convergent thinking tasks. Therefore the second hypothesis must be rejected and the null accepted. Interestingly nevertheless is that the straight path was considerably lower than either of the other pathways. Although not significant there are clearly differences between these groups. Therefore it could be discussed that the straight path is more of an influence on convergent thinking tasks. As these tasks are often solved through insight type moments it could be that the stimulation of a fluid or non-fluid pathway prepares the brain for the task. That the perhaps increased activation that comes from the constant movement adjustments during the walking section of the task allows for quicker and more successful recall of the answers. One way that this hypothesis could be tested would be to use an EEG whilst completing the experiment. This could be linked to a virtual reality headset to provide further immersion within the levels and would allow potential subsequent research to capture more data surrounding the phenomenon. This would also allow EEG data to be gathered and compared between the fluid and non-fluid pathways. Investigating the brain activation linked with fluid movement, non-fluid movements and the straight pathway may provide further knowledge into how and why fluid movements promote creative thinking and also why the straight pathway is such a hindrance upon creative thinking behaviours.

This is a fairly speculative argument though it may be that the difference within scores across the pathways may well be linked to activation of differing brain regions through the temporo-spatial lobe during embodied tasks. Something noted by Lenggenhager, Smith and Blanke (2006) who discuss the importance of the temporo-spatial lobe in relation to embodiment. This must be the next step for research to attempt to provide a better understanding of embodied creativity. In an earlier work Blanke and Arzy (2005) found links between the temporo spatial junction and out of body experiences. Not necessarily an explanation for the links between embodiment and creativity, though the temporo spatial junction appears to be often linked with similar concepts.

Hypothesis three relates to the straight pathway, that the straight path will differ significantly from the fluid and non-fluid pathways and will fall somewhere in-between the mean scores on both the convergent and divergent thinking tasks. Though like in the first experiment this hypothesis must be rejected and the null accepted as for three out of five tasks the straight pathway participants scored the lowest mean scores. However, for two of the tasks the straight path scores did differ from the fluid and the non-fluid and these scores were in-between both other groups. Suggesting as hypothesised that the straight path would be a better promoter of creative thinking than non-fluid, though not as good as the fluid pathway.

This hypothesis was based on no previous evidence from research, so this result is more an additional to current knowledge than a disappointment. This is the first study to include a third variable whilst researching creativity and embodiment. The results show that completing the straight pathway, or not embodying any particular movement is less successful in terms of promoting creative thinking. Perhaps in hindsight the straight pathway hypothesis could have been linked to the fluid pathway, that embodying linear movements are similar to embodying fluid movements.

The fourth hypothesis is perhaps the main one within the current study. The knowledge within the area is that embodied fluid movement, in comparison with non-fluid movement promotes creative thinking (Slepian and Ambady, 2012; Leung et al., 2012). Experiment one found no significance between these two conditions, that fluid movements and non-fluid movements provided similar benefits in creative thinking when compared with the straight movement condition. This was similar to the finding on the first task in the second experiment. Actually the non-fluid path scores were higher than the fluid pathway scores in disparity with the hypothesis and previous research. Participants who completed the non-fluid path, in stark contrast to the results within the first experiment and previous research scored similarly to the fluid condition. This result opposes what was already known about embodied creativity.

This result however can be approached as a slight irregularity. The scores were similar; though the non-fluid was higher there were no significant differences. In addition to this for the two subsequent tasks participants on the fluid pathway scored higher than the non-fluid task, this difference for the first time throughout the experiment was found to be significant. Supporting previous research and the hypothesis in the noting that fluid movement promotes creativity over a non-fluid movement condition. Showing that with the revised paths the action of both fluid and non-fluid movement are being sufficiently embodied displaying a difference in scores between both pathways. Hypothesis four can therefore be accepted as a difference between fluid and non-fluid has been shown consistently. Consequently it can be presumed that fluid, virtually embodied movement promotes creative thought. That structured, fluid movement, in comparison to free movement (Leung et al., 2012) can be used as a predictor of improved creative thinking. The movements elicited within the virtual pathways altered participants thought processes that embodying either fluid or non-fluid movement decided the level of creativity provided within the answers. Rather abstractly is one possible application for this finding is that building design can be altered to accommodate more fluid walkways. New buildings for creative enterprises could be engineered to incorporate the notion of fluid movements into corridors. A bespoke take on architectural design may improve creativity as opposed to a more, standard design incorporating non-fluid type corridors. As fluid movement has been shown to promote creative thinking within virtual pathways, essentially fluid movement within a physical curved pathway may have the same result.

Hypothesis five was in relation to insight and predicted that fluid movement would stimulate insight moments more frequently than either the straight or non-fluid paths. Insight was perhaps the least successful aspect of the current study. The manner by which this phenomenon was researched was underwhelming in relation to the overall importance of insight. The focus was not sufficient and therefore subsequent research must take more focus into insight as a construct and its relationship with embodied movement.

As fluid movement has been shown to promote both convergent and divergent thinking fairly successfully, it would be assumed that there would be several associations for insight in regard to the embodiment of certain movements. Due to the importance of insight as a problem solving method, studies may decide to focus specifically upon insight and embodying fluid movement to develop worthwhile knowledge. In regard to the mean scores for insight, across the board the fluid pathway was higher in terms of self-reported insight, and although the differences were small and non-significant, there is perhaps justification for following research.

The third task which participants were required to complete has not been discussed thus far due to the abnormality of the results, similarly to that discussed in the first experiment discussion. There were no significant differences across condition; means were similar, though in favour of the fluid pathway. This task should have been excluded from the second experiment due to the advice from the first experiments results. Either the tasks itself is of poor design, or both samples used in this study found this specific task difficult. Future research should select a differing task from Torrence's work to replace the third task within this study.

In summary the second experiment highlights how the fluid path and the straight path scored similar results, this may be again due to path design as the straight path and the fluid path are similar in there linearity though vary on vertical axis movement. The most important result however, was the difference between the fluid and the non-fluid paths, which goes in line with past research regarding embodied creativity (Slepian & Ambady, 2012; Leung et al., 2012). Displaying how individuals virtually embodying fluid movements score higher creativity scores than those embodying non-fluid movements.

Chapter 5 - Conclusion

The consensus in the field of embodied creative thinking has been that fluid movement, when directly compared to a non-fluid movement task allows individuals to process creative thought more successfully. Though the area is fledgling, and underdeveloped (Stancui, 2015 the pioneers in the field (Slepian & Ambady, 2012; Leung et al., 2012) agree that fluidity, or free flowing movement is an instrument to which creative thinking and problem solving can be stimulated. The current study is in partial agreement with these findings. For the first experiment, the results indicated several things. Firstly that fluid movement was unsurpassed as a tool to fuel creative thinking, the non-fluid and straight pathways were lower on all but one task. Participants following the fluid pathway scored the highest means, whether the task was convergent or divergent in structure. The second finding from the first experiment was that participants on the non-fluid task never significantly differed from the fluid pathway, though the fluid pathway was always higher on means. Therefore it could not be concluded after the first experiment that the fluid pathway in comparison to the non-fluid was better in terms of stimulating creative thinking on either divergent or convergent thinking tasks. This was in contrast to previous work in the field. The final important finding from experiment one was that the straight pathway, for several possible reasons was a poor stimulator of creative thinking in comparison to the fluid and non-fluid pathways. Those who completed the straight path scored significantly lower mean scores on all but one task. Experiment one required participants to make movements on a horizontal plane, no variance in vertical movements. Potentially horizontal embodied fluid or non-fluid movements may have a significant impact on creativity scores when compared to the linear straight pathway.

The path design was altered in the second experiment to overcome suspected issues regarding the fluid and non-fluid pathways. The second experiment incorporated paths that moved in fluid, non-fluid and straight on a vertical axis. In contrast to the first experiment it was found that this time straight linear movements did not differ significantly from fluid movement on the vertical axis. The straight pathway was this time not a poor predicator of creative behaviour, and the scores were similar to the fluid pathway. This could be associated with results from Leung et al.

(2012), who found that free flowing movement, alongside fluid movement was a successful promoter of creative behaviour. Therefore in comparison to the non-fluid pathway, the fluid and straight paths flowing attributes could explain the similarities though overall differences between the fluid and straight paths with the non-fluid path. From an embodied cognition stance this could be due to an increased state of fixedness coming from the non-fluid path. Non-fluid path participants embodied jagged, discontinued movements. This in turn hindered the participant's ability to think creatively. Whereas the fluid and straight pathways embodied smooth, linear movements allowing for higher creativity scores.

Moving backwards has been linked with thinking in the past (Miles, Nind & Macrae, 2010), while moving forward has been associated with thinking in the future. This may be analogous with creativity, that forward thinking and thinking ahead may be associated with idea production. It may be that similar to the aforementioned study, smooth fluid movement is similar to moving forward, where as non-fluid movement maybe compared with moving backwards. It may be that similar processes are being activated, and this may be explained in terms of metaphor (Gibbs, Lima & Francozo, 2003). That for the fluid pathway an associated metaphor may be 'having a smooth ride' or 'smooth sailing'. Having a 'rough time' may be a metaphor for the non-fluid pathway.

This may be a speculative link between embodying the specific movements and how they are interpreted in terms of language by the individual completing the specific action. Though perhaps individuals completing the more fluid pathways feel more constructive and potentially more creative due to the pathway eliciting more positive internalised language and metaphors due to the experience of the pathway. On the other hand the non-fluid path may produce action words that cause negativity and thus a lack of creative potential when completing the tasks. Possibly one further action for research therefore would be to collect data regarding language and words during the tasks. Analysing the language used may be associated with the embodied actions undertaken within the paths and this may provide subsequent knowledge to support embodied creativity and metaphor.

It also appears that perhaps embodied movement and exploration within virtual worlds is dependent on axis, as the current research findings differ significantly in relation to pathway and axis. Though potentially quite difficult to undertake, future knowledge within the area would benefit greatly from a multi axis and multi directional approach. Embodied movement would take into account both fluidity on a horizontal plane, and a vertical plane allowing to sufficiently investigate related phenomena.

Possibly the major finding within the current research is the notion of soft embodiment within virtual worlds. The current study explicitly improves upon the knowledge within the area of virtual embodiment, showing how soft embodiment alongside hard embodiment can improve creative thought. The results show that completing a virtual pathway altered the manner by which creative problems were solved, embodying certain movements increased creative thought. That virtual actions undertaken by the body can influence problem solving and creativity. The soft embodiment of certain movements has been shown to go in line with previous research into embodied creativity (Leung et al., 2012).

The important aspect is that these embodied actions were not taken by the participant's physical body as in typical embodied work, but by a virtual character within a virtual world. The participants never truly walked down a pathway, they observed and controlled a computer generated simulation of a human body. To break this down, participants were required to control a video game character through a series of pathways and solve several creative problem solving tasks. The participants were never situated materially inside the pathways, they merely were observing through a PC monitor a three-dimensional body of which they were in control. Manipulating the characters movements via a keyboard and mouse walking through a virtual pathway. Physically they were completely external to the virtual environment, though mentally they existed, immersed within their virtual character as indicated by the emergent results.

It must be debated then that whether the mind has the ability to situate itself within another body, in this case virtual. That the mind can place itself within a virtual body and has the ability to embody virtual stimuli such as fluid movement, the action does not physically have to take place. It could be that through currently unknown mechanisms the mind has the ability to transcend the physical and digital boundaries between an individual and a virtual character, allowing for the mind to appear in situ with the virtual character. This would be in line with previously discussed research from Kilteni, Bergstrom & Slater (2013). Essentially providing support surrounding immersion and presence that an individual has the capacity to feel at one with the virtual entity.

Therefore, in relation to the current studies results, any physical movement undertaken whilst immersed in a virtual world creates a comparable effect to that undertaken in the physical world. So physical fluid movement as in Slepian and Ambady (2012) in which the participant was required to move their hand in a fluid motion whilst tracing a line, is comparable to that of walking along a fluid pathway whilst sufficiently immersed within a digital world. Any movement performed within a virtual world may be comparable to the same movement performed in the real world.

This may be fairly plausible, and could be linked with emotional mental states like Empathy, “empathy in the broadest sense refers to the reactions of one individual to the observed experiences of another” (Davis, 1983 p1). Although externally observed the caring individual attains the mental attributes to ‘put oneself in another’s shoes’, essentially associating their feelings of pain, or loss from another individual. In regard to individuals emphasising with pain Lamm, Decety and Singer (2011) indicated several prominent areas of the brain that are activated during a pain empathy experiment, participants often grimaced or felt uncomfortable when shown human body parts in physically painful situations. One of these activated brain areas was the temporo-parietal junction, also linked with creative moments (Kounios et al., 2006) and also embodiment (Lenggenhager, Smith & Blanke 2006). Although immersion is deemed a fairly reasonable assumption within virtual environments to a certain extent, the notion that virtual embodied movement can stimulate high level cognition is remarkable. The current study provides evidence to support soft embodiment in virtual environments. Additionally, in contrast to some of the negative effects shown to be associated with participation in virtual environments (Anderson & Bushman, 2001; Bushman & Anderson, 2002; Adachi & Willoughby, 2011), the present study describes a positive use for virtual environments in the promotion of creative thinking behaviours.

Though the results for this study are promising for the field of embodied creativity, the difficulty comes when attempting to explain these observed phenomena. This is where previous research, for a valid reason, has been unsuccessful. Previous research should be commended for discovery of the concept of embodied creativity, and virtual embodied creativity. Though an explanation for both these phenomena may take an inordinate length of time, and several further research attempts. Throughout the current study there have been attempts at explaining several aspects of the findings, and guidance for future research has been provided.

The current study demonstrates how virtually embodied movements can influence high level cognitive processing. That creativity can be improved by embodying certain virtual movements, and be hindered by completing opposing movements.

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Appendices

Appendix 1

1-A – Example of the task sheet completed by participants

Task Sheet

Please complete the following tasks, mark on this sheet using a pen. Remember your answers are completely anonymous, so relax and have a go.

Sex, Male ☐ **Female** ☐

Age, ……………..

Task 1

Think of as many alternative or unusual uses for a Brick as you can. *Example: A Paperweight.* You have 3 minutes.

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Task 2

The problems include three clue words, try and complete the blank with the correct word that relates to each of the other three clue words.

Example: Elephant/ Lapse/ Vivid	*Answer: Memory*	
Cottage/Swiss/Cake	Answer:…………………………………………..	☐
Cream/Skate/Water	Answer:…………………………………………..	☐
Loser/Throat/Spot	Answer:…………………………………………..	☐
Show/Life/Row	Answer:…………………………………………..	☐
Night/Wrist/Stop	Answer:…………………………………………..	☐

Task 3

List as many impossibilities as you can; try and list things that you believe are not physically achievable. You have 3 minutes.

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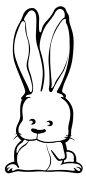
Task 4

The problems include three clue words, try and complete the blank with the correct word that relates to each of the other three clue words.

Example: Elephant/ Lapse/ Vivid	*Answer: Memory*
Cracker/Fly/Fighter	Answer:…………………………………………… ☐
Safety/Cushion/Point	Answer:…………………………………………… ☐
Dream/Break/Light	Answer:…………………………………………… ☐
Fish/Mine/Rush	Answer:…………………………………………… ☐
Political/Surprise/Line	Answer:…………………………………………… ☐

Task 5



This is a soft toy Bunny, try and think of creative ways in which this could be improved to make it more, useful, educational or fun for children. You have 3 minutes.

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Task 6

The problems include three clue words, try and complete the blank with the correct word that relates to each of the other three clue words.

Example: Elephant/ Lapse/ Vivid	*Answer: Memory*
Sense/Courtesy/Place	Answer:…………………………………………… ☐
Worm/Shelf/End	Answer:…………………………………………… ☐
River/Note/Account	Answer:…………………………………………… ☐
Opera/Hand/Dish	Answer:…………………………………………… ☐
Stick/Maker/Point	Answer:…………………………………………… ☐

Task 7

Think of as many alternative or unusual uses for a Newspaper as you can, think out loud if you wish, speak into the recorder with your ideas. *Example: scrap paper.* You have 3 minutes.

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1-B Recruitment email to participants

Hello, my name is Alastair Broadhead and I am postgraduate Master's by research student in the division of Psychology. I am undertaking the experiment section of my research and I would be very grateful is you would participate in my research; the experiment should take around 30 minutes.

The study aims to look at navigation and problem solving in a virtual environment. The experiment itself will require you to navigate through a video game made up of several paths leading to rooms. Upon reaching the rooms you will be required to complete one of seven simple problem solving tasks. When this is completed you can progress to the next room by following the path.

Due to the nature of the experiment, please do not volunteer if you have a history of photosensitive epilepsy.

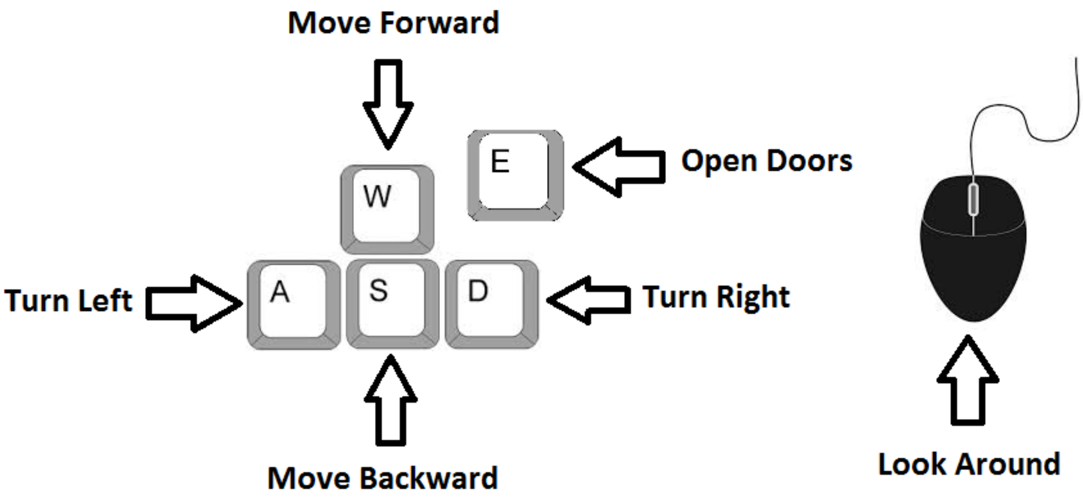
All information collected from you during this research will be kept secure and anonymous and confidential. It is your decision whether or not you take part in the study. If you decide to take part you will be asked to sign a consent form, and you will be free to withdraw at any time up to the point of statistical analysis for the results and without giving a reason.

If you would like to volunteer, or if you have any further questions surrounding the study you can contact me on; U0960268@hud.ac.uk

Thank you for your time. Cheers,

Alastair Broadhead

1-c In game controls presented to participants before starting.



Appendix 2

Q-Q plots for Remote association's experiment 1