

# Chance and Interactivity Stimulate Creativity

**David Kirsh**  
(kirsh@ucsd.edu) Cognitive  
Science La Jolla, CA 92093-  
0515 USA

**Daniel Smithwick (djs2@mit.edu)**  
Department of Architecture / International Design Center 265 Massachusetts Avenue  
Cambridge, MA 02139 USA

## Abstract

To study the value of interactivity and chance in creative cognition we looked at the creative process in architecture, choreography and word discovery. Seventeen architects and novice students were given a set of blocks and asked to design their dream house. Although the blocks seem simple they are filled with perceptual surprises. Manipulation led to seeing new things and these in turn led to thinking up new structural forms. In choreography we studied the creative method of a noted choreographer and observed how random objects in the environment often figure in tasks he assigned his dancers. The dancers would look for interesting attributes in the objects that they then played off of in interesting ways. In a word discovery task we gave subjects a string of 7 letters and asked them to call out all the words of three or more letters they could make. They were tested in three conditions: static - letters are fixed, interactive - letters can be moved, and shuffle - spacebar randomly reorders the letters. Subjects scored best on Shuffle followed by Interactive and then Static. The element common to all these creative methods is that changes to the local environment lead subjects to notice aspects of the scene in new and interesting ways. This perceptual variety facilitates creativity.

**Keywords:** Creativity; interactive behavior; externally supported cognition.

## Introduction

In design companies a materials shed, sometimes called an ideas cart, is often relied on for stimulation during the ideation phase of design. A materials shed is a collection of artifacts, such as mechanisms, fabrics, patterns, iconic designs, and toys or gadgets that a designer, in the early part of research, is encouraged to visit. Among the thousands of items filling the shed someone in search of inspiration might respond to an odd metallic texture, an unusual gear configuration, a suction device, a mechanism exploiting a physical principle in an uncommon way. The aspect that triggers interest need not be an element that will ever work in the final design. It need not be part of something central to the design. Its role is to provoke an idea that had not been considered; an idea that helps the designer re-align how he or she thinks, or that arouses consideration of candidates outside the norm. Looking, feeling and playing with things is an important part of this process.

The idea explored in this paper is that interactivity and chance are powerful stimulations of creativity. The reason

they are stimulative is that they facilitate perceiving new aspects in scenes and then thinking new thoughts. In a materials shed there are so many things to see and touch. It is provocative in the extreme. Our hypothesis is that even perception of the mundane, such as looking at a familiar setting in a slightly new way, can also offer us novelty, and that this everyday activity is an important constituent of creative thought systematically exploited by many creative professions and by most of us during problem solving.

Our idea begins with an intuition shared by phenomenologists: our phenomenal experience is far richer than typically described. We can and do discover new properties and new possibilities in the same scene over and over again. Often without appreciating it. These new ways of 'seeing' a familiar situation are sometimes as big and surprising as a gestalt switch – as when an ambiguous figure like the necker cube toggles shape. These sort of startling experiences we always notice. Small phenomenal shifts, however, are so common we ignore them as noteworthy. They occur whenever we attend to some *aspect* of a scene we have not appreciated before or when we organize component elements of a scene in a slightly new way. There is no limit to the number of aspects a person might perceive in a scene. But this is so much a part of everyday perception that it rarely warrants discussion or reflection. For a designer, each time such a shift occurs it creates an opportunity to trigger a new idea. The shift may contain the germ of an idea, something that can be developed into a 'genuine' idea. Interactivity and chance are useful ways of sparking these new ways of seeing, potentially leading to perceptual surprise and creative insight.

To investigate this idea that interactivity and chance are stimulants for creativity we look at three domains: architecture, choreography and a word game that resembles scrabble. We do not define creativity per se, nor assume there is a reasonable metric for it. We work, rather, on the intuition that a person who generates more live candidates in a problem such as scrabble is more creative than one who generates fewer (other things like memory and expertise being held constant). This is because scrabble is not simply a recall task, akin to stem completion or fragment completion. It is constraint based. Hence it is more like memory intensive problem solving than recall.

In architecture and dance making, we again work without a definition of creativity. Audience and critics, working without a formal definition of creativity, routinely evaluate the creativity of these products. Their assessment is notoriously subjective. To avoid hard to defend value judgments we rely instead on the intuition that professionals are trained to be creative. It is the job of architects and choreographers to produce novel outcomes. Accordingly, for these domains our approach is more ethnographic: we examine the practices of members of each community and assume that they use methods that tend on average to lead to creative outcomes. This means we do not try to judge how creative an architectural or choreographic product is, we just scrutinize the activities displayed by participants. In architecture, we expect experts to have methods and habits that lead to more creative output than the methods and habits of novices.

The importance of such methods is most certainly the case in choreography where our subject of study is the dance making process of Wayne McGregor, noted British choreographer and practitioner of methods strongly based on interactivity and chance. Similar approaches are widely practiced by other choreographers making contemporary dance, for instance, William Forsythe (The Forsythe Company) in Frankfurt, and Garry Stewart of the Australian Dance Theatre to name two companies well known to the first author. For McGregor, chance is not a component in the final performance as it is in aleatoric performance. Unlike John Cage and others who incorporate chance events as part of live performances, McGregor's dance compositions once made are performed the same on each occasion. In Random Dance (McGregor's company), chance or something close to it, serves as a mechanism during the 'making phase' to draw attention to features or structural elements that the dancers and choreographer then use as seeds or hints. These hints help them think up movement forms that depart from previous ones they have seen or performed. Both dancers and choreographer must still work hard to transform their seed ideas into something more polished and useful. But chance and the interactive task that provided the starting point for the eventual idea are the key factor in stimulating new movement ideas.

Interactivity and chance work in a different way in the architectural activity we studied. We created a quasi-experimental situation to observe the creative process of expert and novice subjects working with physical blocks to come up with design concepts for a dream home. Architects do not typically play with blocks in their studio as a generative process. They work with diagrams and sketches, 3D models (digital and physical), and they review hundreds of images of related projects. While working with physical materials and prototypes is a large part of modern architectural practice and an important component of architecture school curricula, little is understood about how tangible interaction facilitates creativity (Maher et al 2014). The primary objective in our

study initially was to observe how architects, architectural students and non-architects use physical materials to develop design concepts--how they think with physical things. But we were struck by the interactive behavior we observed and the comments made by the participants. We weren't surprised to see and hear that in the early stages of the 15-minute task we assigned them, participants worked with the blocks in an exploratory manner: fishing for design ideas by adding, removing and manipulating blocks frequently. With 51 pieces, the appearance of interesting assemblages is far too hard to simulate without physical exploration. The comments that startled us were those that suggested that chance 'noticings', perceptual surprises, are a vital element in what drives their ideation. Through interaction the participants appear to be looking for ideas – trying to see new things. And they reported that thought too. The benefit of expertise shows up in the way experts differ from novices in their interactive strategies: the way they move head, hands and blocks to help stimulate the 'noticing' process. They seemed to be more skilled in strategies that lead to architecturally fruitful ideas.

Our third study, 'scrabble' is the only classical experiment we performed and, as mentioned, it differs from the other two in not being a large-scale activity with established methods for being creative. We compare word-finding performance in three conditions, static, interactive and chance (shuffle). Our objective was to observe the role that both chance and interaction plays in stimulating idea formation – in this case word discovery. Our main conjecture is that the chance condition produces the most words with interaction being second best and looking at tiles lying stationary on a tray the worst. This is indeed what we found and we talk briefly about the relevance of the scrabble problem and our findings.

### How interactivity helps architectural creativity

To study the cognitive role that interacting with tangible objects plays in design thinking, we gave 17 architects and novice students a set of blocks and asked them to design their dream house on the site shown in figure 1. There were ten kinds of blocks available for use, a total of 51 individual blocks. See figure 1. There was no requirement to use all the blocks, and there was no indication of scale. Nothing specific was said about what would constitute a completed structure, or how the product would be judged.

**Participants:** 6 experts, 6 novice students, and 5 non-architecture students were selected for participation.

The experts (mean age 36, 2F, 4M) were professionally trained practicing architects with 4-8 years of teaching experience at the college and graduate level.

The novices (mean age 20, 5F, 1M) were second or third year undergraduates all enrolled in the same architectural design department.

The non-architectural design students (mean age 20, 2F, 3M) were all undergraduates enrolled at the same university, but from different departments, such as mechanical engineering.

As can be seen in figure 2 the blocks may seem simple at first, but being parallelepipeds, based on parallelograms, they have greater complexity and visual interest than cubes, all of whose faces are squares. When a parallelepiped is rotated 90 degrees, or when a subject repositions him or herself, the shapes that are in view are all different. As a result of this high structural complexity there are many 2D shapes that can be generated by rotating a single block. Completely unexpected attributes might be noticed for the first time. These shapes might be seen in projected shadows, or in the angle of an occluded surface, or even in the texture and shading of a block viewed from a non standard perspective.

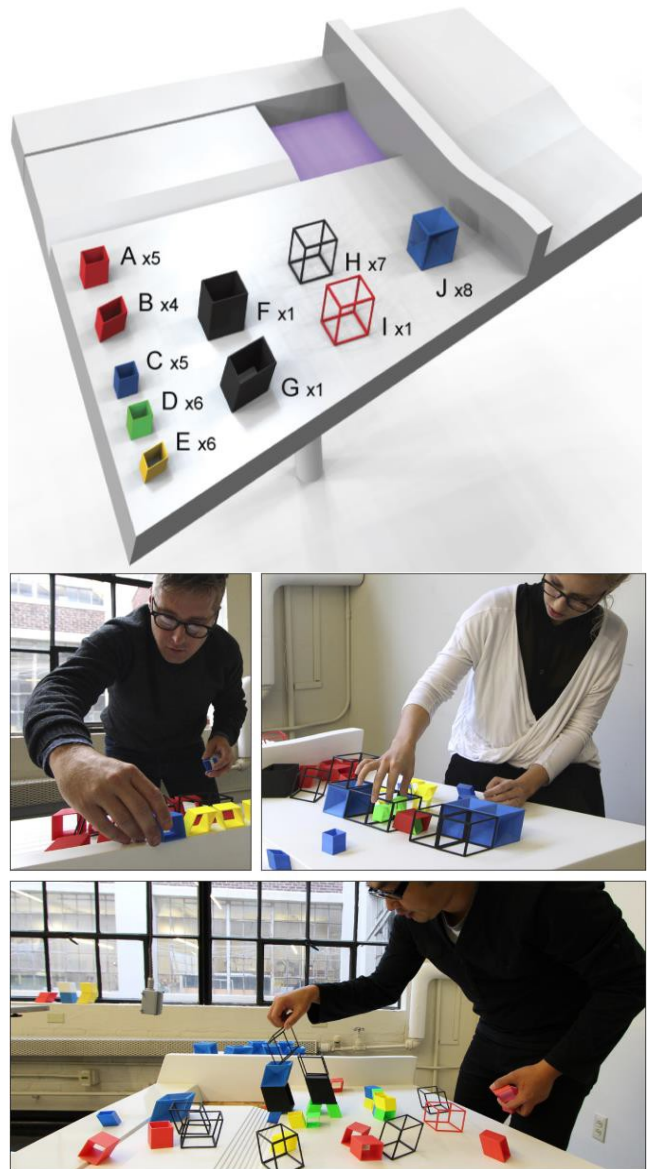


Figure 1: The top figure shows the design task site and block type counts. The bottom three images show participants working with blocks to design their dream house.

If our conjecture is right then perceiving surprising aspects in a setting, regardless of whether those aspects are easy or hard to create, lies at the heart of much creative

cognition. Architects, like artists, benefit by wandering through perceptual richness, especially when that richness has structural implications.

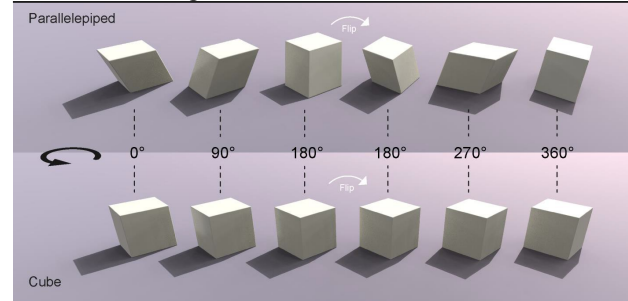
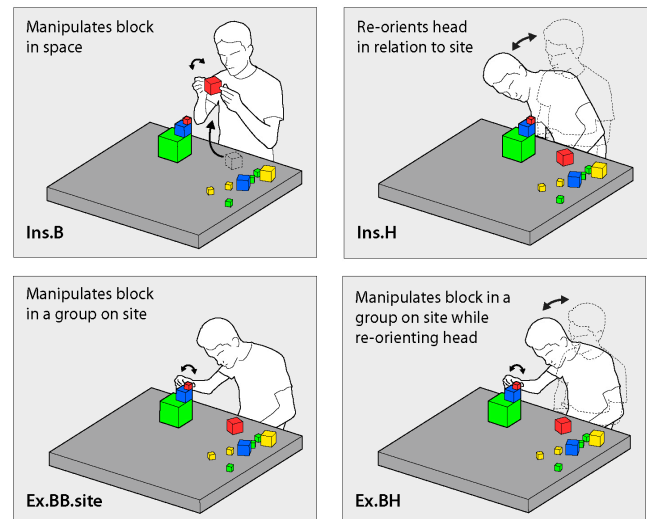


Figure 2. Both shading and the shape of faces change unpredictably when a parallelepiped is rotated. Both remain constant for cubes under the same rotation.

We found that our subjects have dozens of interactive strategies for moving themselves and blocks so as to see novel possibilities. In figure 3 we show a few of the interactive strategies that we observed. There were substantial differences in the way the groups behaved. Experts, compared to novices, spent far more time looking at the site and in particular at how their constructions interact with the site. They also spent more time looking at their constructions from multiple perspectives.



|                             | <u>Ins.B</u> | <u>Ins.H</u> | <u>Ex.BB.site</u> | <u>Ex.BH</u> | <u>TOTAL</u> |
|-----------------------------|--------------|--------------|-------------------|--------------|--------------|
| Novice 1-N<br>(time in sec) | 80           | 0            | 315               | 40           | 505          |
| (% of total)                | 16           | 0            | 62                | 8            |              |
| Expert 9-E<br>(time in sec) | 5            | 40           | 110               | 60           | 235          |
| (% of total)                | 2            | 17           | 47                | 26           |              |

Figure 3. Interaction differences between novices and experts. Percents do not sum to 100 because not all actions are shown.

We also found significant differences in the way experts and non-experts discussed their designs. Not surprisingly the experts used more technical language. But they also

concerned themselves far less with the functions of individual rooms or spaces and instead focused on developing a design concept. For instance, one expert said “I really like the ability to make a single figure that has a lot of interior/exterior spaces. I can’t go through it and say what’s my bedroom, what’s my living room...but as a plain figure I like it and can imagine it occupied in many ways.” This contrasts with a typical remark from a non-expert “I’m using this [area] as the entrance...and I’m going to use these [green blocks, not shown] as the grass and flowers...and these [the wireframe blocks] will be windows. These [the blue blocks] look heavier so those will be the big walls...like the frame of the house...These are my flowers, oh...and a fountain now too.”

Interactive strategies work because they reveal novel shapes and possible configurations. Our inspiration here stems from an observation by George Stiny (2006) on the relentless ambiguity of structure. For any 3D or even 2D shape there are an indefinite number of ways of looking at it. See figure 4 where Y might be seen as (A) three X’s on their side; (B) three clipped hexagons; or (C) one triangle and three small V’s.



Figure 4: Shapes are relentlessly ambiguous. Figure adapted from Stiny (ibid).

The idea that at any moment a new aspect of a scene might catch one’s eye was discussed in post-task interviews. Experienced architects spoke of looking for guiding design principles that serve to circumscribe their design space. They might work with a subset of blocks, turning them this way or that, changing their viewing angle, hoping to find a simple relation that can form the basis for variation or elaboration. They might focus on big ideas such as spatial proportions, lighting, and massing. Each time an architect changes position or stance – as when leaning forward, moving sideways, or handling a block – s/he constructs new the opportunities to see things. When probed most found serendipity to be important.

### The use of Randomness in Choreography

From the early to mid-20th century performance artists, painters, musicians, writers, and poets often wove random elements into their artistic performance. They used “free association and accidental movements to generate randomness” (Leong et al, 2008) at the time of performance. By contrast, chance and interactivity is used by the choreographer Wayne McGregor, (henceforth WM), to stimulate and hint at movement ideas in the ideation phase of creation.

For several years the first author has been studying how

WM makes a new dance.<sup>1</sup> WM relies on giving dancers problems or tasks that involve using arbitrarily selected ‘seeds’, typically derived from materials found in the local environment, as prompts or stimuli to generate movement. For example, dancers might be told to look around the dance studio and pick out six arbitrary curves, surfaces or structures. They then are asked to choose six arbitrary parts of their body – their left hip, perhaps, or their navel, right ear, left shoulder, mid thigh, and tailbone – and then to sequentially ‘sketch’ their chosen curves and structures using a random assignment of body part to curve. A dancer might sketch the elliptical curve of a ceiling lamp using her tailbone, then using her left shoulder she might sketch the joint of a folding chair, then pick up the end of that chair’s curve with her right ear and continue on to sketch the pedals of the piano with her navel before using her hip and so on. The result is an odd mixture of smooth and irregular movements that may contain forms that rarely arise. No one expects the dancer to stop there. These movements themselves are ideas that dancers can build on to make more integrated, interesting phrases.

Sketching tasks, such as the one just described, are for beginners. WM has extended this sort of method in many ways. Here is a brief transcript of an actual task he gave his (super-expert) dancers when making his 2009 piece “Dyad 1909”. The group was working in a modern studio with a 30ft high ceiling and diverse electronic equipment suspended. WM asked the dancers to lie down and after a few moments said:

Look Up. Pick boundaries in your field of vision to pay attention to. Describe the boundary in which to work in detail (while on the floor). Pick one detail or aspect within the boundary and describe it. Where is it most black? Assign that blackest thing to your body as a weight. Use that concept of weight as an anchor for what you are exploring. Describe something that is outside your boundary. Move to a new location and repeat these steps. Do the task about 5 times total.

The term ‘describe’ in dance often means to describe through body motion. In this case, WM wanted the dancers to characterize the detail or aspect they found interesting in their self-chosen boundary using internal language or imagery before using that description as inspiration for movement. They spent the next 55 mins on the floor, moving their bodies in original and often striking ways as they worked on this task. They came back to this task a few times in later sessions.

The output from this task, selected and refined by the dancers, then selected and modified by WM, goes through many more transformations. Two dancers, each with their own independent movements in pace and shape might be told to work together to make a duet. Dancer B might be told to take part of A’s movements and incorporate them

<sup>1</sup> For description of this project see (Kirsh, 2013) and (Kirsh et al 2009).

somehow, or use them as counterpoint movements to help B modify his own. The seed ideas that the task generated are edited, cherry picked by WM, added to, altered, combined, stretched, reworked, used as seeds for new random functions. At no time is the process mechanical or out of human intervention, especially by WM who personally appropriates the movements himself to ensure consistency in feel.

Nonetheless, over the next three or four weeks it remains open to novel influences while at the same time being refined and thematically shaped. In choreography as in other areas of design a germ idea is subject to hundreds of constraints and adaptive forces. Steve Jobs put it like this:

there is a tremendous amount of craftsmanship in between a great idea and a great product. And as you evolve that great idea, it changes and grows. It never comes out like it starts because you learn a lot more as you get into the subtleties of it and you also find that there are tremendous trade-offs that you have to make. (1995)

But without that great idea there would be no great product. The curious thing is that the source of this idea may come from a seemingly arbitrary feature or detail in the environment. Creative choreographers today have dozens of techniques to help their dancers and themselves to find inspiration in small things. They have techniques that start from some essentially unconnected, dance irrelevant place, such as the shape of a lampshade, the behavior of a moving image on a computer screen (Leach & deLahunta, 2015) and draw from that a movement idea that can be refined, combined with others, and structured into a part of a larger dance that has no narrative or semantic relation to the original seed.

### An experiment on chance in scrabble

To experimentally explore the value of chance as a creative stimulant we carried out a small study to test how well subjects play a computerized scrabble-like game. There were three conditions: Shuffle: hitting a 'shuffle' button randomly shuffles seven scrabble tiles, Interactive: subjects can manually move tiles using a mouse, and Static: scrabble tiles are fixed in place.<sup>2</sup> Subjects were given 3 minutes and asked to call out all the English 3, 4, 5, 6 and 7 letter words they could compose from a 7-letter stimulus such as 'ETCUSFA'. In each of the three conditions, there were 4 stimuli, and each was capable of making about 80-100 three to seven letter words of comparable frequency. We tested 26 subjects (11 Females, 15 Males, mean age 25) recruited from students at UCSD campus and the local population. All participants were native English speakers, defined as having learned English before age 5.

<sup>2</sup> This is a revision of an experiment we ran many years ago (Matlock et al, 1999) that now includes the random reset condition and a new set of analytical techniques.

The results as shown in table 1 confirmed our conjecture: Subjects produced the most words in Shuffle followed by Interactive then Static with the main effect being significant  $F(2,50) = 11.28$ ,  $p < .001$ . Data were analyzed using a repeated measures Anova.

| Condition   | Mean # of words | SD   |
|---|-----------------|------|
| Shuffle   | 18.88           | 4.14 |
| Interactive   | 17.67           | 4.31 |
| Static  | 16.56           | 5.35 |
| Shuffle > Interactive ( $t=2.49$ , $p=.02$ );<br>Interactive > Static ( $t=2.20$ , $p=.038$ );<br>Shuffle > Static ( $t=4.90$ , $p<.001$ ). |                 |      |

Table 1. Results of scrabble experiment show that shuffling helps subjects find more words, with interaction also helpful.

**Discussion:** in scrabble it is easier to evaluate ideas than to generate them, so any process that helps to generate good candidates ought to improve performance. The same often applies to problem solving and creative thought more broadly. But chance alone is unlikely to deliver good ideas. The chance of shuffling directly producing a legal word is so small at 60 to 1 that we almost never find usable words from shuffling. And yet shuffling reliably stimulates legal word finding.

There are a few reasons to think that shuffling is about hinting and that its success is generalizable. First, random generators lower the cost of hypothesis production. Pressing a shuffle or randomize button is fast, so fast that a button can be pressed many times in the hope that it will eventually surface a good search region for closer exploration. Internal and ordinary interactive generation in scrabble is slower, more complex and more effortful. People hoping to produce more ideas might want to find a hint-maker that relies on chance. This seems to be McGregor's modus operandi.

Second, by using randomness in generation an entire search space can be probabilistically guaranteed to be covered (Rabin, 1976; Motwani & Raghavan, 1995). Randomized algorithms break patterns we don't know we are following. Random generators produce candidates with larger variance than subjects can on their own because there are no biases or filters that limit candidates based on prior expectations of what is good. Every element and every region in a domain has equal probability of being chosen. As long as agents can decide quickly whether a candidate is interesting – once they see it – they can cash in on the variance, taking up good opportunities when they arise and ignoring the rest.

The third and perhaps most interesting reason why random resetting facilitates performance better than other conditions is that it duplicates the effect of adding additional people to a team. Adding cognitive diversity to a team is known to facilitate creativity. (Kurtzberg, 2005) Each new person operates with a different cognitive outlook and method; hence biases are partly washed out. Where this is not viable adding chance may be the easiest way to diversify. In fact, incorporating chance may be

even more facilitative: there are no group dynamics that hinder participants from suggesting truly wild ideas.

These ideas, while quite unconnected to the skilled methods we observed choreographers and expert architects using, are not at odds with them. Although shuffling is not much like the interactive strategies found in large-scale creative practices, both our artistic groups made efforts to add churn to their thinking. They counted on the causal richness of the world to throw up surprises when poked. Interactivity that goes beyond mere externalization of what is in the head offers the possibility of this sort of surprise.

## Conclusions

We have been arguing that interactivity and chance play a special role in creative cognition. There is no one way to be creative or to stimulate creativity. But when creativity begins to dry up and architects and choreographers are searching for new ways to fuel their ideation they often turn to processes that churn things up in the environment – processes that help them see things in a new way. In the case of scrabble, when word generation slows down, we found that random shuffling of tiles is better than intentional rearrangement – which often duplicates ideas close to those already conceived. Both are better than just thinking in one's head.

In architecture the use of interactivity and the hope of chance encounter is central to most stages of the process. Architects continually build and play with models. These constructions make it possible to aspects and things that were invisible before or were never considered. This is a major reason to work with physical assemblages. As perception changes so too does a designer's thoughts and visualizations of the possible. We found that expert architects have more interactive strategies for looking at how shapes and forms play off each other than novices.

In dance creation, modern choreographers often assign their dancers tasks that involve choosing semi-random stimuli as inspirational forms. The forms they observe do not in themselves bear much resemblance to the form of the movements they will perform on stage because how a dancer 'plays off of' a form – how they 'riff' – is where most of the creativity lies. Two dancers will almost never riff the same off the same external cue. By giving dancers diverse external structures to improvise off of choreographers help ensure novelty. By probing those structures for new aspects dancers and choreographer come up with new ideas. We observed dancers being given dozens of choreographic tasks that contained chance-like or arbitrary components, all with the intent of broadening the range of movement forms that dancers might consider. Such tasks seem to enlarge their 'hypothesis space'.

In a less magnificent but nonetheless real way, chance and interactivity facilitates creativity in word discovery. The process of seeing or realizing that a word can be formed from a sequence of letters is not creative in the sense that creating architecture or dance is, but it still requires creative invention. The obvious 'extra' that

interactivity and chance (shuffling) offers is motion and rearrangement. These processes change letter order which in turn leads to new noticing's. Words that were unseen before are now discovered.

Phenomenologists have pointed to the richness and variety of phenomenal experience. It is precisely this richness that artists and others use for creative stimulation. They have learned how to interact with things to increase serendipitous seeing.

## References

- Jobs, Steve. (1995) quoted in Kasper Tidemann "Steve Jobs on the difference between a great idea and a great product." 23 June, 2014  
<<http://www.kaspertidemann.com/steve-jobs-on-the-difference-between-a-great-idea-and-a-great-product>
- Kirsh D., Muntanyola, D., Jao, R. J., Lew, A., & Sugihara, M. (2009). Choreographic methods for creating novel, high quality dance. In Chen, et al. (Eds.), Design and semantics of form and movement. DeSForM 2009, 188-195.
- Kirsh, D. (2013). Embodied cognition and the magical future of interaction design. (2013). ACM Trans. Comput.-Hum. Interact. 20, 1, Article 3
- Kurtzberg, T., (2005) Feeling Creative, Being Creative: An Empirical Study of Diversity and Creativity in Teams. Creativity Research Journal. Vol. 17, No. 1, 51–65
- Leach, J., & deLahunta, S. (2015). Dance "Becoming" Knowledge. Leonardo, 150416090823009. doi:10.1080/17530350.2013.858058
- Leong T., Howard S., Vetere F., (2008) Take a Chance on Me: Using Randomness for the Design of Digital Devices, Interactions 15, 3: 16-19
- Maglio, P. P., Matlock, T., Raphaely, D., Chernicky, B., & Kirsh, D. (1999). Interactive skills in Scrabble. In M. Hahn, & S. C. Stoness (Eds.), Proceedings of the Twenty-First Conference of the Cognitive Science Society. Mahwah, NJ: Lawrence Erlbaum Associates, Publishers. pp. 326-330.
- Maher, M., Gonzalez, A., Grace, K., and Clausner, T. (2014). Tangible Interaction Design: Can we Design Tangibles to Enhance Creative Cognition? *Sixth International Conference on Design Computing and Cognition*, June 23-25, London, UK.
- Motwani R., Raghavan P., (1996). Randomized Algorithms. ACM Computing Surveys, Vol. 28, No. 1.
- Rabin, M.O., (1976). Probabilistic algorithms. JF Traub (Ed.), Algorithms and Complexity, Academic Press, New York. pp. 21–40
- Stiny, G. (2006). *Shape: Talking about Seeing and Doing*. MIT Press, Cambridge.
- Wood, K. and Lindsey, J. (2006). Understanding the Art of Design: Tools for the Next Edisonian Inventors. *Psychology of Learning and Motivation*, Vol 47, pp 65-122