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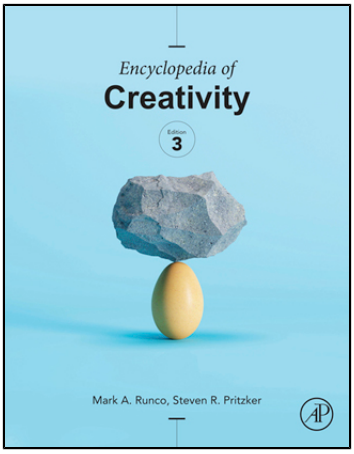

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Magic

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An Overview of the History of Magic

Magic, also called conjuring, aims at entertaining the audience with counterfactual illusions, such as making objects disappear or suspending them in the air. The person who performs the magic is referred to as a magician or conjuror. Historically, people's views toward magic have varied, which is reflected by the terms used to describe magic, such as illusions, tricks, black magic, supernatural power, and scientific spectacles. Accordingly, the magician's role has also changed throughout history and has included entertainer, showman, witch, trickster, and scientist.

The first historical record of magic is from 1700 BCE Egypt in the book known today as *Westcar Papyru* (Blackstone and Reynolds, 1985). This book described a magician named Dedil, who performed magic for Cheops, the Pharaoh who built the pyramids. Other historical records also indicate that magic was performed in ancient Greece and Rome. For instance, Hero of Alexandria, the Greek engineer and physicist, who lived around CE 62, designed various mechanical devices for the temples. Those devices enabled him to perform magical divine phenomena to enhance the religious belief of worshipers. Some early magic records have also been found in Asian locations such as China and India. When Marco Polo (late 13th century) travelled to Asia, he described in his book *The Travels of Marco Polo* that Chinese conjurors could prevent rains and caused thunder and lightning (Blackstone, 1985). Polo reported that these Chinese performers performed solely for entertainment purpose at that time.

Although some audience members did regard magic performances as illusions and viewed conjurors as magic-entertainers or jugglers, some royal members of the audience may have interpreted the sleights of hand as displays of supernatural and occult powers. In early centuries, people even described magic performance as "black magic", and early Christianity regarded magic performances as pagan practices. Augustine (CE 354–430), in *City of God*, described magicians as men who used demonic arts. *The Discovery of Witchcraft*, written by Reginald Scot in 1584, aimed to dispel the myth of the supernatural power of magicians and exposed them as conjurors' tricks. Thus, magicians have played roles throughout history, including entertainer, trickster, and witch.

In the mid-eighteenth century, some magicians in Europe began to adopt the fruits of the industrial revolution—the latest scientific technology—in their performances. Thus, they played a new role as science demonstrators. For instance, Maillard demonstrated his artificial magical swan that could mimic the behavior of a natural swan in 1733. Starting in 1735, Jean-Antoine Nollet utilized electricity to produce his special effects, such as transmission of electric shocks to a group of people holding hands. These scientific magic shows occurred in small scientific fairs. When theaters began to appear in late 19th century America and England, magicians seized this opportunity and moved their shows from the street and scientific fairs to theaters. Nowadays, the main purpose of magic is still entertainment, but we also have witnessed several innovative uses of magic in fields such as education, therapy, neuroscience, and psychology.

The Innovative Use of Magic in Different Fields

Science Education. In recent years, magic has become a pedagogical tool for science educators to raise students' motivation in science education. There are two reasons for this: 1) the seemingly impossible magical effects always raise students' curiosity about the secrets of the magic; 2) some magic is based on scientific principles and knowledge. Therefore, some creative science educators use magic performance as a discrepant event stimulus to engage students in the scientific inquiry process with the goal of uncovering the science behind the magic. For example, *Brain Powered Science – Learning with Discrepant Events*, written by Thomas O'Brien (2010), is a science magic encyclopedia covering various types of science magic tricks and related pedagogical strategies to teach

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chemistry and physics. In this book, he suggested that the unexpected outcomes demonstrated by magic challenged students' preconceived ideas and motivated them to examine their assumptions with empirical data and draw new scientific conclusions. His argument was also supported by the increasing number of empirical studies in science education research.

Therapeutic tools. Magic has also been used as a therapeutic tool to help students with disability or learning challenges. Since performing magic requires a high motor object manipulating skill, engaging students with motor disabilities in learning magic can improve their motor ability. The Project Magic program, established by the world famous magician David Copperfield, aims at teaching therapists how to use magic tricks as a form of therapy for improving patients' motor skills. A similar program, Hocus Focus, developed by Kevin Spencer, teaches individuals with disabilities magic tricks. Besides improving skills, both programs emphasize the positive influences of performing magic on individuals' self-esteem and communication skills. This is because magic enables individuals to create "miracles" that their non-disabled peers cannot achieve and thus gives performers a sense of achievement.

Neuroscience Psychologists testing tools. The magic props and mechanics developed by magicians is not the only reasons why magic is achieved. The main reason is that magicians know how to take advantage of the limitation of people's attention and perception. Magicians developed principles of misdirecting people's attention to hide the method and persuade the audience to believe in the reality of the magic effects. Those principles caught the attention of psychologists and neuro-scientists, who adopted magic tricks as an experimental tool to study visual attention, insight problem solving and memory distortions. To help psychologists use magic to conduct scientific study, Rensink and Kuhn (2015) developed a framework outlining how magic could be fully exploited to understand the human mind from four different levels: methods in magic, the effects of magic, the combination of effects and magic, and the experience of wonder.

While magic has been used in different fields for different purposes, the potential of magic has not been fully tapped. An increasing number of studies suggesting the connections between magic and creativity have begun to emerge. Before introducing how magic has been used as a tool for facilitating creativity, it is necessary to discuss these studies to understand why magic can be used to facilitate creativity.

Cognitive Dissonance

The effects brought about by magicians present a reality that differs from people's expectations. These effects create a magical experience that elicits a cognitive dissonance in the minds of audience members. The cognitive dissonance might disturb people's implicit beliefs about impossibility and possibility in the world, which might encourage them to think beyond the realistic world and thus enhance imagination. This special experience elicited by magic has been studied in the neuroscience, psychology, and social science fields, which establishes a foundation for using magic to facilitate creativity.

Recent neuroscience studies identified the brain areas influenced by the magic watching experience, which confirmed that magic performance is more effective in eliciting cognitive dissonance than other stimuli. For instance, Parris et al. (2009) used an MRI machine to investigate brain activity while watching a magic performance. Their results suggested that compared to other surprising stimuli, magic is more effective in activating the dorso-lateral prefrontal cortex (DLPFC) and the anterior cingulate cortex (ACC). The ACC is the area of the brain that mediates cognitive dissonance and controls the perception of causality. The ACC is activated when the brain is confronted with inconsistent information, such as impossible events. An example of this kind of event is a performance of the "suspended ball" trick. In this trick, a magician throws a ball into the air, where it remains suspended. When the ball is thrown into the air, the audience likely assumes that the ball will fall back down, according to their experiences. After seeing the ball suspended in the air, an alternative reality brought about by the magic disturbs the causal relationships learned through previous experience and knowledge, which activates the ACC. It is worth noting that ACC is related to people's cognitive flexibility, meaning that magic performance could be used as a stimulus to activate the ACC and further enhance creativity. However, no neuro-science study to date has directly tested such a connection.

On the other hand, research in social science studies indicated the connection between cognitive dissonance and divergent thinking, which indirectly provides evidence for the magic-creativity connection. For instance, Ritter et al. (2014) investigated the influence of cognitive dissonance on people's thinking flexibility. Specifically, they asked the participants to watch a film scenario that violates traditional thinking, and they found that those who watched the film scored higher on Guildford's Unusual Uses Task than those who did not.

This result was also supported by several cognitive studies. For instance, Gocłowska et al. (2013) reported that individuals tended to generate more creative ideas when their mind were disturbed by counter-stereotypical social examples (such as a hippy-lawyer, a woman-rugby player). Galinsky and Moskowitz (2000) also showed that individuals who encountered a counterfactual mindset attenuated their confirmatory bias and generated more creative solutions to a problem. Although these social science studies did not use magic directly in their experiments, all of the stimuli used by them aimed at eliciting a cognitive dissonance in individuals' minds, and the results suggested a positive influence of cognitive dissonance on thinking flexibility. This implies that magic performance can facilitate creativity as magic is more effective at eliciting cognitive dissonance than other stimuli. However, these studies did not further investigate the underlying cognitive mechanism and explain why cognitive dissonance can lead to creativity. Therefore, to clarify this mechanism, the following section introduces magical thinking, an important concept that helps understand the underlying cognitive processes.

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Magical Thinking

The term *magical thinking* varies by field. In psychology, magical thinking is generally used to describe people's belief that their thoughts, wishes or desires can influence the external world. Magical thinking has also been used in psychiatry to describe mental health disorders such as schizophrenia and obsessive compulsive disorder.

In this chapter, Subbotsky et al. (2010)'s definition of magical thinking is used to illustrate the connection between magic performance and creativity because of its emphasis on imagination. Subbotsky et al. (2010) defined magical thinking as the ability of individuals to construct an alternative world using their imaginations. In his book *Magic and the Mind* (2010), Subbotsky made a clear distinction between magical thinking and magical belief: magical thinking is related to imagination, whereas magic belief refers to an individual's belief that magical events may exists in reality and impact the real world. For instance, imagining Harry Potter or his magical power does not require believing either that Harry Potter exists or that his power could have a real impact in actuality. It is also worth noting that magical thinking differs from ordinary imagination in that it must involve violations of known physical principles. For instance, imagining flying with a broomstick like Harry Potter belongs to magical thinking, whereas imagining having a fancy car does not. In addition, children and adults differ in levels of magical thinking. As a child grows up, the magical view of this world is gradually replaced by realistic causal explanations. Compared to adults, children's fantasy and imagination are "stronger and richer because of the greater excitability of feeling, the intensiveness of experience, and uncritical judgement" (Vygotsky, 1991, p. 82). In other words, children's ideas are more original because they think less about reality and rely more on their own feelings and magical thinking.

The relationships among magical experience, magical thinking, and creativity have been investigated by a series of studies conducted by Eugene Subbotsky. One of his studies (2010) suggested that children who watched magical films (such as the *Harry Potter* series) significantly scored higher on originality on the Torrance Test than children who did not. He concluded that watching magical content encouraged participants to use their magical thinking and develop novel and counterfactual solutions to a problem.

A recent study conducted by Tong (2018a) further confirmed this. In this study, magic performance was used as a stimulus to facilitate thinking flexibility in an undergraduate class. Participants not only watched magic performance in class but also were taught to perform magic and learned the magic principles. The results suggested that participants' divergent thinking was significantly increased after the intervention. Furthermore, this study also clarified how magic influences people's magical thinking at different cognitive levels. The main influence is caused by the priming effect. Priming refers to a temporary activation of certain thinking that influences people's responses to tasks that follow. When participants had magical experience by either watching or performing magic tricks, they were primed with a magical thinking process. Once magical thinking was activated, participants were more likely to apply this thinking process to other activities and to come up with alternative ideas. Additionally, magic can also influence people's thinking at the reflective level. In Tong's study, participants not only watched magic performance but also learned how magical thinking benefits magicians and enabled them to develop creative magic ideas. Thus, they understood the value of magical thinking and became more willing to make changes and take actions toward the direction indicated by it.

The underlying mechanism revealed by studies mentioned above provides a theoretical support for the efforts made by practitioners in exploring the use of magic to facilitate creativity in design and science fields. These practitioners used magic and magical thinking to reduce cognitive fixation and inspire creativity in various ways, which will be introduced in the following sections.

Magic and Creativity in Design

In the design field, design fixation becomes a barrier for designers in finding and developing effective and creative solutions, especially during the ideation phase of design thinking. One method to reduce fixation is temporarily ignoring realistic constraints and imagining the possibilities and alternatives. Magic has been used to help designers escape those constraints and generate novel design ideas. For instance, Al'tshuller (1999) proposed a method for reducing designers' fixation by asking them to imagine that they were given a magic wand and they had the magic power to solve the design problem. The designers needed to think of idealized magical solutions so as to increase the uniqueness of their design idea. He suggested that using this method maximizes the imaginations of the designers and improves their design creativity. Similarly, Stanford professor John Arnold (2016) asked designers to imagine they were on a magical planet called Arktur IV to solve design problems. In both cases, magic was used to create a novel design space for designers. The magical design space elicited cognitive dissonances in designers and stimulate their magical thinking. The magical thinking mindset activated encourages designers to make unusual combination of different thoughts and ideas that cannot be achieved within a design environment full of rigid constraints.

In addition to using magic to create a magical design space, a few design researchers focused on the value of magic effects and the magic experience created by magicians to enhance the magical thinking of designers. For instance, Watson et al. (2014) proposed using stage magic effects (such as vanishing, levitation, etc.) to help designers develop creative products that can provide magical experiences to their users.

They translated the meaning of these magical effects into design elements that could be adopted by designers. For instance, the magic effect "levitation" means designing a product that can rise or hover by itself. Designers were encouraged to think of methods that enabled the products they designed suspend in the air. The study suggested that products embedded with such magical elements were more innovative and more preferred by the target users.

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In another study, Busk et al. (2012) proposed a conceptual framework to inform product designers how to create a magical experience like a magician to improve user experience. The framework divides the magical experience into internal and external magical experience, depending on whether the user has control over the magic power. They suggested that designers should practice thinking about magic and consider how their design products could facilitate both types of magical experience so as to provide a pleasurable feeling for their users. In addition, there are design practitioners whose design practice directly benefits from magic performance and magical thinking. For instance, in England, designer Adrian Westaway adopted the principles he learned from magic in his design practice. He established Special Projects (http://specialprojects.studio), a design company that provides magical design solutions. In his TED talk, he shared the story of how being a magician inspires him to come up creative design ideas. His magic performing experiences encouraged him to consider improving the "magical feeling" of his design products.

Besides the use of magic effects and principles to improve magical thinking of designers and the uniqueness of their design products, the magic creating process of magicians also drew attention of design researchers. As suggested by a designer (Tognazzini, 1993), the development of a magic performance is similar to that of a user-centered digital product in that both try to create a virtual reality or magical experience based on the psychological understanding of human nature. Inspired by this, Tong (2018b) used the magic creating process of magicians to guide students' product design process, in which students learned magic and the design principles from a magician and applied the principles to their design projects. The results showed that magic learning performance increased students' empathy for their target audience and also enhanced their creativity. This study demonstrated a new approach to using magic to facilitate creativity—encouraging people to perform magic so that they can form a deeper understanding of the principles of magic. For instance, as a magician, in order to successfully trick the audience, it is necessary to think from the perspectives of the audience and refine the magic accordingly. Such magic performing experience might help people focus less on their own ideas and care more about the suggestions given by others, which might reduce their fixation and improve thinking flexibility.

Magic and Creativity in Science

As quantum physics emerges, the line between magic and science is becoming blurred. Some seemingly impossible magical effects become true in the quantum world. This requires scientists to not only rely on the traditional scientific reasoning but also on their magical thinking to envision the new possibilities. Österblom et al. (2015) used the fact that magicians trick their audiences as a metaphor to remind scientists not to be tricked by perceived experiences and realities. He suggested that scientists should think like magicians to challenge the perceived reality and explore this world with their imaginations. Previous research also suggested that such an imaginative mindset is crucial for scientist to make great scientific breakthroughs. For instance, studies of Nobel Prize and MacArthur Genius award winners indicated that their scientific contributions were connected to their early experiences with artistic practices (Root-Bernstein and Root-Bernstein, 2006). The imaginary experiences they received in the artistic activity enabled those award winners to conduct similar imaginary play in the scientific world.

Like magicians who try to break the realistic law with their imagination and are driven by unexpected magical events, those scientists who made scientific breakthroughs are aiming for expanding scientific knowledge with their imagination and searching for surprises and anomalies. For instance, Alexander Fleming, the British bacteriologist known for the discovery of penicillin, was also famous for his love of painting with germs. Although he was not an artist, his painting provided an imaginary space for him to play freely with living bacteria. To paint his pictures, he formed a familiarity with his "friend"— knowing which microbes produce which color and the timing of their growth rates. Most importantly, such special intimacy enabled Fleming to see through biological phenomenon and sense the unexpected patterns and outcomes. Fleming's discovery of penicillin was a manifestation of his ability to envision new possibilities. If he had never imagined the possibility that mold could benefit human beings, we would not have penicillin to use today. Similarly, the virologist Jonas Salk, who discovered polio vaccine, said in his book *Anatomy of Reality*,

> I would picture myself as a virus, or as a cancer cell, for example, and try to sense what it would be like to be either. I would also imagine myself as the immune system. I soon found myself in a dialogue with nature using viruses, immune systems …

Magical thinking enabled Salk to not only establish relationships with the unfolding nature of mystery but also look at the problems in new perspectives. This increased his chances of discovering serendipity that lead to the next scientific breakthrough.

Interestingly, in the history of magic, many magicians were also great inventors. For instance, Hero of Alexandria, mentioned earlier, is believed to be the first person to invent a vending machine. Unlike the vending machines used today for simplifying people's lives, Hero's machine was built to demonstrate this automation miracle and enhance the magic belief of the temple followers. Georges Méliès (1861–1938), a French stage magician and film director, made the first fictional movies and invented the method of adding special effects to film. His magic performance experience and magical thinking inspired him to invent the tricks that changed movie history. Additionally, modern inventors also benefit from magic. For instance, Richard Garritt, an inventor, astronaut, and well known game designer who came up with the idea for the famous multiplayer online game Ultima Online, was inspired by his magic performing experience. In his book *Explore and Create*, he discussed how his early magic

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performing experiences encouraged him to seek the real magic by becoming a game designer and adventurer. His experience inspired him to explore the unknown and believe that everything is possible.

Arthur C. Clarke, a well-known British science fiction writer, famously stated, "Any sufficiently advanced technology is indistinguishable from magic," which suggests that technology inventors should think like magicians and believe that everything is possible. Magic thinking can encourage scientist or inventors to challenge traditional thinking and come up with ideas that can revolutionize the field. It is possible that performing magic can also encourage people to challenge traditional thinking and come up with great ideas.

Conclusion

Magicians devote their time and effort into creating wonder for audiences. This wonder- and magic-driven mindset might also benefit people in other fields in different ways. Watching magic performances may encourage people to expand their thinking and to change the existing world with their imaginations. The priming effect makes it possible to use magic to activate a counterfactual thinking mindset in people's minds so as to enhance creativity. Additionally, through thousands of years of practice and development, magicians have developed their principles of creating magic that amazes their audiences. Those principles could be adopted by other fields that need to provide similar magical experiences, such as user experience design. It is worthwhile for educators to consider bringing magic into their classes and creating a magical environment for enhancing students' creativity. And finally, thinking like a magician may encourage scientists and inventors to think beyond reality and explore the unknown world and thus bring about more scientific breakthroughs and inventions.

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