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The Electrophysiological Correlates of Scientific Innovation Induced by Heuristic Information

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In this study, novel and old scientific innovations (NSI and OSI) were selected as materials to explore the electrophysiological correlates of scientific innovation induced by heuristic information. Using event-related brain potentials (ERPs) to do so, college students solved NSI problems (for which they did not know the answers) and OSI problems (for which they knew the answers). A new experimental paradigm (heuristic information learning–problems testing model) was adopted to make subjects actively find a solution. The results showed that the P3 amplitude was higher for OSI than for NSI between 360 and 430 ms after onset of the problem stimuli. This finding most likely reflects an automatic matching process based on the known answer retrieval, which would be easier for OSI than NSI problems. However, the N4 amplitude was higher for NSI than for OSI between 430 and 500 ms and a greater negativity in the NSI (in comparison with OSI) developed between 500 and 900 ms. This pattern could reflect the generation of novel solutions due to the application of heuristic information (retrieved from memory) during NSI problems solving.

Creativity is commonly agreed to be the production of something both novel and useful (Fink et al., 2010; Flaherty, 2005; Sternberg, 1999) and is the fountainhead of human civilizations (Dietrich & Kanso, 2010). Numerous cases have shown that creative behavior appears to occur when a heuristic event is suddenly activated by mentally searching the problem space (Tian et al., 2011). For example, "Archimedes obtained his insight into the relationship between weight and volume from observing the displaced water in a tub while taking a bath" (Tian et al., 2011). Furthermore, many major inventions in history have heavily relied on bionic imitation (Dickinson, 1999; Vogel & Davis, 2000), applying knowledge of biological systems to the invention of

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artificial devices and machines seems critical to such creations.

Creativity such as this has been investigated through many psychometric measures, which identify some basic principles of this high-level cognitive process. Most recently, neuroscientific methods, such as single photon emission computerized tomography, positron emission tomography (PET), near infrared spectroscopy (NIRS), and functional magnetic resonance imaging (fMRI), have facilitated the reliable and precise measurement of brain activity associated with creative problem solving. From these tests, creative thinking does not appear to critically depend on any single brain region (Dietrich & Kanso, 2010).

Although these techniques (e.g., PET, NIRS, and fMRI) can provide more accurate information about which brain areas are involved in creative problem solving, their ability to inform one about the timing of activations is relatively weak. Better are electrophysiological measures, such as event-related potentials (ERPs) which provide a temporal resolution of evoked cognitive processes in the millisecond range. Creative thinking has been investigated through divergent thinking tasks, artistic production, and insightful problem-solving (Dietrich & Kanso, 2010). However, the ERP approach has only been successfully applied to insight. For instance, some ERP studies have reported a more negative deflection associated with insight, yet it has occurred at different latencies in different studies (e.g., 250–500 ms negativity in Mai, Luo, Wu, & Luo, 2004; 250–400 ms negativity in Qiu, Luo, Wu, & Zhang, 2006; 1500–2000 ms negativity in Qiu et al., 2008; 1200–1500 ms negativity in Wang et al., 2009). However, insight has also been related to a more positive deflection (e.g., P3 in Lavric, Forstmeier, & Rippon, 2000; 1200–1500 ms positivity in Wang et al., 2009; 500–700 ms positivity in Zhao et al., 2011). Furthermore, Lang et al. (2006) found that several ERP precursors (e.g., N1, P3a, P3b, and slow positive wave) are associated with insightful behavior. Existing empirical evidence in this field has been inconsistent, which may be due to the different materials (e.g., candle problem, riddles, and Chinese character-generation task), reference states (routine problem, unsuccessful insight problem solving, no-Aha experience), and test procedures (passive or active insight process).

Although these findings helping researchers to understand creativity, it remains unclear whether scientific invention is identical to the processes investigated in the aforementioned empirical studies. Until now, no ERP studies have investigated creativity using realistic scientific innovation cases. Inspired by the examples of Archimedes and the significant inventive discoveries based on bionic imitation, in addition to acquiring novel methods to resolve problems by applying heuristic information, people first need to activate the related heuristic information. Thus, it was speculated that the activation of heuristic information and forming novel associations (i.e., realizing the relationship between the heuristic information and a problem) might be the most critical processes of heuristic creativity. In this study, two types of problems were, therefore, selected as the experimental tasks: novel scientific innovations (NSI), for which participants did not know the answers; and old scientific innovations (OSI), for which participants did know the answers. The spatiotemporal pattern was investigated with a high density (64 channels) ERP recording while participants found a solution to a problem induced by heuristic information (heuristic information learning–problems testing model). Subjects had to find a solution on their own, rather than receiving answers passively. It is believed that retrieving prior knowledge with a heuristic information is needed to establish novel associations (i.e., to realize the relationship between the function of a prototype and a problem) and to produce a novel solution to a related problem. Based on previous work (e.g., Luo et al., 2011; Mai et al., 2004; Qiu et al., 2008; Qiu et al., 2006; Wang et al., 2009), it was hypothesized that it should be more difficult for participants to generate a new solution under the NSI condition than the OSI condition, which should be reflected in the ERP components (e.g., N400-like effect) involved in creative problem solving (e.g., access to semantic information from long-term memory; see Federmeier, 2007; Lau, Phillips, & Poeppel, 2008; Luo et al., 2011). By recording and analyzing high-density ERPs elicited by solution generation under different conditions, ERP data should therefore allow a more precise examination of the time course of scientific innovation induced by heuristic information.

METHOD

Participants

As paid volunteers, thirteen undergraduate students (6 women, 7 men) from 22–24 years of age ($M = 23.1$ years) were recruited from an advertisement in Southwest China University. All participants were right-handed and had no reported neurological disorders. This study was approved by the local Ethics Committee, and all participants signed an informed consent form before the experiment.

Experimental Stimuli

In this study, two different types of problems (NSI and OSI) were used to investigate the neural correlates of scientific innovation. The NSI were collected from various media outlets, such as recent books, television, and the Internet. Thus, the NSI tasks were all recent scientific problems solved by scientists using specific heuristic information to which college students would not likely know the answer. An example scientific problem is as follows:

> Scientists were trying to improve the performance of body armor made of Kevlar (a plastic). Although Kevlar has high tensile strength, it is not very malleable (Background of a question). How could it be made more malleable (NSI problem)? Spider silk might inspire the scientists. "Spider silk has incredible tensile strength, like Kevlar, and is often proposed to be several times stronger than steel of the same thickness"[1] (Heuristic information).

Participants in this study were only required to report the general method of solving the scientific problem, rather than specifying steps or concrete processes. For this example, the correct solution would be to "imitate the constituents of spider silk, producing some special material which is not only lightweight but also very sturdy and stretchy."

The OSI tasks were classic scientific problems that had been solved by scientists, the answers to which would be well known by college students. For example, Archimedes invented the Archimedes Law while in a bath and "used his principle of buoyancy to determine whether a golden crown was less dense than solid gold."[2] In each task (50 NSI problems and 40 OSI problems), the stimuli included a heuristic information, a background for a question, the question itself, and a solution.

In a preparatory experiment, college students ($N = 28$, 15 women and 13 men; $M = 22.1$ years old; $SD = 1.2$; Range = 20–24 years) had to provide solutions for these 90 problems. The results showed that their accuracy for NSI problems was 20.5% ($SD = 13.2$), and the accuracy for OSI problems was 83.1% ($SD = 12.1$). When another group of college students ($N = 29$, 15 women and 14 men, $M = 22.3$ years old, $SD = 1.3$, Range = 20–24 years) solved the problems after being presented with the relative heuristic information, their accuracy for NSI problems was 82.4% ($SD = 11.9$) and 83.9% ($SD = 13.1$) for OSI problems. Thus, most college students could solve NSI problems when they had been provided with heuristic information.

Procedure

To familiarize participants with the procedure and pace of the experimental task, they were trained with a set of similar materials with the same procedure before they entered the formal experiment. In the formal experiment, 90 trials (50 NSI and 40 OSI) were presented in an event-related design. There was no repetition of stimuli in the formal test. The words that appeared in both types of problems and answers were of high frequency. The flow of the learning–testing procedure is shown in Figure 1. During the learning stage, five bits of heuristic information were presented in the center of the screen one at a time for 11 sec. The five pieces of heuristic information were presented in random order. Participants were instructed to try to understand the heuristic information and provide the corresponding response by pressing keys. If participants understood the heuristic information, they were asked to press the *1* key quickly, but press no key if they did not understand it. After they had seen five pieces of heuristic information, the testing stage began. The test stage began with a 2-sec ready signal ("Ready?") followed by the background of a question for 6 sec (either an OSI or a NSI randomly selected from the five test problems). After a jitter of 0.2–0.4 sec, the relative problem (NSI or OSI) was then presented in the center of the screen for 5 sec. Participants were asked to solve these problems quickly, pressing the *1* key once they decided on a method for solving the problem but pressing no key if they did not reach a solution. Next, a solution was presented on the screen for 4 sec, during which time participants judged whether the solution was correct or incorrect (the ratio of correct to incorrect solutions was 1:1). After the formal experiment, participants were asked to complete a questionnaire that included all problems in the formal test and to rewrite the solutions for each problem.

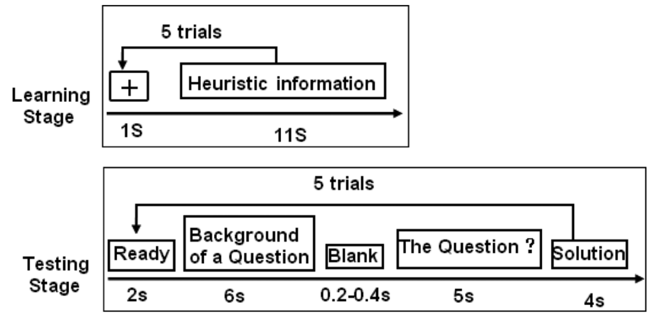

FIGURE 1 The flow of learning and testing logogriphs in each trial. The ERP locked to "The question?" stimuli.

ERP Recording[3]

Electroencephalography (EEG) was recorded at 64 scalp sites using tin electrodes mounted in an elastic cap (Brain Product, Brain Products GmbH, Gilching, Germany), with the reference on the left and right mastoids. The vertical electrooculogram (EOG) was recorded with electrodes placed above and below the left eye. All

[1]This sentence quoted from http://www.oocities.org/~gaiachurch/sci-nuz4.html.

[2]This sentence quoted from http://en.wikipedia.org/wiki/Archimedes.

[3]The data was recorded mainly referred the relevant information by previous work (see Qiu et al., 2007).

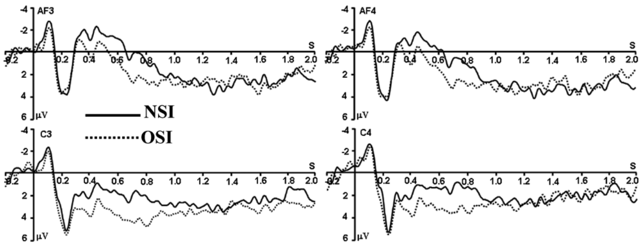

FIGURE 2 Grand-average waveforms at Cz and topographic maps of the difference wave (NSI minus OSI) in the 360–430, 430–500, and 500–900 ms time windows.

interelectrode impedance was maintained below 5 kΩ. The EEG and EOG were amplified using a 0.05–100 Hz bandpass and continuously sampled at 500 Hz/channel for off-line analysis. Eye movement artifacts were rejected offline. Trials with EOG artifacts (mean EOG voltage exceeding ±80 μV) and those contaminated with artifacts due to amplifier clipping, bursts of electromyographic activity, or peak-to-peak deflection exceeding ±80 μV were excluded from averaging.

ERP Data Analysis and Statistics

The ERP waveforms were time locked to the onset of the problem stimuli. The averaged epoch for ERP, including a 200-ms prestimulus baseline, was 2,200 ms. The reason for the 2,200 ms window of analysis was that the shorter mean response times to the problem stimuli were 2040 ± 460 ms (OSI). Correctly solved trials were separately averaged for the two task types (OSI and NSI). As seen in Figure 2, the difference wave was obtained by subtracting the averaged ERP of OSI from the averaged ERP of NSI. The topographical maps (see Figure 2) showed that these differences were mostly large over the fronto-central scalp regions. Therefore, the following 15 electrode points (including an anterior frontal site and a central site) were chosen for statistical analysis: FPz, AF3, AF4, Fz, F3, F4, FCz, FC3, FC4, Cz, C3, C4, CPz, CP3, and CP4.

RESULTS

Behavioral Performance

Only trials to which the students responded correctly in questionnaires, as well as in the formal test, were considered as correct responses. According to their behavioral response in the formal test and written answers in the questionnaire, the accuracy rates for the OSI task were greater (74.3%, $SD = 7.7\%$) than for the NSI task (62.6%, $SD = 7.2\%$); $F(1, 12) = 30.560$, $p < 0.001$. In addition, the mean reaction time to correctly solve the OSI and NSI problems was 2,040 ms ($SD = 460$) and 2,439 ms ($SD = 675$), respectively and thus significantly different; $F(1, 12) = 21.176$, $p = .001$. Together, this indicates that the NSI problems were indeed more difficult for subjects to solve than OSI problems.

Electrophysiological Scalp Data

As shown in Figure 3, clear N1, P2, N2, P3, and N4 components were elicited by the two task types. The amplitude (from baseline to peak) and latency of the N1 component were measured in an 80–120-ms time window. The amplitude and latency of the P2 were measured in a 220–260-ms time window. The amplitude and latency of the N2 were measured in a 280–320-ms time window. The amplitude and latency of the P3 were measured in a 360–430-ms time window. The amplitude and latency of the N4 were measured in a 430–500-ms time window. From 500 ms, the two conditions elicited some different ERP components. Mean amplitudes in the time windows of 500–600, 600–700, 700–800, 800-900, and 900–1000 ms were measured.

The ERP component amplitudes and latencies were analyzed in a series of two-way repeated-measures analyses of variance (ANOVA) using the factors task type (OSI and NSI) and electrode sites (15 sites). When appropriate, ANOVA results were corrected using the Greenhouse–Geisser procedure.

There were no main effects of condition or electrode for N1, P2, and N2 amplitude and latency. For the peak amplitude of P3, there was a significant main effect of task type, $F(1, 12) = 9.735$, $p = 0.009$. The P3 amplitude was higher for OSI than for NSI. The main effect of electrode site was significant, $F(14, 168) = 10.903$, $p < 0.001$. For the P3 latency, there was no main effect of task type. For the peak amplitude of N4, there was a marginally significant task type main effect, $F(1, 12) = 4.323$, $p = 0.06$. The N4 amplitude was higher for NSI than for OSI. The main effect of electrode site was significant, $F(14, 168) = 10.751$, $p < 0.001$. For the N4 latency, there was no main effect of task type.

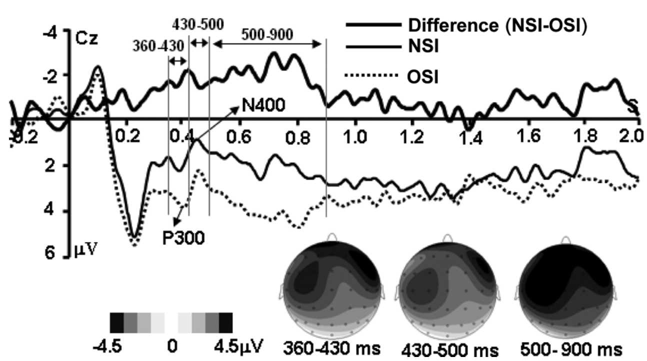

FIGURE 3 Grand-average ERPs at AF3, AF4, C3, and C4 for OSI and NSI problems.

Given that this was an initial effort using this methodology, exploratory analyses were justified. These indicated that there were main effects of task type for mean amplitudes in the time windows of 500–600, 600–700, 700–800 and 800–900 ms; $F(1, 12) = 8.422$, $p = 0.013$; $F(1, 12) = 10.474$, $p = 0.007$; $F(1, 12) = 11.237$, $p = 0.006$; $F(1, 12) = 7.034$, $p = 0.021$. The main effect of electrode site was significant in the 500–600 and 600–700 ms time windows; $F(14, 168) = 6.643$, $p = 0.001$; $F(14, 168) = 3.542$, $p = 0.017$. Additionally, the interaction between task type and electrode site did not reach significance in any time window. Overall, the mean amplitudes were more negative for NSI than for OSI at the 500–900 ms interval; $F(1, 12) = 10.240$, $p = 0.008$.

DISCUSSION

In this study, the ERPs was used to explore the electrophysiological correlates of scientific innovation induced by heuristic information. Scalp ERP data showed that NSI problems and OSI problems elicited some different ERP components between 360 and 900 ms after onset of the problem stimuli. To our knowledge, this is the first ERP study to investigate the time course of generating novel solutions behind scientific innovation. The implications of these findings were discussed in terms of creative problem-solving.

As shown in Figure 3, OSI and NSI problems both elicited a more positive ERP deflection between 360 and 430 ms after onset of the problem stimuli. Observing the ERPs grand-averaged waveforms, it was found that the positivity might be a P300 component. It is believed widely that the P300 are often linked to memory updating, encoding, or retrieval (Donchin & Coles, 1988; Kutas, McCarthy, & Donchin, 1977). In studies using the masked priming paradigms (a prime word presented subliminally before a target word), ERP results revealed an expectation-related positive effect around 300 ms (Carreiras, Gillon-Dowens, Vergara, & Perea, 2008; Grainger & Holcomb, 2009; Holcomb & Grainger, 2006). As Molinaro and Carreiras (2010) summarized, the P300 effects can be considered evidence of an automatic process that monitors the bijection between an unambiguously activated internal representation and the perceived stimulus word. In this study employing a learning–testing model, similar processes could have also occurred (i.e., participants might have formed the different bijection between a heuristic information and the current problem). Relative to the NSI problems, participants could associate heuristic information with an OSI problem faster as a result of having known the answers to the OSI problems. Thus, it was speculated that the positive component might reflect the degree of the matching between heuristic information and a problem, with higher P3 under the OSI problem suggesting that easier retrieval of the heuristic information leads to an automatic match between a heuristic information and the current problem.

Subsequently, both NSI and OSI problems elicited a more negative ERP deflection in the time window from 430 to 500. Based on the peak latency and grand-average ERPs, the negativity might be an obvious N400 component. The N400 is a negative deflection in the ERP, peaking at approximately 400 ms and elicited by words presented without an appropriate sentence context (Kutas & Hillyard, 1980, 1982, 1989). N400 is associated with the processing of semantic information that is incongruent with semantic expectancy (Mai et al., 2004; McPherson & Holcomb, 1999). Therefore, it was assumed that the N400 elicited by NSI and OSI problems might be related to the processing of semantic information. Furthermore, the N400 amplitude was higher for NSI than for OSI problems. As discussed, the participants needed to retrieve a prior experience with appropriate heuristic information to form a new relation with the NSI problem to generate a novel solution. In other words, the higher N4 amplitude for NSI problems observed in this study might reflect the generation of novel solutions due to application of heuristic information (retrieved from memory) during NSI problems solving. In a similar vein, it has been suggested that the N400 is related to the process of retrieving semantic concepts from memory (Barber & Kutas, 2007; Coulson & Van Petten, 2002; Federmeier, 2007; Lau et al., 2008).

In comparison with OSI problems, a greater negativity in the NSI developed between 500 and 900 ms after onset of the problem stimuli. From the topographic map of the difference wave, it was found that strong activity mainly distributed at a frontal center. An examination of the difference waves (NSI–OSI) in Figure 2 suggests the possibility that the later effect (the 500–900 ms negativity) is a delayed version of the N400 effect as a result of their similar topographical distribution (see Figure 2). Similarly, in the previous literature (e.g., Mai et al., 2004; Qiu et al., 2008; Qiu et al., 2006; Wang et al., 2009), a more negative deflection was related to creativity when using a proxy (Riddle Task) of a creative problem.

REFERENCES

Barber, H. A., & Kutas, M. (2007). Interplay between computational models and cognitive electrophysiology in visual word recognition. *Brain Research Reviews*, *53*, 98–123.

Carreiras, M., Gillon-Dowens, M., Vergara, M., & Perea, M. (2008). Are vowels and consonants processed differently? Event-related potential evidence with a delayed letter paradigm. *Journal of cognitive neuroscience*, *21*, 275–288.

Coulson, S., & Van Petten, C. (2002). Conceptual integration and metaphor: An event-related potential study. *Memory & Cognition*, *30*, 958–968.

Dickinson, M. H. (1999). Bionics: Biological insight into mechanical design. *Proceedings of the National Academy of Sciences*, *96*, 14208–14209.

Dietrich, A., & Kanso, R. (2010). A review of EEG, ERP, and neuroimaging studies of creativity and insight. *Psychological bulletin*, *136*, 822–848.

Donchin, E., & Coles, M. G. (1988). Is the P300 component a manifestation of context updating? *Behavioral and Brain Sciences*, *11*, 355–372.

Federmeier, K. D. (2007). Thinking ahead: The role and roots of prediction in language comprehension. *Psychophysiology*, *44*, 491–505.

Fink, A., Grabner, R. H., Gebauer, D., Reishofer, G., Koschutnig, K., & Ebner, F. (2010). Enhancing creativity by means of cognitive stimulation: Evidence from an fMRI study. *NeuroImage*, *52*, 1687–1695.

Flaherty, A. W. (2005). Frontotemporal and dopaminergic control of idea generation and creative drive. *The Journal of comparative neurology*, *493*, 147–153.

Grainger, J., & Holcomb, P. J. (2009). Watching the word go by: On the time-course of component processes in visual word recognition. *Language and linguistics compass*, *3*, 128–156.

Holcomb, P. J., & Grainger, J. (2006). On the time course of visual word recognition: An event-related potential investigation using masked repetition priming. *Journal of cognitive neuroscience*, *18*, 1631–1643.

Kutas, M., & Hillyard, S. A. (1980). Reading senseless sentences: Brain potentials reflect semantic incongruity. *Science*, *207*, 203–205.

Kutas, M., & Hillyard, S. A. (1982). The lateral distribution of event-related potentials during sentence processing. *Neuropsychologia*, *20*, 579–590.

Kutas, M., & Hillyard, S. A. (1989). An electrophysiological probe of incidental semantic association. *Journal of cognitive neuroscience*, *1*, 38–49.

Kutas, M., McCarthy, G., & Donchin, E. (1977). Augmenting mental chronometry: The P300 as a measure of stimulus evaluation time. *Science*, *197*, 792–795.

Lang, S., Kanngieser, N., Jaskowski, P., Haider, H., Rose, M., & Verleger, R. (2006). Precursors of insight in event-related brain potentials. *Journal of Cognitive Neuroscience*, *18*, 2152–2166.

Lau, E. F., Phillips, C., & Poeppel, D. (2008). A cortical network for semantics:(de) constructing the N400. *Nature Reviews Neuroscience*, *9*, 920–933.

Lavric, A., Forstmeier, S., & Rippon, G. (2000). Differences in working memory involvement in analytical and creative tasks: an ERP study. *Neuroreport*, *11*, 1613–1618.

Luo, J. L., Li, W. F., Fink, A., Jia, L., Xiao, X., Qiu, J., & Zhang, Q. L. (2011). The time course of breaking mental sets and forming novel associations in insight-like problem solving: an ERP investigation. *Experimental Brain Research*, *212*, 583–591.

Mai, X. Q., Luo, J., Wu, J. H., & Luo, Y. J. (2004). 'Aha!' effects in guessing riddle task: An ERP study. *Human Brain Mapping*, *22*, 261–270.

McPherson, W. B., & Holcomb, P. J. (1999). An electrophysiological investigation of semantic priming with pictures of real objects. *Psychophysiology*, *36*, 53–65.

Molinaro, N., & Carreiras, M. (2010). Electrophysiological evidence of interaction between contextual expectation and semantic integration during the processing of collocations. *Biological Psychology*, *83*, 176–190.

Qiu, J., Li, H., Huang, X., Zhang, F., Chen, A., Luo, Y., … Yuan, H. (2007). The neural basis of conditional reasoning: An event-related potential study. *Neuropsychologia*, *45*, 1533–1539.

Qiu, J., Li, H., Yang, D., Luo, Y., Li, Y., Wu, Z., & Zhang, Q. (2008). The neural basis of insight problem solving: An event-related potential study. *Brain and cognition*, *68*, 100–106.

Qiu, J., Luo, Y., Wu, Z., & Zhang, Q. (2006). A further study of the ERP Effects of "insight" in a riddle guessing task (article written in Chinese). *Acta Psychologica Sinica*, *38*, 507–514.

Sternberg, R. J. (Ed.). (1999). *Handbook of creativity*. New York, NY: Cambridge University Press.

Tian, F., Tu, S., Qiu, J., Lv, J., Wei, D., Su, Y., & Zhang, Q. (2011). Neural correlates of mental preparation for successful insight problem solving. *Behavioural brain Research*, *216*, 626–630.

Vogel, S., & Davis, K. K. (2000). *Cats' paws and catapults: Mechanical worlds of nature and people*: New York, NY: WW Norton & Company.

Wang, T., Zhang, Q., Li, H., Qiu, J., Tu, S., & Yu, C. (2009). The time course of Chinese riddles solving: Evidence from an ERP study. *Behavioural Brain Research*, *199*, 278–282.

Zhao, Y., Tu, S., Lei, M., Qiu, J., Ybarra, O., & Zhang, Q. (2011). The neural basis of breaking mental set: An event-related potential study. *Experimental Brain Research*, *208*, 181–187.