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Moments of Insight in Problem-Solving Relate to Bodily Arousal

ABSTRACT

Problem-solving involves both cognitive and physiological changes. Since most prior work has focused on examining the cognitive side of problem-solving, there is more to explore on the physiological side, including skin conductance. The present study examined skin conductance reactivity (SCR) to the moment participants solved three different types of problems: (a) straightforward (basic), (b) analytic processing (analytic questions), and (c) a sudden insight (riddles). The authors predict different responses in SCR between basic, analytic, and riddle conditions, and the level of difficulty in riddles. Moreover, the authors predict that a faster and correct response is related to larger physiological arousal. Thirty-one participants were confronted with problems that were best solved using either sudden insight (riddles) or analytic thinking, as well as a control condition with basic questions. Participants showed the largest SCR amplitudes to the insight condition versus the basic control condition. Furthermore, hard insight problems had greater SCR amplitudes than easy insight problems. These findings suggest that physiological response to problem-solving is dependent on the type of problem and the amount of challenge it poses to an individual.

Keywords: creative insight, problem-solving, riddle, skin conductance.

Problem-solving is a fundamental cognitive process that can happen in everyday life. Problems that one may experience range from a simple mathematical problem to a complex riddle problem. When people attempt to solve such problems, they can spontaneously experience insight. Insight has been identified as an important characteristic of creative thought (Andreasen, 2005; Ansburg & Hill, 2003; Friedman & Förster, 2005; Robertson, 2017; Schooler & Melcher, 1995; Walinga, Cunningham, & MacGregor, 2011) and thus a crucial element of problem-solving. A considerable number of studies have been done to examine psychological correlates of insight problem-solving (Jung-Beeman et al., 2004; Lin et al., 2020; Qiu, Li, Jou, Wu, & Zhang, 2008; Sandkühler & Bhattacharya, 2008; Tian et al., 2011; Zhao et al., 2011); however, considerably fewer attention has been given to the physiological mechanisms. The present study aimed to examine the physiological correlates of insight by comparing skin conductance responses to three different types of problems. Results from the study enable us to understand whether moments of insights have physiological correlates and whether these are differentiated by problem type. This understanding is significant since knowing the physiological correlates of insight can help to catalyze physiological sensing applications that support human cognition.

TYPES OF PROBLEM-SOLVING

A sudden insight, or "aha moment," is generally defined as a clear and sudden understanding of how to solve a problem (Bowden, Jung-Beeman, Fleck, & Kounios, 2005; Sternberg & Davidson, 1995). Problems can be solved using either straightforward or analytic processing or by insight (Salvi, Costantini, Bricolo, Perugini, & Beeman, 2016). Straightforward problems typically do not require much cognitive processing as they consist of common facts based on one's prior knowledge. Analytic problems require a more deliberate and conscious process characterized by a "step-by-step" systematic approach (Fleck & Weisberg, 2013; Metcalfe & Wiebe, 1987; Salvi et al., 2016). An insight, in contrast to an analytic process, is usually described as

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an "all-at-once" process or a sudden leap of understanding without external hints or conscious forewarning (Shen et al., 2017; Sheth, Sandkühler, & Bhattacharya, 2009).

Measuring problem-solving and disentangling insight versus analytic processes has been challenging. In analytic problem-solving, for example, one can usually assess how far he or she is from a solution, but when such assessment is not possible during the problem-solving process, a solution may unexpectedly come to mind, causing an Aha! experience or insight (Durso, Rea, & Dayton, 1994; Fleck & Weisberg, 2013; Metcalfe & Wiebe, 1987).

Most problems used in educational and psychological testing are analytic problems. An example of a problem that would elicit an analytic type of processing would be a simple mathematical calculation problem (DeYoung, Flanders, & Peterson, 2008; Pretz, Naples, & Sternberg, 2003). As opposed to analytic problems, problems that require insight cannot be broken down into smaller components and often require a change in mental representation to reach the solution because the path to a solution is not clear (Pretz et al., 2003; Robertson, 2017). Riddles are an example of a problem type that often relies on insight as they are defined as a metaphor or a group of metaphors that are neither self-evident nor employed in a common way (Durso et al., 1994; Tupper, 1910; Vallée-Tourangeau & March, 2019; Winner, Engel, & Gardner, 1980).

AFFECT AND PROBLEM-SOLVING

Problem-solving does not just involve cognition but is also intertwined with affective processes. The role of cognition in emotion and its interdependency has been studied by a considerable body of research (Dolcos, Iordan, & Dolcos, 2011; Pessoa, 2009; Phelps, 2006). In contrast to the traditional distinction of emotion and cognition, the integrated contribution of both emotion and cognition to behavior has been supported by neuroscientific evidence (Dolcos et al., 2011; Pessoa, 2009). Phelps (2006), while investigating the role of the human amygdala, a brain region involved in mediating emotional significance, found that the mechanisms of emotion and cognition work in tandem across neural systems involved in early perception to decision making and reasoning.

Dynamic interaction between perception, emotion, and cognition influences autonomic responses of the body (Critchley, Eccles, & Garfinkel, 2013). The elicited physiological reactions, as indicated by changes in heart rate (HR) and sweat secretion level, for example, have been seen to reflect the mobilization of energy to facilitate coping responses from perceived challenges (McCorry, 2007; Tomaka, Blascovich, Kelsey, & Leitten, 1993).

The influence of emotions on cognition is not just limited to rudimentary thought and decisions. In fact, emotions have been proposed as a dominant driver of making meaningful and complex judgments and decisions (Lerner, Li, Valdesolo, & Kassam, 2015). According to Damasio's (1994) somatic marker hypothesis, cognitive images become marked with physiological responses that reflect emotions, which affect the ability to make fast and rational decisions in complex problems. Each behavioral option typically involves unconscious somatic responses that could indicate "the feeling of what happens" or a signature triggered by the mere thought of how to select an option (Shen et al., 2017; Suzuki, Hirota, Takasawa, & Shigemasu, 2003).

Similarly, it has been proposed that insight problem-solving also involves affective processes (Gick & Lockhart, 1995; Gnezda, 2011). The moment of insight is often described as "a strong thrill of intense feeling (Canfield, 1920)" or "a feeling of knowing (Metcalfe, 1986)." Problem-solvers often need to choose an appropriate option among multiple pathways to successfully solve the problem. This decision-making process may involve somatic markers relevant to the solution to a problem that is solved with insight (Shen et al., 2017). In a sense, at the moment the insight occurs, the autonomic nervous system (ANS) response can be seen as a reflection of the nervous system orienting itself to its self-perceived significance (e.g., solving a problem).

PSYCHOPHYSIOLOGY OF PROBLEM-SOLVING

The bodily signatures of insight can be measured through indices of the autonomic nervous system (ANS), such as changes in HR, sweat level, muscle tension, breathing rate, and facial expression (Healey, 2014). Studies using heart rate have been conducted and have found a greater sudden increase in HR with insight vs analytic problems (Jausovec & Bakracevic, 1995; but also see Goldstein, Harman, McGhee, & Karasik, 1975, for null result). Whereas HR involves both sympathetic and parasympathetic influences, skin conductance is seen as a more pure indicator of sympathetic arousal (Blascovich & Kelsey, 1990; Fowles, 1986). Skin conductance is a sensitive measure, activated by attention-demanding tasks (Bergstrom, Duda, Hawkins, & McGill, 2014; Dawson, Schell, & Filion, 2017; Leiner, Fahr, & Früh, 2012). Goldstein et al. (1975) also measured skin conductance along with HR in their study. In contrast to similar HR patterns between analytic problems and riddles, the affective response in skin conductance showed a pattern suggesting more change (as measured in skin conductance reactivity from the question to the answer period) during riddle compared with analytic problems. Recent work by Shen et al. (2017) used the Compound Remote Associates (CRA) problems to examine different strategies employed to solve the problems. They observed greater skin conductance reactivity (SCR) for the problems solved with insight as compared to the ones solved analytically.

THE CURRENT STUDY

Despite the extant research on insight problem-solving and its relation to physiological activity, research using skin conductance has received little attention. Based on a similar theoretical framework of Shen et al.,'s (2017) recent study investigating the moment of insight through skin conductance measures, this study examined how different the SCR is for different types of problems: a. straightforward (basic), b. analytic processing (analytic questions), and c. a sudden insight (riddles). Moreover, the varied level of difficulty of the insight task was employed to ascertain whether different levels of challenges relate to the SCR.

The authors predicted differences in SCR amplitude and rise time within subjects between basic, analytic, and riddle conditions to moments of insight, with riddle and analytic conditions showing higher magnitudes than the basic condition (H1). This prediction was largely based on Shen et al.,'s (2017) finding, suggesting that riddles may be more emotionally loaded as they are more ambiguous, complex, and surprising (see, also, Goldstein et al., 1975). Furthermore, the authors predicted difficult riddles to have higher SCR than easy ones (H2). This prediction is based on research demonstrating higher ANS responsivity to more complex challenges (e.g., see Light & Obstrist, 1983; Veltman & Gaillard, 1998). Finally, faster behavioral reaction times and higher accuracy (number of correct responses) were predicted to be positively related to larger physiological arousal (H3). If the latter is found, it may further support the notion that physiological responses may serve an adaptive function, that is, that the psychophysiological response to successful problem-solving may reflect a somatic marker that was integral in reaching the correct answers sooner.

METHODS

PARTICIPANTS

Thirty-one participants over 18 years of age (17 males, mean age = 26.2; and 14 females, mean age = 26.1) were recruited through bulk email at Texas A&M University. The authors aimed for a higher number of participants than Shen et al.,'s (2017), a study most similar to the presented work. Data collection ended after the budgeted funds for the study had ceased, and key recruitment personnel had to move out of state. Data analysis only began after the final sample in the current study was collected (n = 31). The demographics of the final sample were as follows: Asian, 41.9% (n = 13); White, 38.7% (n = 12); and Hispanic, 19.4% (n = 6). All participants had normal or corrected-to-normal vision. The majority of the participants were college students (n = 25). 56.7% of participants had an education level of bachelor's degree and higher, and 43.3% had a high school diploma. The study was carried out with the IRB approval (IRB # 2017-0910D) from Texas A&M University.

PROCEDURE

Before the experiment began, participants were explained the purpose and procedure of the study. All participants provided informed consent and answered basic demographic questions. They were seated in a quiet, temperature-controlled (70 °F) room in front of a stimulus presentation screen where they were hooked up to skin conductance leads. The research assistant made sure participants were comfortable, double-checked recording quality, and explained the task in the testing room during a practice block (n = 3 trials). When the task began, the research assistant left the room and remained in the control room to monitor progress. The task lasted, on average, around 90 minutes. After completion, participants were compensated with a $10 Amazon gift card. The entire procedure lasted, on average, no longer than 2 hours.

INSIGHT TASK

Participants were asked to provide answers to 40 questions developed by the research team mostly through Internet searches. A list of the items can be found in the supplements (Table S1). The questions were of three types randomized into 4 blocks of 10 questions each (each block contained several types of questions) throughout the study:

1. *Basic* questions (BQ): *Basic* questions ($n = 10$) were intended as control questions that did not require much cognitive processing on the part of the respondent. Examples of BQ were "Do you have a car?" and "What is your age?"
2. *Analytic* questions (AQ): *Analytic* questions ($n = 10$) were questions for which finding the answers required the respondent to engage in logical and systematic thought processes (see, also, DeYoung et al., 2008; Fleck & Weisberg, 2013; Pretz et al., 2003). An example of an AQ was "How many minutes are in one week?"
3. *Riddle* questions (RQ): *Riddle* questions ($n = 20$) were divided into *easy* ($n = 10$) and *hard* ($n = 10$) questions that were more difficult to reason through and were more likely to rely on spontaneous insight.

In a pilot study, participants ($n = 10$; 5 males and 5 females; mean group age = 24.1) were asked to solve 20 riddles to assess their levels of difficulty. Based on the accuracy rate of each question, the researchers selected the 10 most difficult (score = 1.2, SD = 1.135) and the 10 least difficult riddles (score = 7.6, SD = 1.713) for use in the study (a score range from 0 to 10). Questions with 4 correct answers and below were considered as difficult, and questions with 5 correct answers and above were considered as easy. An example of a difficult RQ was "What goes in the water black and comes out red?" [Answer: A lobster], and an example of an easy RQ was "Take off my skin - I won't cry, but you will! What am I?" [Answer: An onion].

For each trial, participants were asked to press the "p" keyboard key when they were ready to see the question. The question would remain on the screen. Participants were given as much time as they needed to come up with an answer to not have time pressure affect the outcomes. Participants were asked to hit the "spacebar" key when they thought they had a final answer to the question. The spacebar key press triggered the appearance of a text field on the screen into which participants could type in an answer. Participants had to press the "Enter" key to submit the answer. If the participants could not come up with an answer for a question, they could just hit the "Enter" key (instead of the spacebar) in which case the system skipped the answer entry step and proceeded to the next step. In the next step, an image of nature scenery was shown on the screen for 6 seconds as a relaxation period. After the nature image, the correct answer to the question was presented for 12 seconds before the next trial began. The participant had to press "p" again to see the following question. Figure 1 shows a simplified flowchart of the insight task.

SKIN CONDUCTANCE MEASUREMENT AND DATA PROCESSING

Electrodermal signals were recorded at a sampling rate of 2000 Hz using the BIOPAC MP150 recording system (BIOPAC Systems Inc., Goleta, CA). Skin conductance was recorded by two sensors attached to each participant's palm of the non-dominant hand. Before having the sensors affixed, participants' hands were abraded and cleaned to increase conductance. In addition to the physiological recordings, participants' responses were reported using the software E-prime 2.0 (Psychology Software Tools Inc., 2012) that was synced with the BIOPAC system.

After smoothing the signal by a 0.25-ms Hanning window, skin conductance signal was epoched 6 seconds before and 8 seconds after the participant pressed the spacebar to indicate their answer. Skin conductance features were extracted through Ledalab (Karenbach, 2005; www.ledalab.de), a MATLAB extension for cleaning and analyzing skin conductance data. SCR detection was performed on the amplitude and rise time

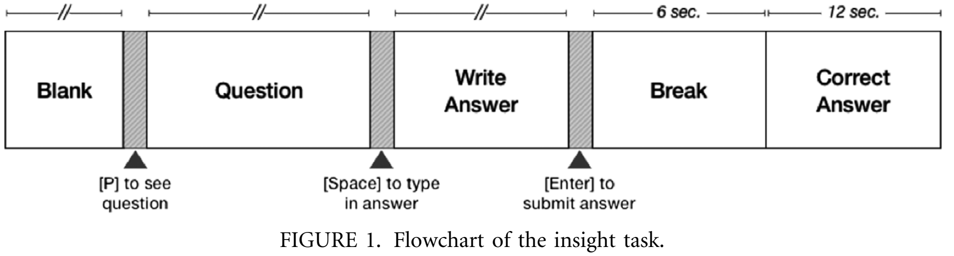

FIGURE 1. Flowchart of the insight task.

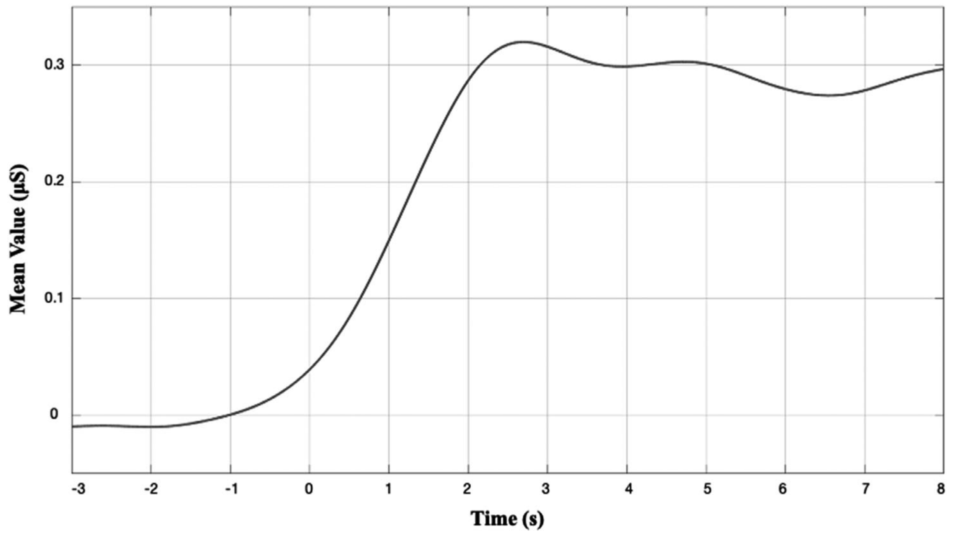

FIGURE 2. Grand average SCR waveform across all conditions.

consistent with Shen et al. (2017) and Figner and Murphy (2011). The a priori determined approach was to first examine the grand averaged waveform locked to the response (e.g., a press of the spacebar) combining all conditions to establish the time window of analysis (see Figure 2). Based on this waveform, the authors decided that the response (press of a space bar) ($t = 0$) would be an acceptable anchoring point with a relatively flat baseline period of 3 seconds. The amplitude was taken as the min–max from the response until 8 seconds for each individual. The rise time was calculated by the period it took for the waveform to reach its peak from the moment the spacebar was pressed.

In addition, the baseline of 3 seconds was also found to be sufficient as determined by a review of the extant literature in similar tasks (see Kobayashi, Yoshino, Takahashi, & Nomura, 2007; Shen et al., 2017 and Yoshino, Kimura, Yoshida, Takahashi, & Nomura, 2005), as well as the general recommendation provided by Boucsein (2012). Further, the authors were not concerned with intertrial spillage effects on the overall conclusions, since these would likely be similar for each condition considering questions of problem types were presented in random order.

DATA ANALYSIS PLAN

Data analysis on the processed data set was performed using SPSS 22.0, and relevant criteria (see below) were discussed among the team a priori. Before analyses were performed, data were tested for normality (Kolmogorov–Smirnov test), outliers (data points with standard deviations > 2.5 from the mean), and homogeneity of variance (Levene's test). Data were normally distributed, and assumptions for the use of analysis of variance were not violated. No outliers had to be removed.

Repeated-measures analyses of variance (ANOVAs) were run to test for within-subject differences between conditions. The authors ran a Pearson product–moment correlation coefficient (Pearson's r) to assess the relationship between physiological reactions and behavioral results. Partial η^2 values were computed to determine effect sizes. According to Vacha-Haase and Thompson (2004), $\eta^2 = 0.01$ corresponds to a small effect, $\eta^2 = 0.10$ corresponds to a medium effect, and $\eta^2 = 0.25$ represents a large effect. Statistics will be reported for significant results with alpha levels set to 0.05 (2-tailed tests).

RESULTS

BEHAVIORAL RESULTS

Table 1 shows the mean value and standard deviation (SD) of accuracy and response time for each of the conditions. Since the questions for the *Basic* condition were mostly asking for participants' information and did not have right or wrong answers, it was left out in Table 1. Across the three conditions, excluding the basic condition, a repeated-measures ANOVA showed a significant main effect, $F(2, 60) = 150.521$, $p < .001$, $\eta_p^2 = 0.834$, of accuracy, with pairwise contrasts showing that the *Analytic* condition had a higher accuracy rate than both the *Riddle easy* ($p < .001$) and the *Riddle hard* conditions ($p < .001$). Response time was significantly different across conditions, $F(3, 90) = 69.956$, $p < .001$, $\eta_p^2 = 0.7$, such that the *Analytic* condition had the longest response time than the others ($p < .001$). In addition, the authors also ran correlations among different conditions. The result showed a negative correlation between the *Riddle easy* response time and the *Riddle easy* accuracy, $r(29) = -.36$, $p = .046$.

SCR RESULTS

To test the first and second hypotheses (H1 & H2), SCR amplitude and rise time were compared among the four conditions (*Basic, Analytic, Riddle easy, and Riddle hard*) using a repeated-measures ANOVA. The results for amplitude showed a main effect of Condition, $F(3, 84) = 5.22$, $p = .002$, $\eta_p^2 = 0.157$. Pairwise contrasts showed a significant difference between: the *Riddle hard* and the *Basic* condition ($p = .002$) and the *Riddle easy* and the *Riddle hard* condition ($p = .019$). The result of having the greatest SCR amplitude in the *Riddle hard* condition was consistent with the hypothesis. No differences between conditions were found for the rise time.

Table 2 shows the descriptive statistics for the dependent variables broken down by condition. Figures 3 and 4 show the raw skin conductance waveform and bar graphs illustrating differences between conditions, respectively.

SCR AND BEHAVIOR

To test the third hypothesis (H3), that is, whether there was any relation between SCR magnitude and accuracy rates, Pearson's r correlations were computed. The results showed a positive correlation between the *Riddle hard* rise time and the *Riddle hard* accuracy, $r(29) = .48$, $p = .006$, $\eta_p^2 = .436$, as well as the *Analytic* amplitude and the *Analytic* accuracy, $r(29) = .47$, $p = .008$, $\eta_p^2 = .303$. A full correlation table can be found in the supplements (Table S2). The authors also ran a linear mixed-effects model to account for the dependency of the data points between conditions within participants. With these adjustments, the authors computed pairwise comparisons and report that the correlation slopes between SCR and accuracy in the *Analytic* condition were statistically different from those of the *Riddle easy* condition ($p = .005$) but not the *Riddle hard* ($p = .10$). The correlation slopes of the *Riddle easy* and *hard* were not statistically different from each other ($p = .06$).

DISCUSSION

This study examined SCR correlates of different types of problem-solving. Results showed a significant difference between the *Riddle hard* and the *Basic* conditions, as well as between the *Riddle easy* and the *Riddle hard* conditions in terms of SCR amplitude. The greatest SCR amplitudes were found for the *Riddle hard* condition. Furthermore, though no relationship was found between the *Riddle hard* SCR amplitude and behavioral measures of accuracy, higher accuracy rates in the *Analytic* condition did relate to greater SCR amplitude. There was no significant difference between any of the conditions in terms of rise time.

The first and main hypothesis predicted higher SCR for the *Riddle* and the *Analytic* conditions versus the basic condition. This hypothesis was mostly confirmed as SCR for amplitude was greater for the *Riddle hard* than the *Basic* condition. The *Analytic* condition did show greater amplitudes than the *Basic* condition;

TABLE 1. Descriptive results regarding behavioral measures on different types of problems (means of problems solved correctly (accuracy) and response time per participants, across the three types of questions)

	Basic		**Analytic**		**Riddle easy**		**Riddle hard**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Accuracy (%)	100	0	83	15	55	17	22	16
Response Time (s)	2.74	0.9	49.56	20.79	19.54	8.62	31.12	17.17

TABLE 2. Descriptive results regarding physiological measures on different types of problems

	Basic		Analytic		Riddle easy		Riddle hard	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
SCR amplitude (μS)	0.4	0.45	0.65	0.51	0.48	0.54	0.96	1.07
SCR rise time (s)	4.08	2.84	4.7	2.59	4.45	2.69	4.19	2.93

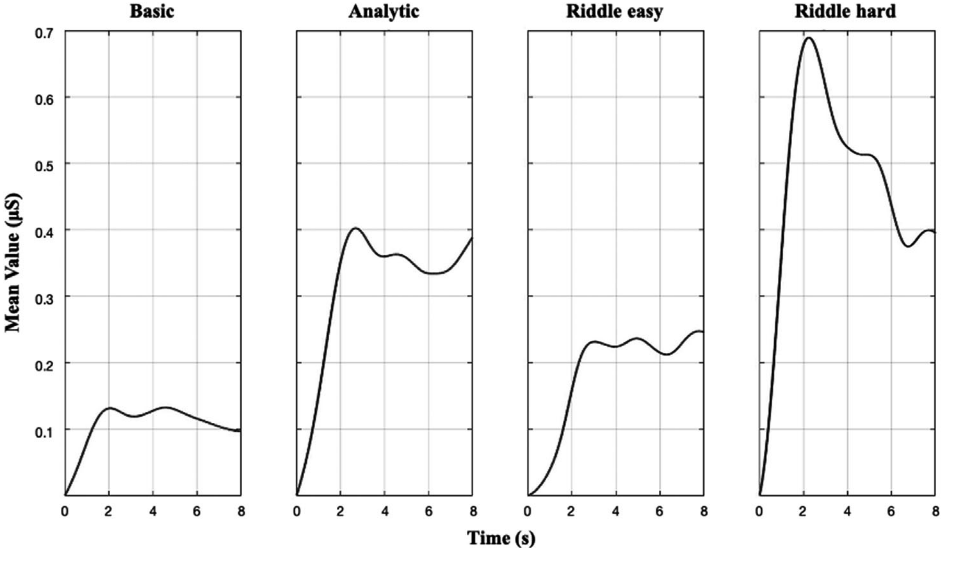

FIGURE 3. The waveform of the skin conductance for each condition.

however, this effect was not statistically significant. These findings were largely in line with Shen et al.,'s (2017) study where they observed a greater SCR amplitude in insight trials as compared to non-insight conditions. At a theoretical level, they support the models proposed by Critchley et al. (2013) that ANS measures are sensitive to mental processing related to problem-solving. That *Analytic* problems did not show a difference with the *Basic* control condition. This could be a result of the manner in which analytic problems are solved. Analytic problems are typically solved through a systematic process and cause a more gradual increase in the mobilization of physiological resources compared with, for example, sudden insights (Bowden & Jung-Beeman, 2003; Metcalfe & Wiebe, 1987; Smith & Kounios, 1996). In the latter case, the feeling of surprise, or the orientation of the nervous system to significance, is larger when the answer is given, explaining why the physiological response in the *Analytic* condition is less pronounced.

Second, the authors also hypothesized that there will be different SCR responses based on the difficulty of questions. As expected, results confirmed the hypothesis that there is a significant difference between the *Riddle easy* and the *Riddle hard* condition. This, in accord with the author's predictions, supports previous studies that showed different physiological responses for the difficulty of the task (Light & Obrist, 1983; Veltman & Gaillard, 1998). One explanation for this finding may be that difficult riddles pose a greater challenge to the individual, which may be reflected in a larger physiological response to solving the problem (Tomaka et al., 1993).

Finally, the authors predicted greater physiological arousal in correspondence with faster response time and higher accuracy. There was a positive correlation between the *Riddle hard* rise time and the *Riddle hard* accuracy and also between the *Analytic* amplitude and the *Analytic* accuracy. This finding has been partially validated by Pecchinenda's (1996) study, which observed a positive correlation between the response rate

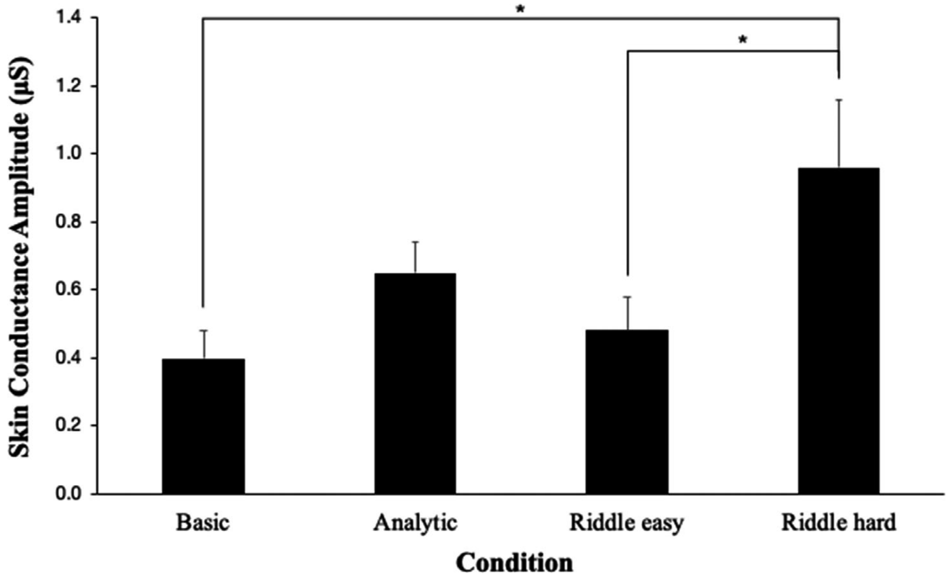

FIGURE 4. Bar graph of the skin conductance amplitude for each condition.

and amplitude. However, other studies in the problem-solving literature have not found any significant relationships between physiological responses and behavioral performance (Shen et al., 2017). In contrast to the prediction, SCR amplitude in the *Riddle hard,* despite having the largest amplitude across all conditions, did not correlate with accuracy or response time measures.

Collectively, the present findings uncover physiological correlates of insight using SCR. This study indicates that physiological activity is associated with moments of insight. The study is unique in that the authors not only examined the physiological response of insight but were also able to contrast it with physiological responses during analytic processing of problems, as well as a basic control condition. In addition, the study also confirmed that SCR amplitudes were generally more sensitive to the different conditions of problem-solving than SCR rise time. Accordingly, these findings provide a better understanding of the nature of the insight process and its measures.

This study features a number of limitations. First, the conditions were not balanced in terms of response times and difficulty. Part of this was per design but it also left potential confounds. Answers to the Basic condition, for example, also had much shorter response times than those of the *Riddle* and/or *Insight* conditions. Second, it is possible the study was underpowered to find a difference between the *Analytic* and other conditions, albeit with a lower effect size than the *Riddle hard*. As it was mentioned earlier, the authors were, unfortunately, unable to recruit more participants due to the relocation of the research personnel. Third, the authors also want to note that most of the participants were college students and the result might not speak for the general population. It is also hard to assess where there were systematic biases related to responsivity due to the crude measures of recruitment targeting the general student population. Lastly, the validity of problems may not have been thoroughly tested. However, this appears to be more of an inherent limitation of the field itself due to the lack of literature (and perhaps feasibility) on the standardization and validation of riddles.

To conclude, this paper is among only a handful of studies examining the physiological correlates of problem-solving using SCR. This paper's hypotheses largely confirmed the notion that problem-solving is also reflected in indices of bodily arousal and deepened the current knowledge by demonstrating differential effects for analytic versus insight problems, as well as difficulty level. These findings may have implications for the theoretical understanding of insight and, practically, may support the development of biometric devices that can aid in the understanding and assessment of learning and creativity within an educational context. One of many possible applications may be harnessing SCR as the basis for designing mobile and wearable systems geared toward supporting problem-solving such as providing additional prompts or hints within the problem-solving time period or depending on the rise time of SCR. This opens up many possibilities for future research directions in the use of physiological sensing for supporting human cognition.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available in the supplementary material of this article.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Table S1. List of items used for each condition.
Table S2. Descriptive correlational results regarding physiological and behavioral measures.