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Moment of Truth: Why Aha! Experiences are Correct

ABSTRACT

Having a sudden insight is often associated with inherent confidence, enough for Archimedes to run naked through the streets shouting "Eureka!". Recent evidence demonstrates that public displays of enthusiasm, such as the ancient polymath's, are actually supported by a higher likelihood of being correct.

Keywords: insight, creativity, problem-solving, Aha! experience, confidence.

The history of great discoveries is full of anecdotally successful insights, suggesting that solutions achieved via insight are more likely to be correct than those achieved without it. But is this sense of correctness actually justified by higher solution accuracy?

Although research on insight problem-solving dates back nearly 100 years, this question has been addressed only recently. For decades, insight has been defined by the assumption that "insight problems" could be solved exclusively by insight, and therefore only accurate solutions were considered, based on small numbers of problems. A new operational definition of insight as self-reported Aha! experience, together with the use of large problem sets that could either trigger an Aha! experience or be solved without one, allowed researchers to escape this circular logic and to produce comparative data on the accuracy of solution types (Bowden, Jung-Beeman, Fleck & Kounios, 2005). Recent evidence converges on the following finding: when the solution to a problem comes to mind accompanied by a self-reported Aha! experience, it is more accurate compared with solutions where this feeling of epiphany is missing (Danek, Fraps, von Müller, Grothe & Öllinger, 2014; Salvi, Bricolo, Kounios, Bowden & Beeman, 2016). This "accuracy effect" holds across several different task domains: Compound Remote Associates problems (CRAs), anagrams, rebus puzzles, line drawings (Salvi et al., 2016), and magic tricks (Danek et al., 2014; Hedne, Norman & Metcalfe, 2016), (Figure 1).

Earlier, Metcalfe found that solution processes which felt "subjectively catastrophic" (i.e., came to mind suddenly) were more often correct than those which did not (Metcalfe, 1986). In the same vein, Kounios and colleagues demonstrated that those who tend to solve more problems via insight make more errors of omission (i.e., when people time out), whereas those who do not, make more errors of commission (i.e., incorrect solutions) (Kounios et al., 2008). Salvi et al. (2016) directly approached this issue, demonstrating higher accuracy for insight solutions compared with non-insight solutions in four different experiments involving different tasks. This effect remained stable when potential confounds were excluded, for example, problems solved too quickly (considered as immediate recognition), or solved in the last 5 s (considered guesses, mostly yielded without a concurrent insight). Despite this converging evidence, it remains unclear exactly why Aha! solutions are more likely to be correct than solutions for which no Aha! is reported. Since problem-solvers do not receive feedback as to whether their solutions are correct, where does this intuitive sense of success come from?

A possible explanation for this effect could be that solvers use confidence in correct solutions as a cue for reporting an insight. In the absence of feedback, indeed, correct solutions receive higher confidence ratings than incorrect solutions (Danek & Wiley, 2017). When accurate, solvers may feel highly confident about their solution and therefore retrospectively report having had an Aha! experience. At first glance, this argument seems to be supported because confidence highly correlates with Aha! experience ratings (Danek & Wiley, 2017; Webb, Little & Cropper, 2016), suggesting that the Aha! experience is rated in alignment with the level of confidence. Furthermore, confidence is a key dimension of this multi-dimensional experience (Danek & Wiley, 2017). However, these two studies (Danek & Wiley, 2017; Webb et al., 2016) specifically mentioned confidence in their instructions, possibly inflating the relation between confidence and Aha! ratings. Two following studies showed (Hedne et al., 2016; Salvi et al., 2016) that the accuracy effect persists even when the confidence confound is eliminated from instructions; i.e., when Aha! experiences were not explicitly defined as associated with confidence. Moreover, solvers sometimes feel confident also about

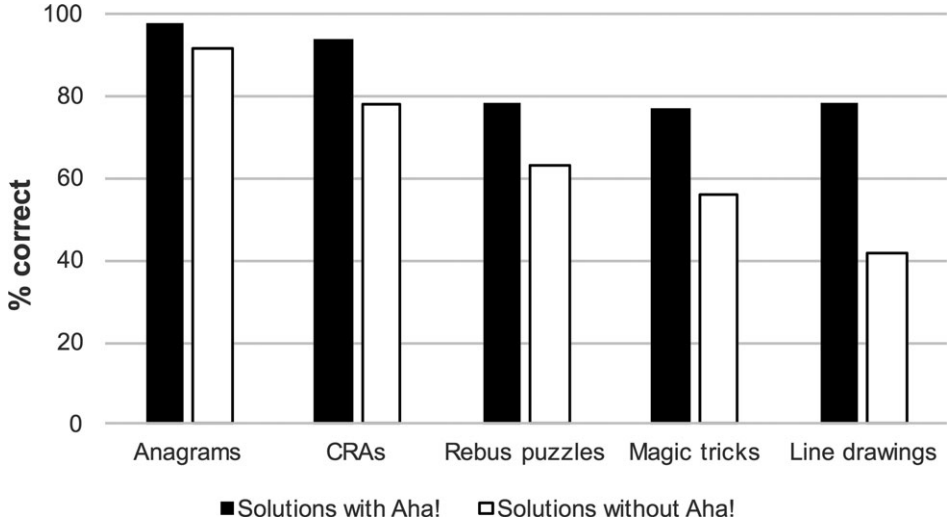

FIGURE 1. The accuracy effect. Data taken from Salvi et al. (2016) and from table 1 in Danek, Fraps, von Müller, Grothe and Öllinger (2013) and re-plotted with permission from the journals Thinking & Reasoning (Salvi's data) and Psychological Research (Danek's data).

incorrect solutions (Danek & Wiley, 2017). Thus, it seems unlikely that the accuracy effect is solely based on high confidence serving as a cue for high Aha! ratings.

It might be argued that this effect is just an artifact resulting from categorizing problem-solving either with or without having an Aha! experience. Crucially, cognitive and neural data show how this dichotomy cannot be the product of *a posteriori* forced categorization. Distinct patterns of neural activity, and eye blinks, have been found during insight solutions, and even preceding problems that people eventually report to have solved via insight (Kounios et al., 2006, 2008; Salvi, Bricolo, Franconeri, Kounios & Beeman, 2015; Salvi & Bowden, 2016).

Instead, we argue that the thought process leading to a sudden feeling of Aha! differs from the process that does not lead to Aha! in three ways: phenomenologically (Aha! experience, confidence), physiologically (involving different brain circuits, for a review see Kounios & Beeman, 2014), and also behaviorally (accuracy). Insight problem-solving, indeed, is a discontinuous all-or-none mechanism—where solvers do not have access to intermediate knowledge while reasoning since it is processed below the solver's threshold of awareness—and only retroactively identifiable by the Aha! experience (Salvi et al., 2016; Smith & Kounios, 1996). This also explains why this type of problem-solving does not yield potential guesses. If the Aha! has not occurred before the deadline, solvers are more likely to time out than to make errors, and guess less frequently (Salvi et al., 2016). As Smith and Kounios (1996) argued, non-insight solutions are instead yielded through an incremental and partial response completion of information, which means that subjects do have access to partial information, about the response before the solution is attained, therefore, are more likely to guess and to produce incorrect solutions.

A complementary explanation for the accuracy effect is that the Aha! experience is caused by solution quality. Correct insight solutions are qualitatively different from incorrect ones, because they require a restructuring of the initial problem representation (Ohlsson, 1992), leading to alternative interpretations of concepts that at first seem unrelated, but suddenly fit together as a whole or a good "Gestalt". Correct solutions bring a sense of closure and pleasure. In contrast, for incorrect solutions, some elements may be missing, or do not fit, yielding an incomplete sense of "Gestalt". This difference is also reflected in solvers' subjective ratings of their solution experience, with correct solutions feeling more pleasurable than incorrect ones, as shown by Danek and Wiley (2017). Therefore, we conclude that there are differences between correct and incorrect solutions with regard to solution quality. The feeling of Aha! is rooted in these differences.

This sense of Gestalt followed by pleasure can be compared with understanding jokes and metaphors. Similar to understanding a joke, having an insight entails reaching out to alternative meanings and concepts,

which then suddenly fit together as a whole, triggering an Aha! experience (or a laugh). Indeed, neuroscientific studies show that part of the brain circuit involved in insight is also crucial for recognizing distant semantic relations, metaphors, and alternative meanings (for a review, see Kounios & Beeman, 2014).

In sum, we conclude that insight solutions are distinct from non-insight solutions because they feel different, they are processed at different levels of awareness and, importantly, they lead to qualitatively distinct outcomes, with one being more accurate than the other.

Future studies will specify the underlying cognitive and neural mechanisms of the accuracy effect, as well as its determinants. Ideally, this line of research could lead to studying collateral factors of this effect, aiming for more ecological robustness (i.e., tests outside of the laboratory), perhaps revealing instances where the accuracy effect no longer holds true. Although the accuracy effect of insight is clearly adaptive, it is important to identify conditions when this intuitive sense of success fails and "erroneous insights" (Ohlsson, 1984, p. 124) occur. We believe this effect opens up important avenues for research on creativity and problem-solving, and could have fruitful applications, for example, in educational settings.

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