Psychology. Journal of the Higher School of Economics. 2023. Vol. 20. N 3. P. 428–444.
Психология. Журнал Высшей школы экономики. 2023. Т. 20. № 3. С. 428–444.
DOI: 10.17323/1813-8918-2023-3-428-444.

# "AHA!" AND "OH YES!": HOW EMOTIONS AFFECT INSIGHT EXPERIENCE

**E.A. VALUEVA[a,b], N.M. LAPTEVA[a,b]**

[a] *Institute of Psychology, Russian Academy of Sciences, 13 build. 1, Yaroslavskaya Str., Moscow, 129366, Russian Federation*
[b] *Moscow State University of Psychology and Education, 29 Sretenka Str., Moscow, 127051, Russian Federation*

# «Ага!» и «Ах, да!»: как эмоции влияют на субъективное переживание инсайта

**Е.А. Валуева[a,b], Н.М. Лаптева[a,b]**

[a] *ФГБУН «Институт психологии РАН», 129366, Москва, ул. Ярославская, д. 13, к. 1*
[b] *ФГБОУ ВО «Московский государственный психолого-педагогический университет», 127051, Россия, Москва, ул. Сретенка, д. 29*

**Abstract**

Besides classical "Aha!" moments after successful solutions, researchers have recently examined the "Oh yes!" phenomenon, which occurs when participants are presented with ready-made answers. We investigated the influence of emotional state on insight ratings in these two situations. We propose two alternative models to predict the impact of emotional state on the likelihood of

**Резюме**

Под инсайтом подразумевается особый способ решения задачи, когда происходит неожиданное понимание правильного ответа, сопровождающееся особым ярким чувством, которое часто называют озарением или Ага-переживанием. Некоторое время назад исследователи стали изучать не только переживание инсайта после успешного решения задачи, но и переживание инсайта, когда решение предлагается испытуемому в готовом виде (Ах, да-переживание). Мы

The research was supported by the Ministry of Science and Higher Education of the Russian Federation (project "Emerging Trends in the Development of Human and Social Sciences in the Context of Digitalization and New Social Problems and Threats: Interdisciplinary Approach", agreement No. 075-15-2020-798).

Исследование проведено при финансовой поддержке гранта Министерства науки и высшего образования РФ (проект «Новейшие тенденции развития наук о человеке и обществе в контексте процесса цифровизации и новых социальных проблем и угроз: междисциплинарный подход», соглашение № 075-15-2020-798).

experiencing “Aha!” and “Oh yes!” moments. The first model is based on the feelings-as-information framework and predicts that a generally more positive mood can be attributed by participants to positive emotions from insight. Participants, interpreting their positive state, believe that it is due to insight and will be more likely to experience both “Aha!” and “Oh yes!” insights. The second hypothesis is based on the attribution theory and connects the evaluation of insight with causal attribution. The causes of failure are attributed to external circumstances, while the causes of success are attributed to internal factors. The prediction aligns with the first hypothesis in the case of correct solutions (success situations). However, in the case of unsuccessful solutions (failure situations), the prediction is opposite. We conducted a study using anagrams as the problem-solving task and employed mood-inducing videos to manipulate the participants' emotional state. Questionnaires assessing participants' states revealed that our interventions improved the participants' mood, reduced anxiety and fatigue. The results of the analysis supported the second hypothesis. We discuss that the mechanisms through which emotional state influences insight ratings may vary depending on the type of insight and may be related to different attentional focuses, decision-making strategies, or emotional congruence effects.

*Keywords:* insight, emotional state, anagrams, "Aha!" experience, "Oh, yes" experience.

**Ekaterina A. Valueva** — Research Fellow, Institute of Psychology, Russian Academy of Sciences; Senior Research Fellow, Laboratory for the Study of Cognitive and Communicative Processes in Adolescents and Young Adults while Solving Game and Educational Problems using Digital Environments, Moscow State University of Psychology & Education, PhD in Psychology.

предложили две альтернативные модели влияния эмоционального состояния на вероятность возникновения Ага- и Ах, да-переживаний. Согласно первой модели, положительное эмоциональное состояние недифференцированно относится испытуемым на счет положительных эмоций от инсайта, поэтому испытуемые с большей вероятностью дают оценки инсайтности в любой ситуации. Вторая гипотеза связывает процессы оценки инсайтности с каузальной атрибуцией, при которой причины неудач атрибутируются внешним обстоятельствам, а причины успеха — внутренним факторам. При правильном решении (в ситуации удачи) предсказание совпадает с первой гипотезой. В случае неуспешного решения (неудачи) предсказание противоположно. Мы провели исследование на материале решения анаграмм, в котором для изменения эмоционального состояния испытуемых использовали индуцирующие видео. Опросник, направленный на оценку состояния испытуемых, показал, что при помощи наших воздействий мы улучшили настроение испытуемых, снизили тревожность и усталость. Результаты анализа соответствовали второй гипотезе: в группе испытуемых, просматривавших видео (позитивное настроение) ответы на нерешенные анаграммы значимо реже оцениваются как инсайтные по сравнению с другой группой, а ответы на решенные анаграммы — наоборот, чаще оцениваются как инсайтные. Обсуждается, что механизмы влияния эмоционального состояния на оценки инсайта могут быть разными в зависимости от типа инсайта и могут быть связаны с разными типами фокуса внимания, с разными стратегиями принятия решений или с эффектами эмоционального соответствия.

*Ключевые слова:* инсайт, эмоциональное состояние, анаграммы, Ага-переживание, Ах, да-переживание.

**Валуева Екатерина Александровна** — научный сотрудник, ФГБУН «Институт психологии Российской академии наук»; старший научный сотрудник, лаборатория исследования когнитивных и коммуникативных процессов у подростков и юношей при решении игровых и учебных задач в цифровых средах, Московский государственный психолого-педагогический университет, кандидат психологических наук.

Research Area: cognitive psychology, intelligence, creativity.
E-mail: ekval@list.ru

**Nadezhda M. Lapteva** — Research Fellow, Institute of Psychology, Russian Academy of Sciences; Research Fellow, Laboratory for the Study of Cognitive and Communicative Processes in Adolescents and Young Adults while Solving Game and Educational Problems using Digital Environments, Moscow State University of Psychology & Education, PhD in Psychology.
Research area: creativity, cognitive psychology, psychophysiology, embodied cognition.
E-mail: n.m.lapteva@mail.ru

Сфера научных интересов: когнитивная психология, интеллект, творчество.
Контакты: ekval@list.ru

**Лаптева Надежда Михайловна** — научный сотрудник, ФГБУН «Институт психологии Российской академии наук»; научный сотрудник, лаборатория исследования когнитивных и коммуникативных процессов у подростков и юношей при решении игровых и учебных задач в цифровых средах, Московский государственный психолого-педагогический университет, кандидат психологических наук.
Сфера научных интересов: креативность, когнитивная психология, психофизиология, воплощенное познание.
Контакты: n.m.lapteva@mail.ru

In our daily experience, every person has encountered situations where their emotional state either helped or hindered their cognitive performance. A good mood can inspire a person to search for new ideas, while a bad mood can impede clear thinking. Conversely, there are instances when stress enhances persistence and pushes a person towards quick problem-solving, while satisfaction and relaxation hinder the tasks completion. The unity of intellect and affect is recognized by many authors; however, the practical implementation of this postulate in scientific studies, both theoretical and empirical, remains a rare phenomenon.

One area in which the relationship between emotional and cognitive processes is extensively studied is the impact of emotions on creative thinking. Two prominent lines in this field include studying the influence of emotions on creativity and investigating insight from an emotional perspective.

Along with the first line, among early research, a series of studies conducted by A. Isen focused on the impact of positive emotional states on various cognitive processes, including creative thinking. Her work demonstrated that positive mood affects the originality of associations (Isen et al., 1985), the success in solving insight problems (Isen et al., 1987), and so on. Similar results have been replicated in numerous experiments (Baas et al., 2008). However, the effect of emotions on creativity is not unequivocal. G. Kaufmann and S. Vosburg showed that sometimes individuals in a positive emotional state perform worse in creative tasks, while negative states, on the contrary, can enhance problem-solving performance (Kaufmann & Vosburg, 1997). Over the past two decades, research on the mechanisms of emotional influence on creativity has continued. More complex explanatory models are tested, incorporating not only the valence of emotions but also the level of physiological arousal (De Dreu et al., 2008). The influence of new factors is examined, such as the degree of awareness of one's own emotions, social attitudes towards creativity (George & Zhou, 2002), gender differences, individual components of positive and negative mood (Filipowicz, 2006), and the impact of emotional manipulation on the process of insight problem-solving at different stages of problem-solving (Vladimirov & Shtykhina, 2017).

A certain evolution of theoretical notions about the mechanisms by which emotions influence creativity has occurred. Initially, the influence of positive affect on creativity was attributed by A. Isen to increased cognitive flexibility through the impact of dopamine on specific brain structures (Ashby et al., 1999). G. Kaufmann and S. Vosburg proposed a more complex idea regarding the connection between emotional states and the choice of information processing strategy. The satisfaction strategy is activated by a positive emotional background and leads to quick problem-solving, which may not always be accurate. The optimization strategy, on the other hand, is predominantly triggered by negative emotions and involves searching for a large number of solutions, from which the most optimal one is selected. Depending on the type of tasks, either strategy can prove effective (Vladimirov & Shtykhina, 2017). Among all the possible mechanisms by which emotions influence creativity, which can act in conjunction, D. V. Lyusin identifies two groups: motivational and cognitive (Lyusin, 2011). Through motivational mechanisms, emotions can influence the amount of effort and persistence, activate a specific information processing strategy, alter the method of solution selection (Kaufmann & Vosburg, 1997), or contribute to maintaining a positive mood by adopting a creative approach to task completion (Hirt et al., 2008). Through cognitive mechanisms, emotions influence creativity by affecting information processing processes. For example, this can occur through broadening the focus of attention or through the activation of information related to the current emotional state.

Another area where the study of emotions and creative processes intertwines even further is in the exploration of insight, which refers to the phenomenon of suddenly and unexpectedly discovering the solution to a given problem. It is generally accepted that insight can include both cognitive components (restructuring the problem representation) and affective components (a strong sense of an "Aha!" experience that arises when the solution is suddenly realized). The question of the relationship between these two components is quite complicated (Moroshkina et al., 2020), and in this article, we will leave it aside, focusing on understanding insight as the "Aha!" experience. The detection of "Aha!" experiences in participants can be carried out using both objective methods, such as skin conductance response (Tikhomirov & Vinogradov, 2008; Shen et al., 2016), eye movements and changes in pupil diameter (Vladimirov & Chistopolskaya, 2019; Salvi & Bowden, 2016), neural activity (Jung-Beeman et al., 2004; Kounios & Beeman, 2009), behavioral activity (Filyaeva & Korovkin, 2015; Vladimirov & Makarov, 2020), muscle contraction strength (Laukkonen et al., 2021), and self-report measures.

There are several methods for detecting insight based on self-reports (Bowden et al., 2005; Danek & Wiley, 2017; Novick & Sherman, 2003; Shen et al., 2016; Wong, 2009). One of the most common methods currently used is the questionnaire by A. Danek and J. Wiley (Danek & Wiley, 2017). It measures the experience of "Aha!" moments using two dimensions. First, the cognitive dimension includes two parameters: the feeling that the solution came suddenly and as a whole, rather than step by step, and confidence in the correctness of the solution. Second, it is determined by the emotional dimension, which includes six parameters: pleasure, surprise, certainty in the correctness of the solution, a sense of relief, surprise that

the solution came, and a feeling of drive that motivates further work on the task (Chistopolskaya et al., 2021).

Since the subjective experience of insight includes a wide range of emotions, it raises the question of whether the basic emotional state influences the ability to experience insight. If a person starts solving a task in an uplifted state, will it lead to synergy and a greater number of insightful solutions? Conversely, does a negative mood enable greater focus on the task, thereby increasing the likelihood of insight?

In this study we explored the influence of emotional states on the participants' evaluation of a strategy for solving anagrams, whether through insight or without insight. Two possible scenarios were tested. First, when a person manages to solve the task themselves and evaluates the strategy (insightful or non-insightful) they used. This represents the classic "Aha!" experience. Second, when an unsolved task is presented along with the correct answer, and the participant must indicate whether they experienced insight in that situation. This scenario is sometimes referred to as an "Oh yes!" experience (Rothmaler et al., 2017).

Our hypotheses were based on two alternative models. The first hypothesis was formulated within the theory of emotions as information (Schwarz, 2011), which suggests that people consider their states, including emotional states, as a source of information. In particular, emotions can provide evidence about the state of affairs when solving a cognitive task. Thus, according to the first hypothesis, a generally more positive mood can be attributed by participants to positive emotions from insight. In other words, participants, interpreting their positive state, believe that it is due to insight. If this hypothesis is true, then in the group with a more positive mood, participants will be more likely to experience both "Aha!" and "Oh yes!" insights.

The second hypothesis is based on an idea of the attribution theory (Miller & Ross, 1975). According to this theory, failures are usually attributed to external circumstances, while successes are attributed to internal factors. In the case of a successful solution to an anagram, the cause of success should be attributed to internal factors. Therefore, in the presence of positive emotions, it may be associated with them and lead to the evaluation of the solution as insightful. Thus, in the case of a correct solution to an anagram, the prediction aligns with the first hypothesis. In the case of an unsuccessful solution to an anagram, the failure should be attributed to external circumstances. Therefore, a person's positive state will not be associated with the result of solving the anagram, and the person will be less inclined to identify their reaction as insight.

## Methods

### *Sample*

The study involved 259 participants who responded to an advertisement to participate in a psychological study for monetary compensation on the Yandex.Toloka platform (Russian analogue to Amazon Mechanical Turk). The sample included 154 males (60%) and 105 females, ranging in age from 20 to 70 years ($M = 37.68$, $SD = 9.06$).

### *Materials*

All stimuli were presented to participants in Russian.

1. Anagrams: 37 anagrams, consisting of 5-7 letters, with 10 anagrams included in the training session and 27 in the main session[1].

2. Two video clips used to influence the participants' emotional state.

a) A mindfulness meditation video provided by the "MindFulness" center (https://mnfs.ru/). The video features a presenter guiding participants through mindfulness practice and providing necessary instructions on where to direct their attention. During the practice, participants are instructed to consciously observe the present moment without any judgment, redirect their attention from thoughts about the past and future to the processes occurring in the present moment, and not to control their thoughts.

b) The animated children's cartoon "Avatar: The Last Airbender. Learning the Elements". It was selected to capture participants' attention with an interesting storyline while avoiding cognitive overload and fatigue.

The duration of the cartoon and the mindfulness video was approximately the same, around 20 minutes. Initially, this stimulus material was used in a study on the influence of mindfulness practice on anagram-solving success. To determine the specific effect of mindfulness practice compared to other types of interventions, one group of participants watched the cartoon (Lapteva, in press). Similar effects of these two video clips on participants' emotional states were identified. Therefore, for the purpose of the current study, the groups were combined.

3. The Questionnaire aimed at assessing four states on a five-point scale: mood, attention, anxiety, and fatigue (see Appendix 1).

### *Procedure*

The experimental procedure is presented in Figure 1. At the beginning of the experiment, participants were provided with an explanation of what anagrams are and how to solve them. They were also informed that solving anagrams may involve insight and were given an explanation of the difference between insight and non-insight solutions (see Appendix 2). Participants were then asked to solve 10 training anagrams, with a time limit of 30 seconds for each anagram. If a participant successfully solved an anagram, they were asked if they experienced insight. If the participant did not solve the anagram, the correct answer was shown to them, and they were asked if they experienced insight upon seeing the correct solution.

Afterwards, participants were asked to complete the state questionnaire.

[1] In accordance with the objectives of another study in the main session, 16 out of 27 anagrams were different between the two groups of participants (these groups were organized independently of those described in this article). Therefore, in this article, a statistical analysis of the accuracy of anagram solving will not be conducted. However, in the current study we applied mixed models that allowed for controlling random effects associated with specific anagrams.

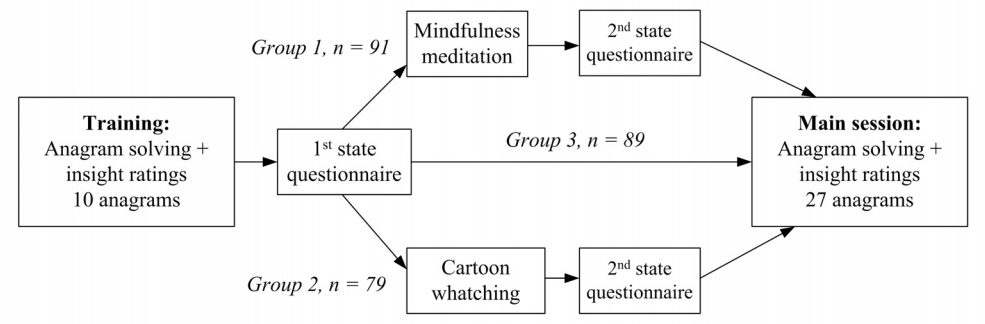
Next, participants were randomly assigned to one of three groups. Two groups (experimental groups) watched either the mindfulness practice video or the cartoon, while the third group (a control group) immediately proceeded to the anagrams solving with the procedure for assessing insightfulness.

After watching the video, the first two groups completed the state questionnaire again and then proceeded to solve the anagrams. The anagrams were presented in a fixed order, which was the same for all groups.

All tasks were presented to participants online on the PsyToolkit platform (Stoet, 2010, 2017).

*Figure 1*

**Experimental Procedure**




## Results

### *Self-Report Measures of Emotional State and Their Changes as a Result of Watching the Videos*

The internal consistency of the questionnaire items for each scale was high (Cronbach's alpha ranging from 0.78 to 0.84), except for the Anxiety scale. After excluding Item 3 ("I am relaxed"), which had a poor correlation with the scale, the remaining two items correlated with each other at 0.78 (for more details on the reliability and factorial structure of the questionnaire, see the article: (Lapteva, in press)).

The average scores on the questionnaire scales[2] for the experimental and control groups at each measurement are presented in Table 1. No significant differences between the groups were found in the initial state measurement on any of the scales. Thus, all participants were in a similar emotional state at the beginning of the experiment. However, it was found that both watching the cartoon and the mindfulness training significantly changed the emotional state on all scales except

[2] The scores for each scale were calculated as the sum score of the corresponding questions.

for the Attention scale: participants experienced improved mood ($t(169) = -7.87$, $p < .001$), reduced anxiety ($t(169) = 9.4197$, $p < .001$), and decreased fatigue ($t(169) = 5.17$, $p < .001$). No significant changes were observed on the Attention scale ($t(169) = -0.18$, $p = .857$).

Therefore, at the time of starting the anagram-solving task, participants in the experimental group, compared to the control group, were in a better mood ($t(169) = -3.07$, $p = .003$), less anxious ($t(169) = 3.89$, $p < .001$), and less fatigued ($t(169) = 2.92$, $p = .004$). There were no significant differences between the groups in self-rated attention ($t(169) = -1.19$, $p = .238$).

### *Insight Ratings*

A preliminary analysis of the data revealed that some participants did not provide insight ratings within the allotted time of 10 seconds, for various reasons. Some participants did not provide any ratings (19 individuals), and they were excluded from the analysis entirely. Another subset of participants (34 individuals) skipped one or more ratings, and data for specific anagrams were excluded for them (a total of 108 cases). Additionally, cases where we manually had to adjust the accuracy of a participant's response were excluded. This occurred when participants made typographical errors, inserted spaces in their answers, etc., causing the system to automatically count their response as incorrect (a total of 119 additional cases). Table 2 presents descriptive statistics for two groups regarding the accuracy of anagram solutions, "Aha!" ratings, "Oh yes!" ratings, as well as reaction times for the last two assessments.

On average, participants solved slightly more than a half of the presented anagrams (59%), and no significant differences were found between the groups in terms of accuracy and time to solve the anagrams ($t(257) = 1.13$, $p = .258$ and $t(257) = 0.10$, $p = .92$, respectively). However, there were differences in insight

*Table 1*

**Descriptive Statistics (Mean (SD)) for the Questionnaire in Two Groups**

| | **Experimental group** | **Control group** |
|---|---|---|
| N | 170 | 89 |
| Mood 1st measurement | 10.24 (2.74) | 10.38 (2.81) |
| Attention 1st measurement | 11.2 (2.47) | 10.87 (2.37) |
| Anxiety 1st measurement | 4.71 (2.08) | 4.46 (2.23) |
| Tiredness 1st measurement | 8.31 (2.83) | 8.47 (2.98) |
| Mood 2nd measurement | 11.45 (2.34) | – |
| Attention 2nd measurement | 11.23 (2.31) | – |
| Anxiety 2nd measurement | 3.42 (1.61) | – |
| Tiredness 2nd measurement | 7.39 (2.49) | – |

-ratings between solved and unsolved anagrams: participants were more likely to report insight for solved anagrams ($t(235) = 8.51$, $p < .001$), and they did so faster ($t(235) = 1.13$, $p = .001$) compared to unsolved anagrams.

The main hypothesis was tested using mixed-effects logistic regression, with insight ratings (insight/no insight) as the dependent binary variable and experience type ("Aha!"/ "Oh yes!"), participant group (experimental/control), and their interaction as predictors. Random effects for participant and anagram factors were included. The results are presented in Table 3 and Figure 2.

The main result of the analysis is the significant interaction between the group factor and the success of solving the anagram. This indicates that there are differences in the insight ratings between solved and unsolved anagrams in the two participant groups: the odds ratio for rating "insight" for solved anagrams compared to unsolved anagrams is approximately 2 times higher in the experimental group compared to the control group. Ratings for unsolved anagrams are significantly more likely to be perceived as insightful in the control group compared to the experimental group (OD = 1.53, z = 2.157, p = .031), while ratings for solved anagrams

*Table 2*

**Descriptive Statistics (Mean (SD)) for Anagram-Solving and Insight Ratings in Two Groups**

| | Experimental group | Control group |
|---|---|---|
| N | 154 | 86 |
| Accuracy of anagram-solving | 0.60 (0.16) | 0.58 (0.17) |
| RT for correct solutions | 13356 (3538) | 13279 (3908) |
| "Aha!" ratings | 0.59 (0.28) | 0.53 (0.26) |
| "Oh yes!" ratings | 0.31 (0.35) | 0.37 (0.37) |
| RT for "Aha!" ratings | 1992 (933) | 1854 (642) |
| RT for "Oh yes!" ratings | 2199 (1002) | 2136 (842) |

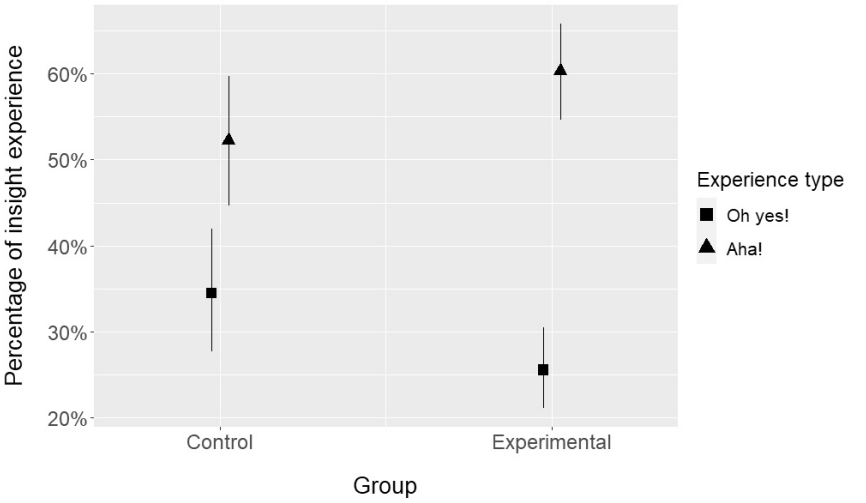
*Table 3*

**Binary Logistic Regression Model (Mixed Effects) with Group and Stimulus Type as Predictors of Insight Ratings**

| Predictors | $\beta$ | Odds Ratios | SE | 95% CI | $p$ |
|---|---|---|---|---|---|
| (Intercept) | −0.64 | 0.53 | 0.09 | 0.38–0.72 | <.001 |
| Group [experimental] | −0.43 | 0.65 | 0.13 | 0.44–0.96 | .031 |
| Experience type ["Aha!"] | 0.73 | 2.08 | 0.23 | 1.67–2.58 | <.001 |
| Group [experimental] × Experience type ["Aha!"] | 0.76 | 2.14 | 0.29 | 1.64–2.78 | <.001 |
| Observations<br>Marginal $R^2$/Conditional $R^2$ | 6253<br>0.073/0.380 | | | | |

*Figure 2*

**Binary Logistic Regression Model (Mixed Effects) with Group and Stimulus Type as Predictors of Insight Ratings (Error Bars Represent 95% CI)**




are less likely to be perceived as insightful in the control group (OD = 0.72, z = −1.748, $p$ = 0.0804).

Additionally, a mixed-effects regression model was used to assess the reaction time for insight ratings (see Table 4 and Figure 3). The fixed and random effects remained the same as in the previous model. The only significant effect in this model was the stimulus type factor, confirming the earlier comparison of means: participants rate solved anagrams faster compared to unsolved anagrams. There was no significant influence of the group factor or the interaction between factors in this model.

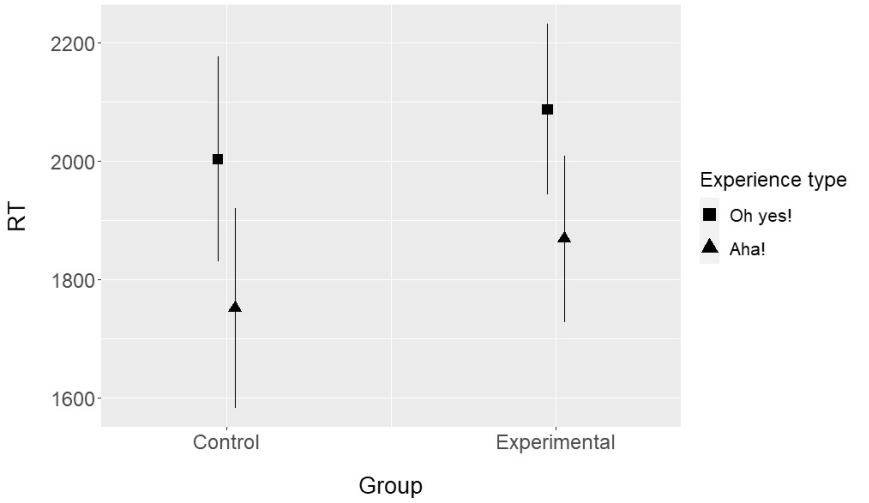
*Table 4*

**Binary Logistic Regression Model (Mixed Effects) with Group and Stimulus Type as Predictors of RT for Insight Ratings**

| Predictors | $\beta$ | SE | 95% CI | $p$ |
|---|---|---|---|---|
| (Intercept) | 2003.10 | 88.08 | 1830.43 — 2175.76 | <.001 |
| Group [experimental] | 83.56 | 92.31 | −97.41 — 264.53 | .365 |
| Experience type [“Aha!”] | −251.40 | 52.75 | −354.82 — −147.99 | <.001 |
| Group [experimental] × Experience type [“Aha!”] | 33.45 | 61.76 | −87.63 — 154.53 | .588 |
| Observations<br>Marginal $R^2$/Conditional $R^2$ | 6253<br>0.0093/0.280 | | | |

*Figure 3*

**Binary Logistic Regression Model (Mixed Effects) with Group and Stimulus Type as Predictors of Insight Ratings (Error Bars Represent 95% CI)**




## Discussion

### *The Influence of Emotional State on Insight Ratings*

The obtained results support the second hypothesis, which links the process of insight evaluation to more complex processes of causal attribution. Participants who watched the videos and thus had a more positive emotional state were more likely to rate their solutions as insightful and less likely to report insight when watching answers to the unsolved anagrams. Similarly to the influence of emotional states on creativity performance, we do not observe a generalized effect of positive emotions on insight ratings. If our hypothesis about different pathways of emotional influence on insight evaluation (depending on success or failure) is true, we could expect opposite effects when inducing negative emotions in participants. Different mechanisms of the emotional influence on "Aha!" and "Oh yes!" experiences may be associated with the mechanisms of these experiences themselves. For example, a study by K. Rothmaler et al. (Rothmaler et al., 2017) demonstrated that insights related to solution discovery are characterized by an increase in alpha rhythm in the temporal cortex, while insights related to solution recognition, on the contrary, by a decrease. One interpretation by the authors suggests that the increase and decrease in alpha rhythm may be associated with different attentional focuses, internal and external, respectively. This is consistent with the assumption of attributing success to internal causes and failure to external causes.

The obtained results do not exclude alternative explanations. One of them could be related to the effects of emotional congruence/incongruence. For example, in the study by N. Hao and colleagues, it was shown that the congruence between implicit emotional states (induced by a closed or open body posture) and explicit emotional states (induced by watching video clips) enhances creativity (Hao et al., 2017). Similar results have been found in other studies (Martin et al., 1993). It is possible that the effect of emotional congruence was also observed in our study. The fact of finding the correct solution could have led to an improvement in mood, which corresponded to the positive mood after watching the video, thereby increasing the number of insight reports (i.e., the number of solutions evaluated as creative). In cases where participants did not find a suitable answer to the anagram, negative emotions may have arisen, which did not correspond to the initially positive emotional state after watching the video, leading to a decrease in the number of reports of insightful ("creative") experiences.

Another perspective on our results can be provided by the signal detection theory. The judgment of insightfulness can be viewed as a decision-making process. In a neutral emotional state, the probability of answering "it was insight" when solving a task is approximately 50%, which may indicate that the participants poorly discriminate their own state and report insight almost randomly. Positive emotional states shift the decision criterion towards a more liberal response, thus increasing the number of reports of insight after the correct solution. In the case of a failed solution, the criterion is initially more stringent (resulting in fewer reports of insight), but it becomes even more stringent when there is a discrepancy between the emotional state and the emotions arising from an unsuccessful solution of the anagram. To fully implement the ideas of signal detection theory, knowledge of the "objective" presence of a signal is required (i.e., knowing whether there was an actual insight reported by the participant). Within the scope of the present study, obtaining this knowledge is already impossible, but future research can combine objective and subjective methods of capturing insight, varying the factors that influence the decision criterion, which can be a promising and interesting direction of work.

### *Comparison of the Ratings of "Aha!" and "Oh yes!" Experiences*

We also found that participants, regardless of their emotional state, were more likely to rate their answers to anagrams as insightful and did so more quickly compared to cases where they were shown answers to unsolved anagrams. This result aligns with findings from some studies (Vladimirov et al., 2022; Kizilirmak et al., 2018) but contradicts the results of other studies (Kizilirmak et al., 2016; Rothmaler et al., 2017) where no differences were found between self-rated insights and demonstrated solutions, or even the opposite effect was observed (Webb et al., 2019).

We do not have a clear hypothesis that could explain both the presence and absence of differences. However, we speculate that lower ratings of "Oh yes!" experiences may be associated with the absence of certain affective components present

in "Aha!" experiences (Danek & Wiley, 2017). Firstly, the element of surprise is absent since participants expect to be presented with the answer. Secondly, when the correct solution is presented, the component of certainty about its correctness is missing because participants are already aware that it is the correct solution. Thirdly, the sense of thrill (drive) motivating further work on the task is absent since the presentation of the ready-made solution may weaken the motivation to work on the task on one's own. Therefore, the "Oh yes!" experience may be subjectively perceived as less intense and therefore more difficult to recognize compared to the "Aha!" experience, resulting in a decrease in the number of reports of insights. The experience of failure itself when unable to solve the anagram may reduce the likelihood of experiencing positive emotions when the answer is revealed, thereby decreasing the likelihood of the "Aha!" experience, which is inherently positive.

It is important to note that in our study, we are not referring to the objective fixation of the fact of an insightful solution but rather to a participant's subjective evaluation of their experience. There can be numerous difficulties in detecting an insightful solution based on subjective reports, as there are various factors that influence participants' evaluations. It is possible that the emotional state of participants is one of such factors, along with their overall introspective ability, understanding of the stages of problem-solving, and characteristics of the task itself (Chistopolskaya et al., 2021).

Our results may have practical implications for researchers studying insightfulness in problem-solving since our work demonstrates that the evaluation of the insight ratings depends not only on the objective component of the solution but also on the participant's emotional state.

## Conclusions

Emotional state influences insight experiences. In a more positive emotional state, one's own correct solutions have higher insight ratings compared to a group in a neutral emotional state, while answers to unsolved anagrams are less likely to be evaluated as insightful.

Our results are consistent with the attribution theory. In the case of a successful solution, the cause of success is attributed to internal factors, thus a positive emotional state is associated with the solution and leads to a higher probability of an "Aha!" experience. In the case of an unsuccessful anagram solution, the failure is attributed to external circumstances, positive emotions are not associated with the task, and this leads to lower probability of an "Oh yes!" experience.

In the case of "Aha!" experiences, where participants find the solution on their own, the answer is more frequently and quickly evaluated as insightful compared to cases of "Oh yes!" experiences, where participants are shown answers to unsolved anagrams.

## References

Ashby, F. G., Isen, A. M., & Turken, A. U. (1999). A neuropsychological theory of positive affect and its influence on cognition. *Psychological Review*, *106*(3), 529–550. https://doi.org/10.1037/0033-295X.106.3.529

Baas, M., De Dreu, C. K. W., & Nijstad, B. A. (2008). A meta-analysis of 25 years of mood-creativity research: Hedonic tone, activation, or regulatory focus? *Psychological Bulletin*, *134*, 779–806. https://doi.org/10.1037/a0012815

Bowden, E. M., Jung-Beeman, M., Fleck, J., & Kounios, J. (2005). New approaches to demystifying insight. *Trends in Cognitive Sciences*, *9*(7), 322–328. https://doi.org/10.1016/j.tics.2005.05.012

Chistopolskaya, A. V., Savinova, A. D., & Lazareva, N. Yu. (2021). The explication of insight criteria and an overview of their measurement methods. *Psychology. Journal of Higher School of Economics, 18*(4), 907–929. https://doi.org/10.17323/1813-8918-2021-4-907-929 (in Russian)

Danek, A. H., & Wiley, J. (2017). What about false insights? Deconstructing the Aha! experience along its multiple dimensions for correct and incorrect solutions separately. *Frontiers in Psychology*, *7*. https://doi.org/10.3389/fpsyg.2016.02077

De Dreu, C. K. W., Baas, M., & Nijstad, B. A. (2008). Hedonic tone and activation level in the mood-creativity link: Toward a dual pathway to creativity model. *Journal of Personality and Social Psychology*, *94*(5), 739–756. https://doi.org/10.1037/0022-3514.94.5.739

Filipowicz, A. (2006). From positive affect to creativity: The surprising role of surprise. *Creativity Research Journal*, *18*(2), 141–152. https://doi.org/10.1207/s15326934crj1802_2

Filyaeva, O. V., & Korovkin, S. Yu. (2015). Povedencheskie patterny v protsesse resheniya tvorcheskih zadach [Behavioral patterns in the process of solving creative problems]. In *Sovremennye issledovaniya intellekta i tvorchestva* [Modern research on intelligence and creativity] (pp. 126–140). Moscow: Institute of Psychology of the RAS.

George, J. M., & Zhou, J. (2002). Understanding when bad moods foster creativity and good ones don't: The role of context and clarity of feelings. *Journal of Applied Psychology*, *87*(4), 687–697. https://doi.org/10.1037/0021-9010.87.4.687

Hao, N., Xue, H., Yuan, H., Wang, Q., & Runco, M. A. (2017). Enhancing creativity: Proper body posture meets proper emotion. *Acta Psychologica*, *173*, 32–40. https://doi.org/10.1016/j.actpsy.2016.12.005

Hirt, E. R., Devers, E. E., & McCrea, S. M. (2008). I want to be creative: Exploring the role of hedonic contingency theory in the positive mood-cognitive flexibility link. *Journal of Personality and Social Psychology*, *94*(2), 214–230. https://doi.org/10.1037/0022-3514.94.2.94.2.214

Isen, A. M., Daubman, K. A., & Nowicki, G. P. (1987). Positive affect facilitates creative problem-solving. *Journal of Personality and Social Psychology*, *52*(6), 1122–1131. https://doi.org/10.1037/0022-3514.52.6.1122

Isen, A. M., Johnson, M. M., Mertz, E., & Robinson, G. F. (1985). The influence of positive affect on the unusualness of word associations. *Journal of Personality and Social Psychology*, *48*, 1413–1426. https://doi.org/10.1037/0022-3514.48.6.1413

Jung-Beeman, M., Bowden, E. M., Haberman, J., Frymiare, J. L., Arambel-Liu, S., Greenblatt, R., Reber, P. J., & Kounios, J. (2004). Neural activity when people solve verbal problems with insight. *PLoS Biology*, *2*(4), 500–510. https://doi.org/10.1371/journal.pbio.0020097

Kaufmann, G., & Vosburg, S. K. (1997). "Paradoxical" mood effects on creative problem-solving. *Cognition and Emotion*, *11*, 151–170. https://doi.org/10.1080/026999397379971

Kizilirmak, J. M., Galvao Gomes da Silva, J., Imamoglu, F., & Richardson-Klavehn, A. (2016). Generation and the subjective feeling of "aha!" are independently related to learning from insight. *Psychological Research*, *80*(6), 1059–1074. https://doi.org/10.1007/s00426-015-0697-2

Kizilirmak, J. M., Serger, V., Kehl, J., Öllinger, M., Folta-Schoofs, K., & Richardson-Klavehn, A. (2018). Feelings-of-warmth increase more abruptly for verbal riddles solved with in contrast to without aha! Experience. *Frontiers in Psychology*, *9*(AUG). https://doi.org/10.3389/fpsyg.2018.01404

Kounios, J., & Beeman, M. (2009). The Aha! moment: The cognitive neuroscience of insight. *Current Directions in Psychological Science*, *18*(4), 210–216. https://doi.org/10.1111/j.1467-8721.2009.01638.x

Lapteva, N. M. (in press). *Vliyanie praktiki osoznannogo nablyudeniya za sobstvennym vnutrennim sostoyaniem na uspeshnost' resheniya anagramm* [The imact of the practice of conscious observation of own internal state on the success of anagramm solving].

Laukkonen, R. E., Ingledew, D. J., Grimmer, H. J., Schooler, J. W., & Tangen, J. M. (2021). Getting a grip on insight: real-time and embodied Aha experiences predict correct solutions. *Cognition and Emotion*, *35*(5), 918–935. https://doi.org/10.1080/02699931.2021.1908230

Lyusin, D. V. (2011). Vliyanie emotsii na kreativnost' [The impact of emotion on creativity]. In D. V. Ushakov (Ed.), *Tvorchestvo: ot biologicheskikh osnovanii k sotsial'nym i kul'turnym fenomenam* [Creativity: from biological foundations to social and cultural fenomena] (pp. 372–389). Moscow: Institute of Psychology of the RAS.

Martin, L. L., Ward, D. W., Achee, J. W., & Wyer, R. S. (1993). Mood as input: People have to interpret the motivational implications of their moods. *Journal of Personality and Social Psychology*, *64*(3), 317–326. https://doi.org/10.1037//0022-3514.64.3.317

Miller, D. T., & Ross, M. (1975). Self-serving biases in the attribution of causality: Fact or fiction? *Psychological Bulletin*, *82*(2), 213–225. https://doi.org/10.1037/h0076486

Moroshkina, N., Ammalainen, A., & Savina, A. (2020). Catching up with insight: modern approaches and methods of measuring insight in cognitive psychology. *Psikhologicheskie Issledovaniya, 13*(74). https://doi.org/10.54359/ps.v13i74.163 (in Russian)

Novick, L. R., & Sherman, S. J. (2003). On the nature of insight solutions: Evidence from skill differences in anagram solution. *The Quarterly Journal of Experimental Psychology Section A*, *56*(2), 351–382. https://doi.org/10.1080/02724980244000288

Rothmaler, K., Nigbur, R., & Ivanova, G. (2017). New insights into insight: Neurophysiological correlates of the difference between the intrinsic "aha" and the extrinsic "oh yes" moment. *Neuropsychologia*, *95*, 204–214. https://doi.org/10.1016/j.neuropsychologia.2016.12.017

Salvi, C., & Bowden, E. M. (2016). Looking for creativity: Where do we look when we look for new ideas? *Frontiers in Psychology*, *7*. https://doi.org/10.3389/fpsyg.2016.00161

Schwarz, N. (2011). Feelings-as-information theory. In P. A. M. Van Lange, A. W. Kruglanski, & E. T. Higgins (Eds.), *Handbook of theories of social psychology: Collection: Volumes 1&2* (Vol. 1, pp. 289–308). SAGE Publications. http://www.google.ru/books?id=SePipgh2z7kC

Shen, W., Yuan, Y., Liu, C., & Luo, J. (2016). In search of the 'Aha!' experience: Elucidating the emotionality of insight problem-solving. *British Journal of Psychology*, *107*(2), 281–298. https://doi.org/10.1111/bjop.12142

Stoet, G. (2010). PsyToolkit: A software package for programming psychological experiments using Linux. *Behavior Research Methods*, *42*(4), 1096–1104. https://doi.org/10.3758/BRM.42.4.1096

Stoet, G. (2017). PsyToolkit: A novel web-based method for running online questionnaires and reaction-time experiments. *Teaching of Psychology*, *44*(1), 24–31. https://doi.org/10.1177/0098628316677643

Tikhomirov, O. K., & Vinogradov, Yu. E. (2008). Emotsii v funkcii evristik [Emotions and functions of heuristics]. In *Psikhologiya myshleniya* [Psychology of thinking] (pp. 443–450). Moscow: AST: "Astrel".

Vladimirov, I. Yu., & Chistopolskaya, A. V. (2019). Eye-tracking and cognitive monitoring as the methods of insight process objectification. *Eksperimental'naya Psikhologiya [Experimental Psychology (Russia)], 12*(1), 167–179. https://doi.org/10.17759/exppsy.2019120113 (in Russian)

Vladimirov, I. Y., & Makarov, I. N. (2020). From "Hmmm..." to "Aha!": Emotional monitoring of representational change. *Psychology. Journal of Higher School of Economics*, *17*(4), 658–681. https://doi.org/10.17323/1813-8918-2020-4-658-681

Vladimirov, I. Yu., Markin, F., & Martyushova, N. (2022). Parameters of aha-experience depending on the solution time and feedback. *Psikhologicheskie Issledovaniya*, *15*(84), 5. https://doi.org/10.54359/ps.v15i84.1200 (in Russian)

Vladimirov, I. Yu., & Shtykhina, A. V. (2017). The dynamic aspect of the emotional state influence on the insight problem solving. *Vestnik Yaroslavskogo Gosudarstvennogo Universiteta im. P.G. Demidova. Seriya Gumanitarnye Nauki, 40*(2), 100–105. (in Russian)

Webb, M. E., Cropper, S. J., & Little, D. R. (2019). "Aha!" is stronger when preceded by a "huh?": presentation of a solution affects ratings of aha experience conditional on accuracy. *Thinking and Reasoning, 25*(3), 324–364. https://doi.org/10.1080/13546783.2018.1523807

Wong, T. J. (2009). *Capturing 'Aha!' moments of puzzle problems using pupillary responses and blinks.* Pittsburgh, PA: University of Pittsburgh.

*Appendix 1*

**State Questionnaire**

Please carefully read each statement. Using the provided scale, indicate the response that best reflects how you are currently feeling.

1 — strongly disagree
2 — somewhat disagree
3 — neutral
4 — somewhat agree
5 — strongly agree

1. I am in a good mood.
2. I am focused.
3. I am relaxed.
4. I have a lot of energy.
5. I am dissatisfied.
6. I can easily concentrate on what is happening.
7. I am worried.
8. I feel tired.
9. I am cheerful.
10. My thinking is clear.
11. I am nervous.
12. I am well-rested.

*Appendix 2*

**Insight Rating Procedure. Instructions**

The solution of an anagram can be accompanied by insight.

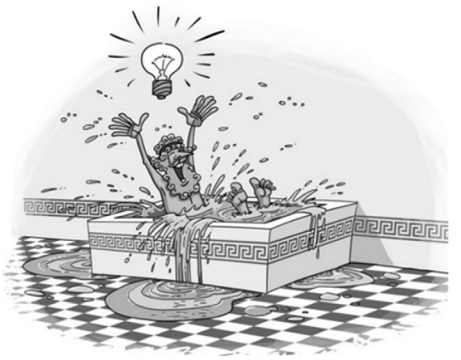
Insight is a solution that comes unexpectedly and all at once, rather than step by step, and there is no doubt about its correctness.

If you can recall how you arrived at the solution, describe how you rearranged the letters, or remember that you have seen a similar anagram somewhere, then it is NOT an insight.

A characteristic feature of insight is a feeling of joy and inspiration.

A well-known example of an insightful solution is Archimedes' discovery of the formula for density. While entering a bath filled with water, he noticed that the water level rose. This led to a sudden insight accompanied by his famous exclamation of "Eureka!"

Take a close look at the picture illustration. Do you understand what insight is?



**Insight:**

✓ Sudden and unexpected
✓ Coming out of nowhere
✓ Joy and inspiration
✓ Aha! Got it!

If you solve the anagram, you will need to indicate whether you had an insight or the solution was found through trial and error.

If you don't solve the anagram, the correct answer will be shown to you, and then we will ask if you had a feeling of insight when you saw the answer (“Yes, exactly!”, “Ah, I see!”).