If you give a rat a tickle

Educator guide

PAPER DETAILS

Original title: Neural correlates of ticklishness in the rat somatosensory cortex

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LEARNING STANDARDS ALIGNMENT

Learning Performance: Students will evaluate evidence that refines our understanding of how activity in specific regions of the brain allows rats to sense and respond to tickling and how rats' responses to tickling integrate information from multiple sensory inputs, including both biological and environmental stimuli.

The following tables provide an overview of the learning standards covered by this article, including the A Framework for K-12 Science Education (Framework), Common Core State Standards English Language Arts-Literacy (CCSS ELA), Common Core State Standards Statistics and Probability (CCSS HSS), AP Science Practices, and Vision and Change for Undergraduate Education. Where applicable, activities and information will be marked with specific standards to which they are linked.

A Framework for K-12 Science Education		
Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions (SEP6) Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. **Engaging in Argument from Evidence (SEP7)** Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.	**LS1.A: Structure and Function** Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. **LS1.D: Information Processing** Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories. **LS4.B: Natural Selection** The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population.	**Cause and Effect** Students understand that empirical evidence is required to differentiate between causation and correlation, and can make claims about specific causes and effects. Changes in systems may have various causes that may not have equal effects.

Science in the Classroom AAAS

Common Core State Standards English Language Arts-Literacy		
Key Ideas and Details	Craft and Structure	Integration of Knowledge and Ideas
RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. **RST.9-10.2** Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text. **RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. **RST.11-12.2** Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.	**RST.9-10.4** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics. **RST.9-10.5** Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy). **RST.9-10.6** Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address. **RST.11-12.4** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics. **RST.11-12.5** Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas. **RST.11-12.6** Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.	**RST.9-10.8** Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. **RST.9-10.9** Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts. **RST.11-12.8** Evaluate the hypotheses, data, analyses, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. **RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

AP Science Standards	
AP Science Practices	AP Biology Content Standards
Science Practice 5 (SP5) The student can perform data analysis and evaluation of evidence. **Science Practice 6 (SP6)** The student can work with scientific explanations and theories.	**Essential knowledge 1.B.1 (EK1.B.1)** Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today. **Essential knowledge 3.E.2 (EK3.E.2)** Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses.

Connections to the Nature of Science	
Vision and Change for Undergraduate Biology Education Core Competencies and Disciplinary Practices	A Framework for K-12 Science Education Understandings About the Nature of Science
Ability to apply the process of science Understand the process of science and how scientists construct new knowledge by formulating hypotheses and then testing them against experimental and observational data	**Science Knowledge is Based on Empirical Evidence** Scientific arguments are strengthened by multiple lines of evidence supporting a single explanation.

ARTICLE OVERVIEW

Article summary (recommended for educator use only)

In this article, researchers characterized the behaviors and vocalizations that result when rats are tickled. They also demonstrated that rats' responses to tickling are suppressed by conditions that generate anxiety. Responses to tickling are correlated with activity in the trunk region of the somatosensory cortex, and stimulation of neurons in this region was sufficient to bring about tickling-associated vocalizations

Importance of this research

Ticklishness is a sensation that is familiar to almost everyone, yet little is known about the underlying mechanisms. This paper establishes rats as a model system for ticklishness and identifies regions of the brain that are responsible for sensing and responding to tickling. The results will allow further exploration of some of the mysteries of ticklishness, including variations in ticklishness that depend on mood and the inability of people to tickle themselves. It also has implications for research into other neurological phenomena.

Experimental methods

- Recording and analysis of rat vocalizations using spectrograms
- Video recording, characterization, and analysis of rat behavior
- Electrochemical analysis of neural firing rates
- Meta-analytic methods and statistical correlations

Conclusions

- Rats respond to ticking with a distinct pattern of vocalizations and increased play behavior.
- Neural activity in the somatosensory cortex increases in response to tickling and correlates with vocalizations.
- Play behaviors, vocalizations, and neural activity in the somatosensory cortex are higher immediately after tickling than before tickling.
- Conditions that cause anxiety suppress behavioral and neural responses to tickling.
- Microstimulation of neurons in the somatosensory cortex is sufficient to induce vocalizations.

ACTIVITIES FOR INTERACTIVE ENGAGEMENT

Learning Performance: Students will evaluate evidence that refines our understanding of how activity in specific regions of the brain allow rats to sense and respond to tickling and how rats' responses to tickling integrate information from multiple sensory inputs, including both biological and environmental stimuli.

Writing an abstract Students write a new abstract for the article at a grade-appropriate reading level.	**RST.9-10.2** **RST.11-12.2** **Nature of Science**
Locating this study in the larger field Students use the annotated list of references to explain how this research builds on the published work of at least one other independent group of scientists. Students will evaluate whether data from this research supports or contradicts previous conclusions, and reflect on the statement that scientific knowledge is a "community effort."	**RST.9-10.8** **RST.11-12.8** **Nature of Science**
Science in the news Students explore news stories in the Related Resources tab and evaluate the stories for tone, accuracy, missing information, etc. They may then write their own news stories on the article.	**RST.9-10.5** **RST.11-12.5** **RST.9-10.6** **RST.11-12.6** **RST.9-10.8** **RST.11-12.8** **Nature of Science**
Results and conclusions Students diagram each of the experiments presented in the study (divided up by figure, if appropriate). They then consider the results depicted in each figure, and how these results support the conclusions of the study.	**SEP6** **SEP7** **SP5** **SP6**
The next steps Students design a follow-on experiment to this study that either addresses flaws or unanswered questions in the research at hand, or builds on it to explore a new question.	**Nature of Science**

DISCUSSION QUESTIONS

1. Like physical traits, behaviors can be selected for over the course of evolution. The authors state that the similarities between rat ticklishness and human ticklishness "suggest that tickling is a very old and conserved form of social physicality." What might be the evolutionary advantages of ticklishness?	**SEP6** **LS1.A** **LS4.B** **Patterns** **SP5** **EK1.B.1** **EK3.E.2**
2. The authors use observations of rat behaviors and vocalizations to draw inferences about rat mood. What behaviors indicate a playful state? What behaviors indicate a fearful state? What are some of the challenges and complexities of trying to interpret the mood of animals?	**SEP6** **SEP7** **SP5** **SP6**
3. The authors state, "Our recordings revealed that USVs (ultrasonic vocalizations) and neuronal activity in the trunk cortex are modulated in a similar way by tickling and anxiogenic conditions. We wondered whether tickling-evoked USVs and neuronal responses to tickling are causally linked." What is the difference between events that are correlated and events that are causal? How did the authors determine the nature of the relationship between USVs and neuronal activity?	**SEP7** **LS1.A** **Cause and Effect** **SP5** **EK3.E.2** **Nature of Science**
4. Scientists often use model organisms to gain information about human biological processes. Why were rats chosen as a model organism to study ticklishness? What evidence suggests that rats are good models for human behavior?	**SEP6** **LS4.B** **SP6**
5. The authors note the "threshold amplitude" needed to trigger USVs in rats was lower when the microstimulation was preceded by tickling. What is the significance of threshold potentials in neural signaling? How might the alteration of threshold potentials play a role in integrating sensory information?	**LS1.A** **Cause and Effect** **EK3.E.2**
6. An important part of an experiment is the initial characterization of the system that is being studied. In Figure 1, the authors describe specific aspects of the rat's response to tickling. What things do they characterize and how does this information provide the groundwork for the experiments in Figures 2 through 4?	**SEP6** **SEP7** **SP5** **SP6** **Nature of Science**