

**Consciousness of Error: How Origin Shapes Awareness and Learning**

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## **Abstract**

Errors are often regarded as obstacles to be minimized, yet psychological and neuroscience research suggests they may serve as critical signals for learning. In *Being Wrong*, Kathryn Schulz (2010) framed error as a universal cognitive condition, but left unanswered whether all errors equally contribute to conscious awareness and adaptation. Building on this gap, the present paper examines how the origin and confidence of errors influence memory and learning. Recent work shows that high-confidence errors are tied to perceptual processing (Alilović et al., 2023), while low-confidence errors reflect later decisional mechanisms; complementary evidence suggests that predictions and errors are anatomically segregated in V1 (Thomas et al., 2024). A behavioural experiment is proposed to test whether perceptual (high-confidence) versus cognitive (low-confidence) errors differ in their likelihood of being consciously encoded and remembered. It is predicted that high-confidence errors will be more accessible to memory and thus more likely to facilitate learning. Counter-evidence shows that confidence and awareness can diverge (Lau & Passingham, 2006; Overgaard et al., 2006) and that learning can occur without awareness (Tsushima et al., 2006), suggesting Schulz's framing requires refinement. Taken together, confidence appears to act as a functional gatekeeper of error-based learning, but unconscious mechanisms also shape adaptation.

*Keywords:* error processing, confidence, awareness, learning

## Introduction

In *Being Wrong*, Kathryn Schulz (2010) describes error as “a condition of life” and “a condition of the brain” (p. 35), framing mistakes as necessary to learning and adaptation. Schulz argues that our brains are not only prone to mistakes but that these mistakes are integral to how we grow, adapt and learn. This framing poses errors as a cognitive phenomenon instead of a flaw. However, her account lacks scientific specificity and clarity as to where and how such errors originate in the brain, and how they contribute to learning. More importantly, Schulz offers little insight into whether all errors are equally “felt” or equally likely to result in change or learning.

Building upon this foundational idea, recent neuroscience has begun to clarify how the brain differentiates between types of errors, especially through the lens of predictive processing. In this framework, the brain constantly generates predictions and updates them in response to sensory feedback. Errors or mismatch between predictions and outcomes serve as an indicator of learning facilitation. But does each and every prediction error enter conscious awareness? And are all errors treated the same by the brain? This paper builds on prior work from Alilovic et al (2023) and Thomas et al (2024), proposing a novel experiment to test whether the origin and subjective confidence of an error affect memory and learning. The hypothesis is that high-confidence (perceptual) errors will be more consciously accessible and more likely to be learned from, whereas low-confidence (cognitive) errors may remain unconscious and have less behavioural implications. Alilovic et al (2023) provide evidence that not all errors stem from the same neural origin. Using EEG and multivariate pattern analysis, they showed that high-confidence false recognition of visual stimuli (oriented gratings) was associated with early activation in the visual cortex, suggesting a perceptual origin. In contrast, low-confidence false recognition lacked early visual tracers and showed delayed frontal activity, indicating a more cognitive and post-perceptual source of error. Their findings suggest that confidence is not just a feeling but also a cue for determining the locus of errors.

Thomas et al (2024), using high-resolution laminar fMRI, expand this understanding by showing that predictions and prediction errors are segregated anatomically in the primary visual cortex. Predictions are represented in deep cortical layers, while superficial layers encode error signals. This cortical separation supports Schulz's metaphor of the brain being "wired to make errors", but also goes further by showing that error detection is an anatomically distinct function of the brain. Together, these studies suggest that error detection is multifaceted; the brain tracks the origin, confidence, and relevance of error signals in subtle ways.

What remains untested, is whether these differences affect learning or conscious awareness. If high-confidence perceptual errors are truly encoded and represented in the visual cortex? Are they more likely to be remembered? Are they "felt" as wrong, and thus more behaviourally impactful? These questions will be addressed in the following experiment.

### **Method**

To test whether perceptual and cognitive (rule-based) errors differ in their contribution to conscious awareness and learning, a behavioural experiment will be conducted using a visual discrimination task. Participants will view a series of briefly presented oriented gratings (45 or 135 degree orientation), amidst Gaussian noise, followed by a two-alternative forced choice asking them to identify the orientation. After each trial, they will rate their confidence on a 4-point Likert scale (1= guessing, 4= very sure) and complete a post-task surprise memory test on a subset of previously displayed gratings. This within-subject experimental design will record stimulus accuracy (correct vs. error) and subjective confidence (high vs. low) on every trial, allowing sorting of errors by confidence level and tracking whether they are remembered or forgotten.

### **Participants**

40 undergraduate students. All participants will have normal or corrected to normal vision.

### **Design**

This study will utilize a within-subjects experimental design, where each participant completes the same set of tasks. This design allows for the interaction between confidence level and error awareness to be analyzed without the need for between-group comparisons.

### **Independent Variables (IVs)**

**Confidence (High vs Low Confidence):** operationalized by participants' self-reported confidence ratings on a 4-point Likert scale after each discrimination trial.

Ratings 1-2 = Low Confidence

Ratings 3-4 = High Confidence

**Response Accuracy (Correct or Error):** operationalized by whether the participant's orientation judgement (45 or 135 degrees) matches the actual orientation of the grating on each trial.

Correct = perceived orientation matches stimulus

Error = perceived orientation does not match stimulus

### **Dependent Variables (DVs)**

**Recognition Memory performance (Hit or Miss):** operationalized using a surprise memory test, whether participants correctly recognize a previously presented grating (hit) or fail to recognize it (miss).

Hit = Correct identification of a previously displayed stimulus.

Miss = Incorrect rejection of a previously displayed stimuli.

**Reaction time:** operationalized by the time taken to respond during two alternative forced choice discrimination task, measured in milliseconds.

### **Materials**

Stimuli will consist of oriented gratings (45 or 135 degrees) presented at a central fixation point on a screen, with each grating embedded in Gaussian noise to introduce uncertainty and induce both perceptual and decision errors. Stimuli will be created and presented using PsychoPy.

Responses will be recorded via keyboard input, and confidence ratings will be collected using a 4 point Likert scale on screen after each trial.

### **Procedure**

Participants will complete 200 trials of the visual orientation discrimination task. Each trial will proceed as follows: a fixation point (500ms), stimulus presentation/oriented grating (100ms), a mask stimulus (100ms), followed by the two-alternative forced choice response screen where participants indicate the orientation and rate their confidence. After the main task, participants will complete a surprise memory test that include a mix of previously seen and novel gratings, during which they will indicate whether each stimulus is “old” or “new”. Both reaction times and accuracy will be recorded throughout the experiment.

### **Result Forecast**

It is predicted that high-confidence errors will be more likely to be remembered on the post-task memory test, suggesting that they were consciously encoded despite being incorrect. In contrast, low-confidence errors are expected to show poorer memory performance, implying that such errors have occurred at a decisional (cognitive) level without entering conscious awareness. A 2x2 repeated measures ANOVA will be used to test for an interaction between confidence (high vs low) and recognition performance (hit vs false alarm).

### **Discussion**

This experiment aimed to investigate whether perceptual and cognitive errors differ in their contribution to conscious awareness and learning, using confidence ratings and memory performance as behavioural measures. The predicted pattern- that high confidence errors are more likely to be remembered on a surprise memory test, while low confidence errors are more likely to be forgotten - would suggest that confidence acts as a marker of whether an error enters conscious awareness and is thus eligible for learning. This supports recent findings by Alilovic et al (2023), who showed that high-confidence false recognitions were associated with early perceptual processing, while low

confidence errors reflected higher-order, decisional processes. The predicted results would extend this by demonstrating that perceptual, confident errors are not just anatomically distinct but also influence memory consolidation.

This interpretation is not without challenges. A significant counter-argument is that confidence and conscious awareness can be disassociated. For example, Lau and Passingham (2006) demonstrated that participants could make confident decisions about visual stimuli they reported not seeing, suggesting that confidence may arise from post-perceptual processes rather than the act of perceiving itself. Similarly, Overgaard et al. (2006) found that participants could assign high confidence to responses even when their subjective reports of awareness were ambiguous. These findings complicate the assumption that confidence directly links to conscious perception, implying the possibility that high confidence errors may not always reflect perceptual awareness, but rather post perceptual and cognitive processes. A second counter-argument comes from literature on implicit learning and unconscious adaptation. Tsushima et al. (2006) provide compelling evidence that learning can occur without conscious awareness. If low-confidence errors reflect unconscious or rule-based mistakes, it is still possible that they contribute to behavioural changes, even if they are not remembered later. Thus, the absence of memory for low-confidence errors does not necessarily imply that they do not contribute to the learning process, but they may influence learning indirectly through discrete mechanisms.

Despite these limitations, the predicted findings strengthens the claim that not all errors are equal in the mind's architecture. Errors accompanied by high-confidence appear to engage perceptual systems more robustly and are more likely to be consciously remembered. This shows that confidence is not merely a by-product of decision making but is also a functional gatekeeper for conscious learning. Future research might investigate how this relationship generalizes across other modalities or explore whether training can modulate the confidence threshold for learning from an error.

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