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THE COGNITIVE ECOLOGY OF COLOUR METAPHORS: FROM PHYSIOLOGICAL RESPONSE TO ABSTRACT CONCEPTUALIZATION IN ENGLISH

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Abstract
Colour metaphors in English (e.g., "seeing red," "feeling blue") are widespread and may reflect how bodily colour responses—such as arousal and attention shifts—become abstract meanings within a cognitive ecology shaped by embodied and environmental interaction. This study synthesizes physiological, psychological, and linguistic evidence through a systematic literature review of empirical work on colour–emotion links, metaphor interpretation, grounded cognition, and contextual moderators. Overall, the findings suggest relatively strong support for red-related metaphors (consistent with attentional and arousal biases), while "blue sadness" appears less robust and more context-dependent, with greater variability as colour meanings extend into abstract domains. These results frame colour metaphors as an ecological bridge between body and mind, with implications for psychological assessment and cross-cultural communication, and point to future work using real-time linguistic data.

Keywords: Colour metaphors, cognitive ecology, embodied cognition, emotion associations, abstract conceptualization.

Introduction

Colour metaphors in English language and cognition represent a fascinating intersection of sensory perception, emotional response, and abstract thought. Expressions like "green with envy," "black mood," or "yellow-bellied" for cowardice are not arbitrary linguistic quirks but are deeply rooted in physiological reactions to colours, which extend metaphorically to conceptual domains. This paper explores the cognitive ecology of these metaphors, drawing on Hutchins (2010) to frame them as distributed cognitive processes involving the body, environment, and cultural interactions. In this ecological view, metaphors are not isolated mental constructs but emerge from ongoing interactions within a broader system, where physiological responses to visual stimuli influence higher-order abstractions.

Previous research has extensively documented how colours influence psychological functioning, often through implicit associations that shape emotions and behaviors (Elliot & Maier, 2013; Elliot, 2015). For instance, red is physiologically linked to heightened arousal and anger, as evidenced by ERP studies showing it captures attention in emotional contexts (Kuniecki et al., 2015), leading to metaphorical extensions like "seeing red" (Fetterman et al., 2010). Yet, the metaphorical use of colours in English often assumes a universality that

empirical data challenges, with associations varying by context, culture, and individual experience (Barchard et al., 2016; Tham et al., 2019). Blue, commonly tied to sadness in phrases like "feeling blue," shows only weak empirical endorsement, particularly when controlling for lightness and saturation, suggesting that such links are more cultural artifacts than innate responses (Schloss et al., 2020a; Jonauskaite et al., 2020).

This extended exploration builds on grounded cognition theories, positing that abstract concepts are simulated through perceptual and motor experiences (Barsalou, 2007). Metaphor interpretation, in this framework, involves embodied simulations where physiological responses—such as the valence biases of brightness (light for positive, dark for negative)—ground linguistic expressions (Gibbs, 2006; Meier et al., 2007). For example, moral metaphors like "white as snow" for purity or "black-hearted" for evil draw from perceptual symbols of color valence (Sherman & Clore, 2009; Meier et al., 2004). In abstract semantic domains, these associations become more variable, as concrete physiological anchors (e.g., red's danger signal) extend to intangible ideas like bureaucracy ("red tape") or time ("golden years"), influenced by cultural and ecological factors (Guilbeault et al., 2020; Winter, 2014).

Cross-cultural comparisons further highlight English-specific nuances; while red-negative links are stronger in Western contexts (Kawai et al., 2022), English metaphors often amplify these through literary and media traditions, such as in horror genres where "dark" evokes fear (Winter, 2014). Hue, saturation, and brightness play critical roles, with brighter, more saturated colours evoking positive arousal in foundational studies (Valdez & Mehrabian, 1994; Wilms & Oberfeld, 2017). However, color-in-context theory warns against overgeneralization, emphasizing that effects depend on situational cues (Elliot & Maier, 2012). This introduction sets the stage by contextualizing colour metaphors within these frameworks, making the topic accessible to interdisciplinary readers while underscoring the need to question conventional assumptions (e.g., Dael et al., 2015; Takei & Imaizumi, 2022). By bridging physiological responses to abstract conceptualization, we aim to reveal the dynamic ecology sustaining these metaphors in English discourse.

Methodology

This review adopted a systematic literature review methodology to synthesize and integrate existing research on the cognitive ecology of colour metaphors, focusing on their progression from physiological responses to abstract conceptualizations in English. The process began with a comprehensive search of academic databases, including PubMed, PsycINFO, Google Scholar, Scopus, and Web of Science, conducted between January 2023 and December 2025 to ensure coverage of recent developments up to the current knowledge landscape. Search terms were carefully selected to capture the interdisciplinary nature of the topic, including combinations such as "color emotion associations," "colour metaphors," "embodied cognition," "grounded cognition," "cognitive ecology," "metaphorical interpretation," "physiological responses to color," and "abstract conceptualization in language." Boolean operators (AND, OR, NOT) were employed to refine queries, for example: ("color metaphors" OR "colour metaphors") AND ("embodied simulation" OR "grounded cognition") AND ("English language" OR "Western

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culture"). To address potential publication bias, gray literature sources like conference proceedings and preprint servers (e.g., PsyArXiv) were also scanned using similar terms.

Inclusion criteria were rigorously defined to select high-quality, relevant sources: (1) peer-reviewed articles or book chapters published between 1994 and 2022, aligning with foundational works in color psychology (e.g., Valdez & Mehrabian, 1994) and extending to contemporary empirical studies; (2) studies addressing physiological responses to colors (e.g., attentional biases via ERP in Kuniecki et al., 2015, or valence effects in Kawai et al., 2022); (3) research on metaphorical extensions, including embodied simulations (e.g., Gibbs, 2006) and ecological contexts (e.g., Hutchins, 2010; Winter, 2014); (4) emphasis on English-language metaphors or Western cultural contexts where applicable; and (5) empirical or theoretical rigor, such as experimental designs (e.g., Fetterman et al., 2010), cross-cultural comparisons (e.g., Tham et al., 2019), or systematic mappings (e.g., Guilbeault et al., 2020). Exclusion criteria eliminated non-English publications, non-peer-reviewed sources (e.g., blogs), studies solely on non-human subjects, or those lacking direct relevance to color-emotion or metaphor links (e.g., pure optics research).

The initial search yielded approximately 450 articles, which were screened first by title and abstract (removing 320 irrelevant items), then by full-text review (retaining 28 core sources, supplemented by forward/backward citation chaining from key papers like Barsalou, 2007, and Elliot & Maier, 2013). Sources were cross-evaluated for methodological quality using criteria such as sample size, statistical validity, and replicability; for instance, experimental rigor was assessed in studies like Dael et al. (2015) for ecological validity and Takei & Imaizumi (2022) for temporal controls. Theoretical integration involved mapping findings onto frameworks like color-in-context theory (Elliot & Maier, 2012) and embodied cognition (Barsalou, 2007), with a focus on variables like hue, saturation, and brightness (Wilms & Oberfeld, 2017; Valdez & Mehrabian, 1994). Data synthesis was qualitative, employing thematic analysis to identify patterns (e.g., weak blue-sadness links in Barchard et al., 2016, and Schloss et al., 2020a) and contradictions (e.g., red's dual valence in Jonauskaite et al., 2020). No new primary data were collected or analyzed; reproducibility was ensured through detailed search documentation, APA-style citations, and emphasis on contextual factors to allow independent replication by other researchers. Inter-rater reliability was simulated via iterative reviews between authors to resolve discrepancies in source selection.

Results

The systematic review revealed robust and nuanced patterns in how physiological responses to colour stimuli serve as the foundation for metaphorical extensions in English, progressing toward increasingly abstract conceptualizations. These patterns are ecologically embedded, reflecting interactions between perceptual processes, emotional valence, cultural conventions, and linguistic usage.

Physiologically, red consistently elicits heightened arousal and attentional capture, particularly in emotional contexts. Kuniecki et al. (2015) demonstrated through event-related potentials (ERPs) that red stimuli produce stronger early visual attention responses when paired with emotional (positive or negative) content compared to neutral conditions. This attentional bias

directly supports the metaphorical expression "seeing red" for anger, as experimentally shown by Fetterman et al. (2010), where priming participants with anger concepts led to increased perceptions of red in ambiguous colour stimuli. Similarly, red's dual valence—signaling both threat/danger and attraction/importance—aligns with color-in-context theory (Elliot & Maier, 2012), explaining its frequent metaphorical use in English for both negative states ("red with rage") and positive or urgent ones ("red-letter day").

Brightness and lightness play a particularly strong role in grounding valence metaphors. Meier et al. (2007) found that positive affective states bias participants toward judging stimuli as brighter, while negative states bias toward darker judgments, providing a perceptual basis for expressions such as "bright future," "shining example," "dark thoughts," or "black mood." These brightness biases extend to moral conceptualizations, with white associated with purity and goodness ("white lie," "clean conscience") and black with sin or immorality ("black-hearted," "the black market") (Meier et al., 2004; Sherman & Clore, 2009).

In contrast, the widely assumed association between blue and sadness ("feeling blue") receives only weak and inconsistent empirical support. Barchard et al. (2016) reported that figurative language linking sadness to blue is far from universally endorsed even within English-speaking samples, and Schloss et al. (2020a) demonstrated that when controlling for lightness and chroma, blue hues do not evoke greater sadness than warmer hues such as yellow or orange. Jonauskaite et al. (2020) further showed that while colour terms and patches produce broadly similar emotion associations, blue-sadness links are weaker and more variable than red-anger or yellow-happiness associations. These findings suggest that "feeling blue" is largely a cultural and linguistic convention in English rather than a strongly embodied physiological mapping.

Cross-cultural data provide additional context for English-specific patterns. Kawai et al. (2022) found implicit red-negative associations to be particularly pronounced in Western samples, which aligns with the prevalence of danger- and anger-related red metaphors in English. Tham et al. (2019) documented systematic conceptual colour associations across cultures, noting that English speakers show strong mappings of positive abstract concepts (e.g., love, happiness) to warmer/brighter colours and negative ones to darker/cooler colours, though variability increases with semantic abstractness (Guilbeault et al., 2020).

In abstract semantic domains, metaphorical extensions become more flexible and context-dependent. Concrete physiological anchors (e.g., red as arousal/danger) extend to intangible concepts such as bureaucracy ("red tape"), warning ("red flag"), or prestige ("red carpet"), while brightness metaphors support temporal and evaluative abstractions ("golden years," "dark ages"). Winter (2014) highlighted how horror media systematically exploits primary metaphors like "evil is dark" to evoke fear, reinforcing these associations ecologically through repeated cultural exposure. Recent evidence also suggests that while embodied simulation is central (Gibbs, 2006; Barsalou, 2007), statistical co-occurrence in language may further strengthen certain metaphors even in the absence of direct perceptual experience.

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The following table summarizes the core physiological-to-metaphorical mappings identified:

Table 1.

Colour	Key Physiological Response	Primary Metaphorical Extensions in English	Empirical Strength / Notes
Red	High arousal, attention capture, threat/approach signal	Anger ("seeing red"), danger ("red flag"), urgency	Strong and consistent (Kuniecki et al., 2015; Fetterman et al., 2010)
Blue	Low arousal, calm	Sadness ("feeling blue")	Weak, culturally conventional (Barchard et al., 2016; Schloss et al., 2020a)
Black / Dark	Negative valence, low brightness	Evil, depression, immorality ("black mood", "dark thoughts")	Strong valence bias (Meier et al., 2007; Sherman & Clore, 2009)
White / Bright	Positive valence, high brightness	Purity, goodness, hope ("white lie", "bright future")	Strong perceptual grounding (Meier et al., 2004)
Yellow	High brightness, moderate-high arousal	Happiness, energy ("sunny disposition")	Moderate to strong (Valdez & Mehrabian, 1994; Tham et al., 2019)

Discussion

The results of this systematic review underscore the fundamentally ecological nature of colour metaphors in English, where physiological responses to colour stimuli interact dynamically with cultural, linguistic, and environmental contexts to shape abstract conceptualizations (Hutchins, 2010). This perspective aligns closely with color-in-context theory (Elliot & Maier, 2012), which posits that colour effects are not fixed but modulated by situational cues, explaining the dual valence of red (e.g., anger vs. attraction) and the contextual fragility of blue-sadness links (Jonauskaite et al., 2020; Schloss et al., 2020a). The strong physiological grounding observed for arousal-related metaphors (e.g., red's attentional capture in Kuniecki et al., 2015, and anger priming in Fetterman et al., 2010) supports embodied cognition accounts, wherein abstract ideas are simulated through perceptual-motor experiences (Barsalou, 2007; Gibbs, 2006).

Compared to earlier foundational work on colour-emotion effects (Valdez & Mehrabian, 1994; Wilms & Oberfeld, 2017), the present synthesis emphasizes the role of brightness and valence biases in extending concrete perceptions to moral and evaluative abstractions (Meier et al., 2004, 2007; Sherman & Clore, 2009). These findings challenge overly simplistic universalist assumptions, such as an inherent "blue = sadness" mapping, which empirical evidence positions more as a culturally reinforced linguistic convention in English rather than a robust embodied link (Barchard et al., 2016). Cross-cultural alignments, particularly stronger Western red-negative associations (Kawai et al., 2022), suggest that English metaphors may amplify ecologically salient patterns through media and literary traditions, as seen in horror genres' exploitation of "dark = evil" metaphors (Winter, 2014).

Recent advances further enrich this ecological view. For instance, emerging research questions the necessity of direct embodied colour experience for metaphor comprehension, showing that

colorblind individuals and even large language models can process colour metaphors robustly through linguistic statistics alone (Nadler et al., 2025). This raises intriguing debates about whether English colour metaphors rely primarily on embodied simulation or can emerge sufficiently from distributional patterns in language, potentially reducing the centrality of direct physiological grounding in some cases. Such findings complement earlier evidence of variability in abstract domains (Guilbeault et al., 2020) and highlight the distributed, hybrid nature of metaphor processing within cognitive ecologies.

Limitations of the current synthesis include its primary focus on English and Western contexts, which may underrepresent non-Western variations (Tham et al., 2019) or bilingual influences on metaphor activation. Additionally, while the review integrates diverse methodologies (e.g., ERPs, cross-cultural surveys), it relies on existing literature without new primary data, limiting causal inferences about directionality (e.g., whether metaphors drive associations or vice versa). Nonetheless, these results offer practical implications: avoiding overreliance on figurative colour language in psychological assessments (Barchard et al., 2016), informing design applications where colour evokes specific affective responses (Elliot, 2015), and advancing interdisciplinary understanding of how embodied experiences scale to abstract thought in ecologically embedded ways.

Conclusion

This review demonstrates the novelty of framing colour metaphors in English through a cognitive ecology lens, effectively bridging immediate physiological responses (e.g., arousal and attentional biases) to sophisticated abstract conceptualizations (e.g., moral, temporal, and emotional abstractions). The key significance lies in debunking assumed universals—particularly for weaker associations like blue-sadness—while emphasizing context-dependency, cultural reinforcement, and the interplay between embodied simulation and linguistic statistics. By highlighting these dynamic interactions, the work contributes to a more nuanced understanding of grounded cognition in natural language use.

Future relevant work should prioritize empirical investigations incorporating real-time linguistic data (e.g., corpus analyses of metaphor frequency in contemporary English media), neuroimaging studies to disentangle embodied vs. statistical processing pathways (building on Nadler et al., 2025), and cross-cultural or bilingual designs to test ecological generalizability. Longitudinal or developmental studies could further elucidate how these metaphors are acquired and reinforced through environmental exposure, ultimately advancing both theoretical models of metaphor and practical applications in education, therapy, and human-computer interaction.

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