Bridging Perception-Reality Gap: Risk-Opportunity Model for Pyro-SFR Acceptance

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1. Introduction

Emerging technologies such as Pyroprocessing coupled with Sodium-cooled Fast Reactors (Pyro-SFR) present significant opportunities and risks, yet their social acceptance remains a major challenge. Public perceptions, often shaped by intuitive and emotional responses rather than factual assessments, frequently misalign with the actual benefits and risks of these technologies [1]. To address this issue, this paper introduces Risk-Opportunity Model, a framework aimed at mitigating psychological distortions, proposed by Ahn [2], [3], refining communication strategies, and fostering informed decision-making to enhance societal acceptance of complex technologies.

2. Risk-Opportunity Model

Risk-Opportunity Model conceptualizes how individuals subjectively frame risk and opportunity based on perceptions of hazard and usefulness, which often deviate from objective reality. Perception begins with sensory detection of external stimuli, followed by primary encoding (measurement, collection, filtering) and secondary encoding (identification, organization, interpretation), shaping mental representations of reality [4], [5]. This cognitive processing frequently introduces perceptual distortions, leading to overestimated risks or underestimated benefits [2], [3].

Within this model, hazard refers to loss factors exceeding acceptable loss thresholds, potentially causing damage, while usefulness refers to gain factors within acceptable loss thresholds leading benefit. Risk represents the subjective evaluation of hazard, and opportunity denotes the subjective assessment of usefulness. By identifying and clarifying perceptual divergences, Risk-Opportunity Model facilitates rational, informed decision-making and reduces social conflicts [2], [3].

Ahn [2] categorizes cognitive biases contributing to perception-reality discrepancies into four primary types: (1) Causal inference biases (e.g., illusory correlation, misattribution), (2) Loss aversion biases (e.g., negativity bias, omission bias, zero-risk bias), (3) Self-assessment biases (e.g., optimism bias, planning fallacy, illusion of control), and (4) Post hoc rationalization biases (e.g., confirmation bias). Addressing these biases through targeted communication strategies is crucial for aligning public perceptions with scientific realities.

3. Bridging Reality and Perception Gap

Risk-Opportunity Model emphasizes strategic communication approaches to effectively bridge gaps between perceived and actual hazard and usefulness associated with technologies such as Pyro-SFR. Individuals typically assess risks and opportunities through intuitive and emotional frameworks influenced by psychological, social, and cultural contexts, leading to potential misalignment with scientific evidence [2]. Therefore, integrating case-based exemplifications with accurate statistical or base-rate information is essential for correcting perceptual biases such as phantom risks and neglected usefulness [6].

Effective communication must extend beyond purely statistical data. Incorporating relatable, emotionally resonant examples enhances cognitive engagement, making abstract data accessible and meaningful. Emotionally engaging narratives increase empathy, facilitating deeper, more accurate understandings of both hazard and usefulness, reducing perceptual discrepancies. Moreover, communication strategies should explicitly target specific cognitive biases through tailored messaging. For instance, addressing causal inference biases requires presenting clear causal explanations alongside counterexamples [2], [3].

Additionally, fostering intellectual humility can significantly reduce cognitive biases. Encouraging intellectual humility helps individuals acknowledge cognitive limitations and reduces defensiveness toward conflicting evidence, thereby fostering a more balanced evaluation of information [7].

Given that correcting cognitive biases typically involves emotional discomfort, promoting self-compassion becomes especially important. Self-compassion allows individuals to accept emotional pain and discomfort without self-judgment, enhancing openness to new information and corrective feedback. It has been identified as a critical factor in psychological flexibility and well-being, effectively facilitating adaptive coping strategies and reducing psychological distress in the face of perceived failures or setbacks [8].

Thus, integrating strategies that enhance intellectual humility and self-compassion into communication frameworks can improve public receptivity to scientifically grounded information, thereby supporting informed decision-making and societal acceptance of beneficial technologies.

4. Addressing Radiophobia

Radiophobia, an exaggerated fear of radiation, remains a significant barrier to rational discourse on Pyro-SFR technology. This fear, deeply rooted in historical nuclear accidents, media portrayals, and public distrust of nuclear authorities, fuels concerns about radiation exposure, waste disposal, and reactor safety [2], [3].

Despite substantial technological advancements significantly mitigating risks, radiophobia persists as a dominant psychological distortion, shaping public discourse based on intuitive and emotional responses rather than empirical evidence. Such distortions manifest as phantom risks—unsubstantiated perceptions of hazard—and neglected usefulness, resulting in an underestimation of the economic, environmental, and safety potentials of Pyro-SFR technology [2], [3], [9].

From Risk-Opportunity Model perspective, overcoming radiophobia requires clearly distinguishing between genuine and phantom risks while highlighting actual usefulness. Effective communication strategies should combine statistical accuracy with emotionally resonant narratives to counteract these perceptual distortions.

Relatable Messages: Educational campaigns should explicitly differentiate between scientifically negligible low-dose radiation exposure and genuinely hazardous radiation levels by presenting comparative risk assessments in clear, accessible, and relatable messages.

Narrative-based: Utilizing narrative-based exemplifications alongside accurate base-rate data can counteract biases such as negativity bias and omission bias, essential for correcting radiophobia-driven misperceptions.

Fostering Intellectual Humility and Public Trust: By integrating intellectual humility into discourse, stakeholders can cultivate an environment for open dialogue and nuanced discussions, mitigating polarization and fear-driven opposition. Likewise, fostering self-compassion enables individuals to navigate uncertainties and concerns with greater emotional resilience, reducing excessive fear or defensiveness and enhancing receptivity to scientific evidence.

5. Conclusion

Risk-Opportunity Model offers a systematic framework for aligning public perceptions with the scientific realities of Pyro-SFR technology. By targeting cognitive biases, integrating case-based exemplifications, and employing emotionally resonant narratives, the model can reduce radiophobia, correct misconceptions, and promote rational assessments of nuclear technologies. Cultivating intellectual humility and self-compassion further supports informed decision-making, enhancing societal acceptance of beneficial technologies such as Pyro-SFR].

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