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Exploring Data-Driven Approaches to Stress Management:

A Systematic Review of Stress Tracking, Intervention, and System Evaluation Methods

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The Rise of Stress Tracking Technologies

Wearables & smartphones **enable real-time stress tracking** in everyday life

Yet, **stress** is deeply **subjective** and **contextual**[1]

Therefore, detection alone is insufficient

How detection-based interventions are designed matters for stress management

[1] Richard S Lazarus and Susan Folkman. 1984. Stress, appraisal, and coping. Springer publishing company.

Fragmented Perspectives in Prior Work

Prior reviews focused on either...

Stress Detection[1,2]

Stress Intervention[3,4]

[1] Abd-Alrazaq, Alaa, et al. "The performance of wearable AI in detecting stress among students: systematic review and meta-analysis." *Journal of Medical Internet Research* 26 (2024).
[2] Nouman, Muhammad, et al. "Recent advances in contactless sensing technologies for mental health monitoring." IEEE Internet of Things Journal 9.1 (2021): 274-297.
[3] Regehr, Cheryl, Dylan Glancy, and Annabel Pitts. "Interventions to reduce stress in university students: A review and meta-analysis." Journal of affective disorders 148.1 (2013): 1-11.
[4] Lamontagne, Anthony D., et al. "A systematic review of the job-stress intervention evaluation literature, 1990–2005." International journal of occupational and environmental health 13.3 (2007): 268-280.

Fragmented Perspectives in Prior Work

Stress Detection

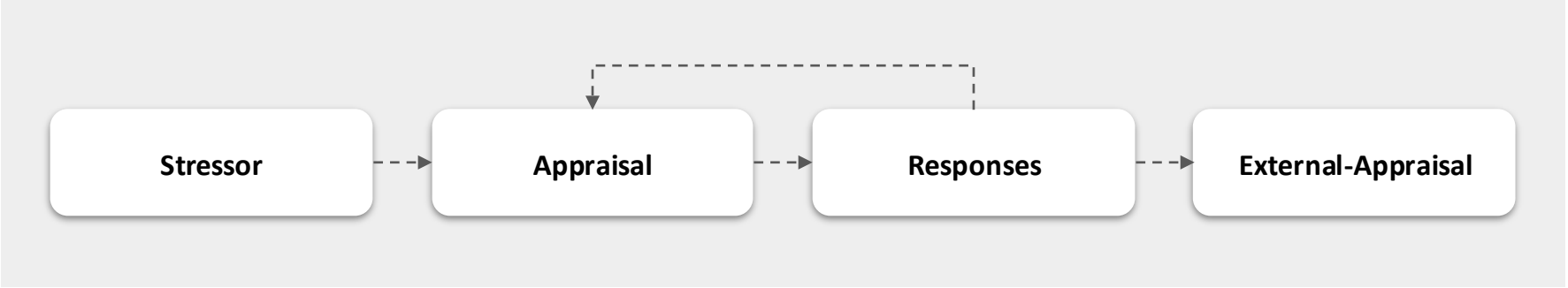
Stress Intervention

No prior reviews systematically examined
detection, ***intervention***, and ***evaluation*** from an integrated perspective

Understanding Stress: A Theoretical Lens

To build an integrated framework, we need to first ask:
"How has stress been defined and operationalized across studies?"

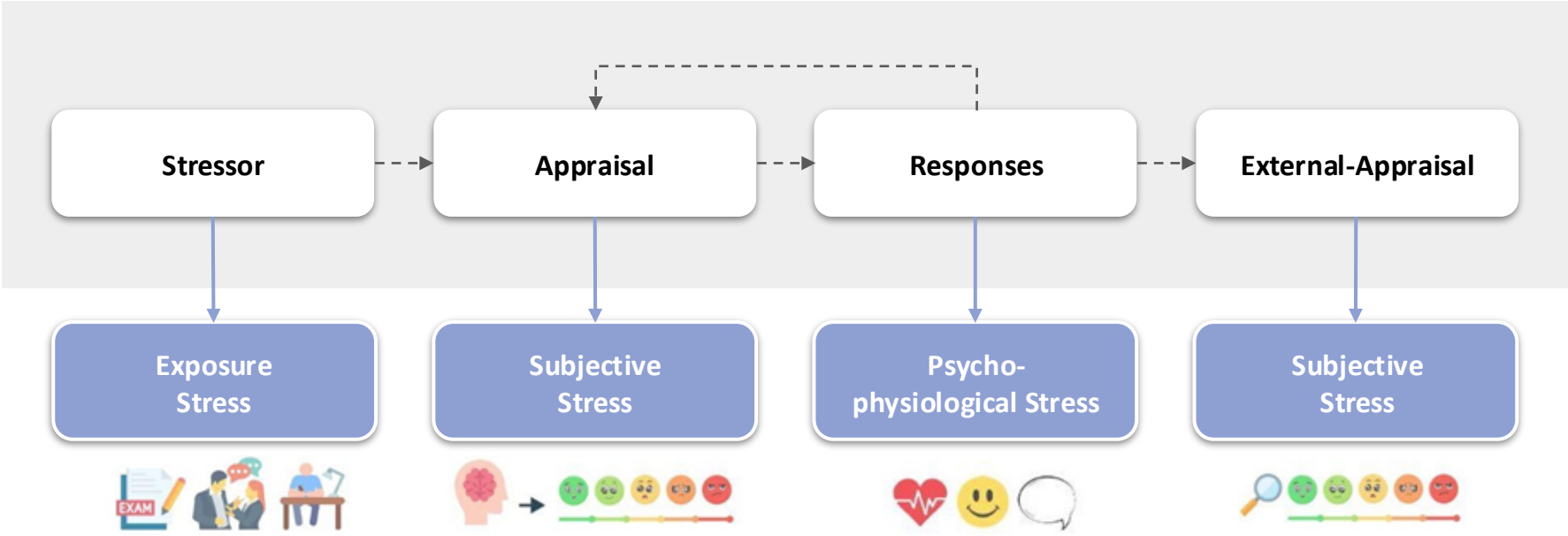
➜ We adopt **Lazarus and Folkman's transactional model**[1], which conceptualizes stress as a dynamic and contextual process



[1] Richard S Lazarus and Susan Folkman. 1984. Stress, appraisal, and coping. Springer publishing company.

Understanding Stress: A Theoretical Lens

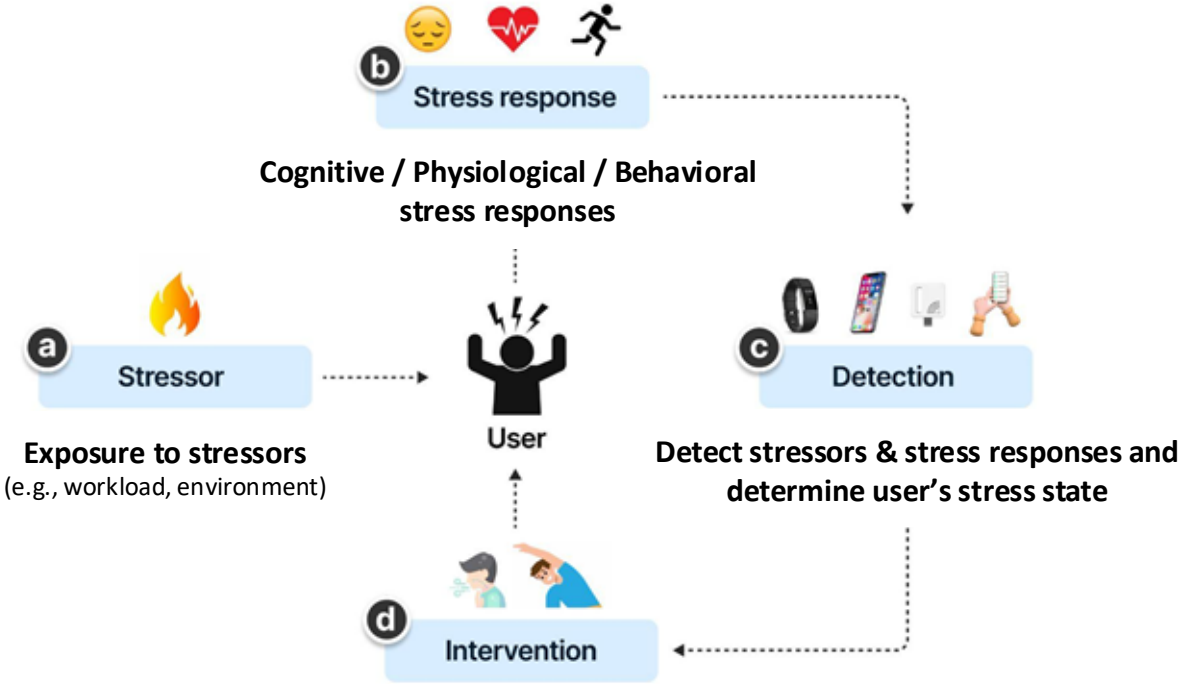
We use this model as a lens to categorize
how stress has been defined across prior HCI work:



[1] Richard S Lazarus and Susan Folkman. 1984. Stress, appraisal, and coping. Springer publishing company.

From Theory to Stress Management Systems

How stress is defined determines ***detection*** and ***intervention***:



Research Goal

**Examine how stress is defined, detected,
and linked to intervention and evaluation in an integrated way**

We set the following RQs:

RQ1. Tracking
How is **stress defined as an inference target**, and **what indicators** are used?

RQ2. Intervention
How are **these inferences connected to the design and timing** of interventions?

RQ3. Evaluation
How are **these stress management systems evaluated** in practice?

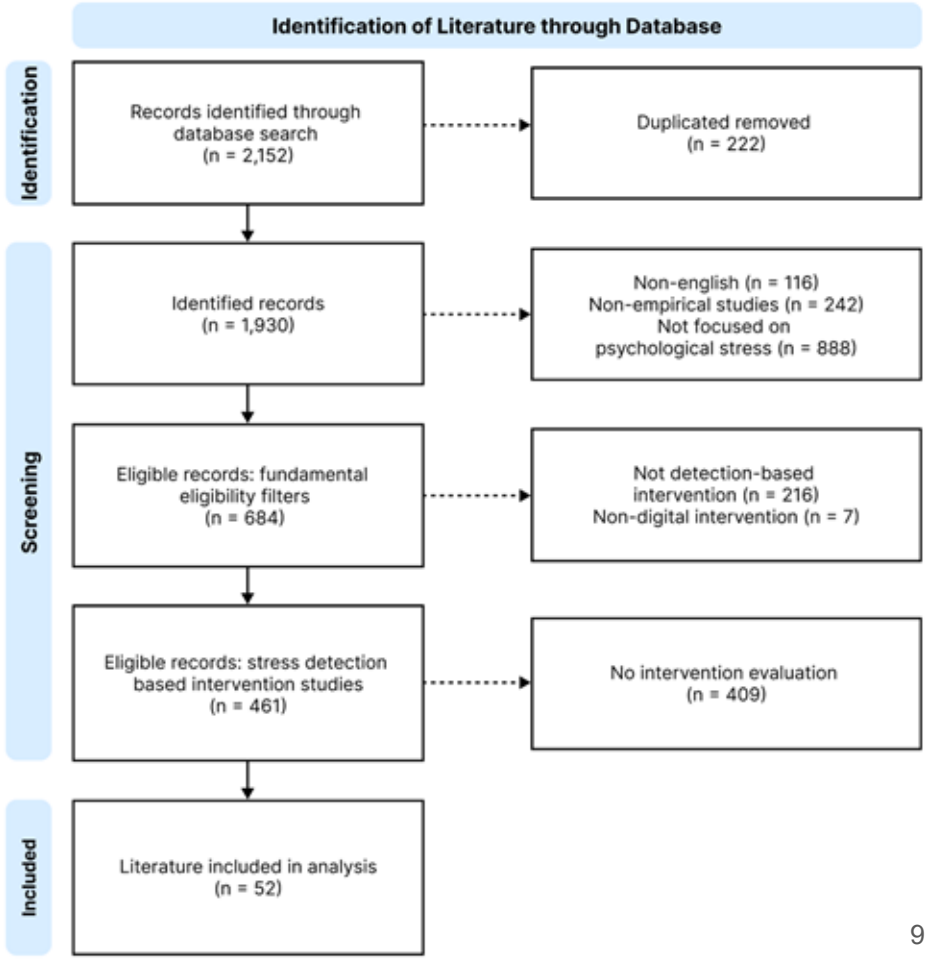
PRISMA Scoping Review

Systematic review of ACM, IEEE, and Web of Science databases

✅ **Inclusion**

- Digital intervention for stress
- Intervention informed by detection
- Includes user study / evaluation

Screened 2,152 papers
→ Included **52 empirical studies**

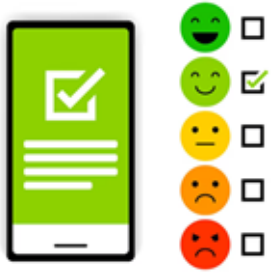


Findings for RQ1. How is Stress Defined?

Most studies targeted either **psycho-physiological** or **subjective stress**

⚠ 49 out of 52 studies focused on a **single inference target** only

Psycho-Physiological Stress (N=22)



Subjective Stress (N=20)

Exposure Stress (N=7)

Findings for RQ1. How is Stress Measured?

Physiological signals were the **most common detection indicator**

Stress Indicators	Data Source	Raw Signals	Derived Features	# of Studies
Physiological Indicator	Wearable	ECG / PPG	Heart Rate, HRV	24
		EDA	Skin Conductance	15
		RESP	Respiration Rate	4
		SkinTemp	Thermal features	2
	Camera	Video	Heart Rate, HRV	1
		SkinTemp	Thermal features	1

Other indicators also used:
Subjective(self-report), Behavioral(GPS, app usage),Expression(facial expression, voice)

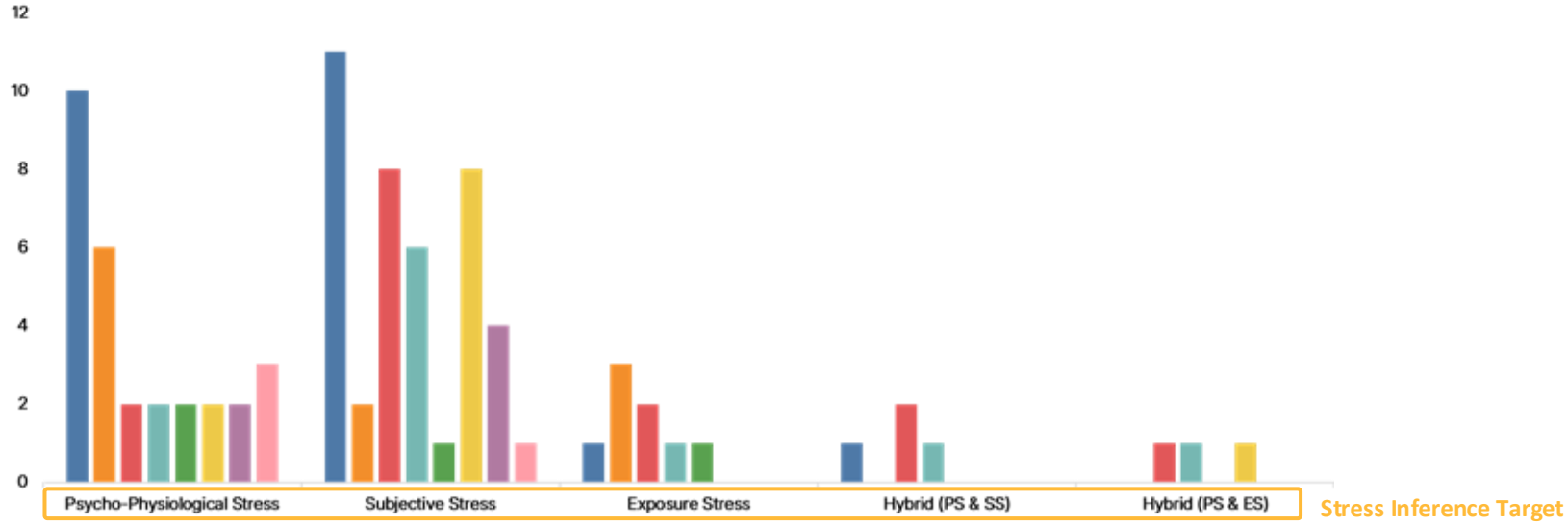
Findings for RQ2. What Interventions Were Used?

Across 52 studies, thematic analysis revealed **8 categories of intervention content**
→ **Visualization & Externalization** was the most common

Stage	Type	Sub-Category
Appraisal (Stress perception and interpretation)	**Awareness / Appraisal-Focused**	**Visualization & Externalization**
Response (Coping and stress management)	**Emotion-Focused Coping**	Biofeedback for Physiological Awareness
		Cognitive Therapy & Reframing
		Mindfulness & Relaxation
		Social Support (Emotional)
	Problem-Focused Coping	Activity Suggestions & Proactive Planning
		Social/Organizational Support (Instrumental)
		Environmental & Task Adaptation

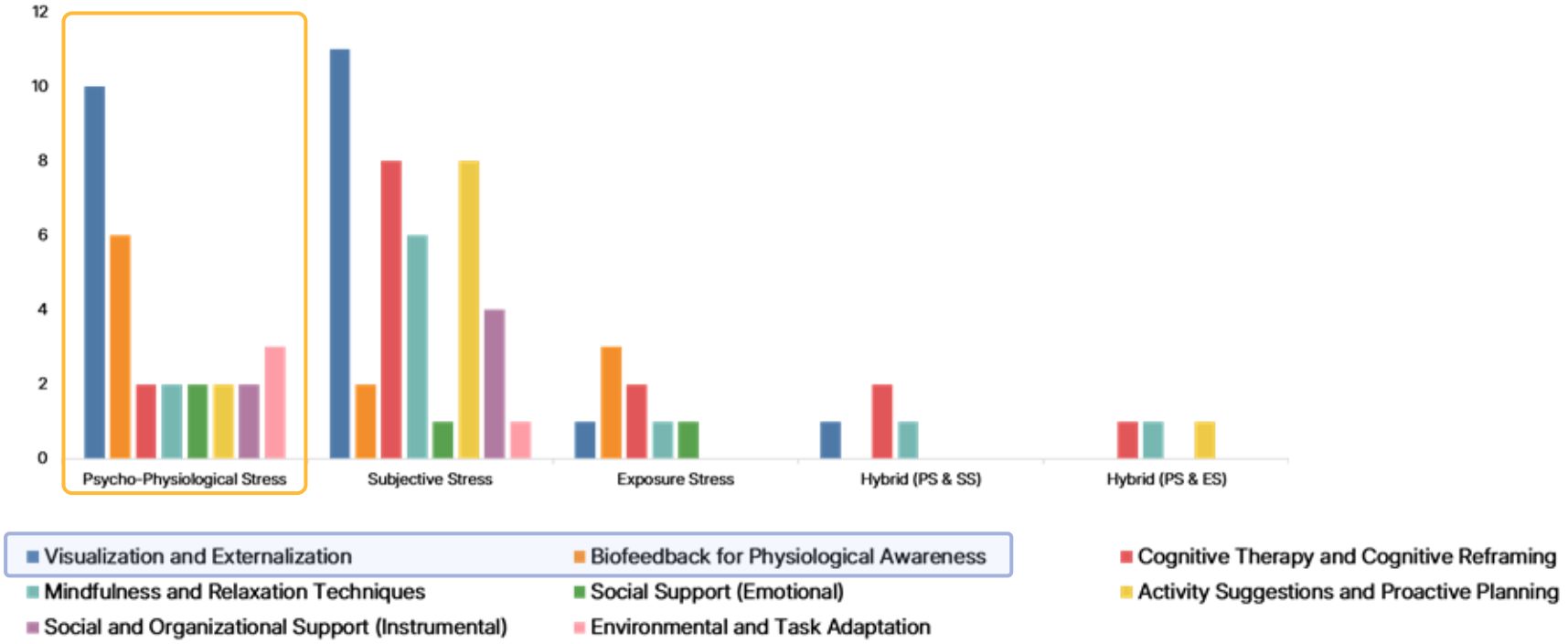
Findings for RQ2. Intervention by Inference Target

Intervention content **differed by stress inference target**



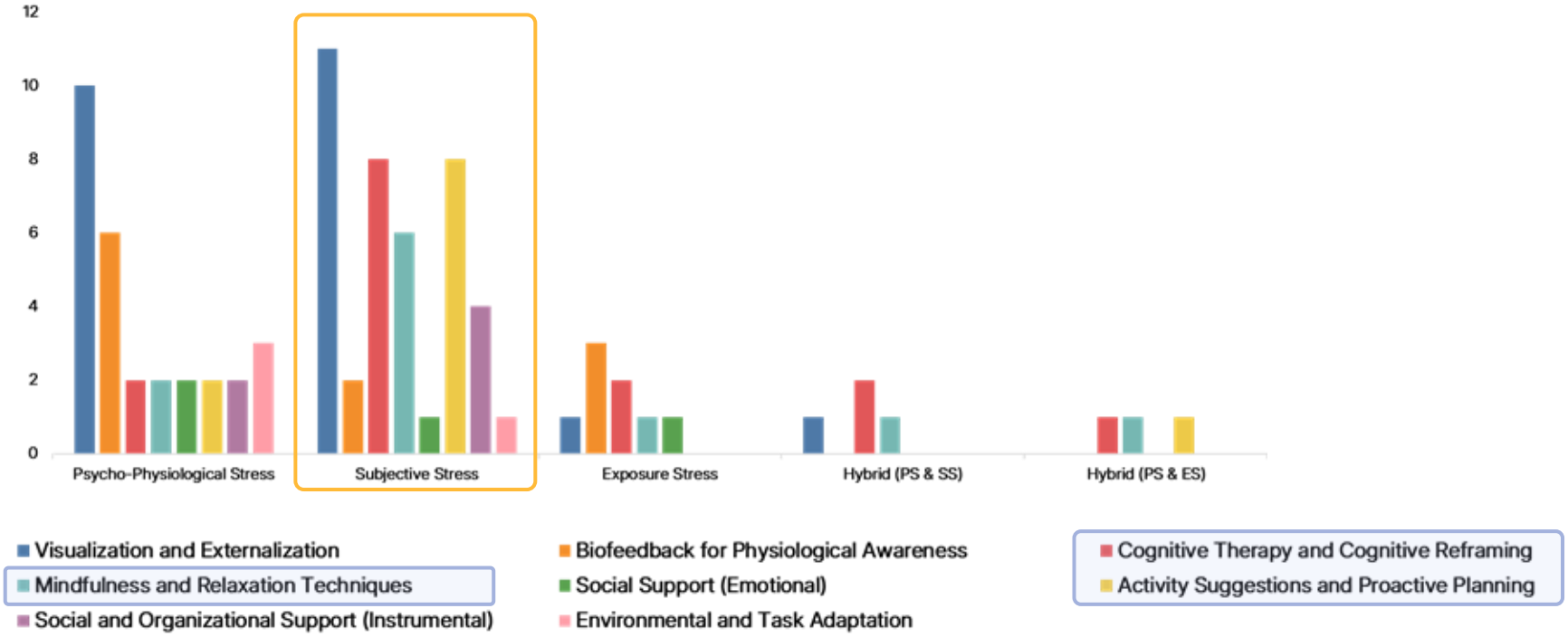
Findings for RQ2. Intervention by Inference Target

Psycho-Physiological Stress predominantly relies on **Visualization** and **Biofeedback**



Findings for RQ2. Intervention by Inference Target

Subjective Stress frequently employs **Active Coping** (e.g., CBT, Planning, Mindfulness)



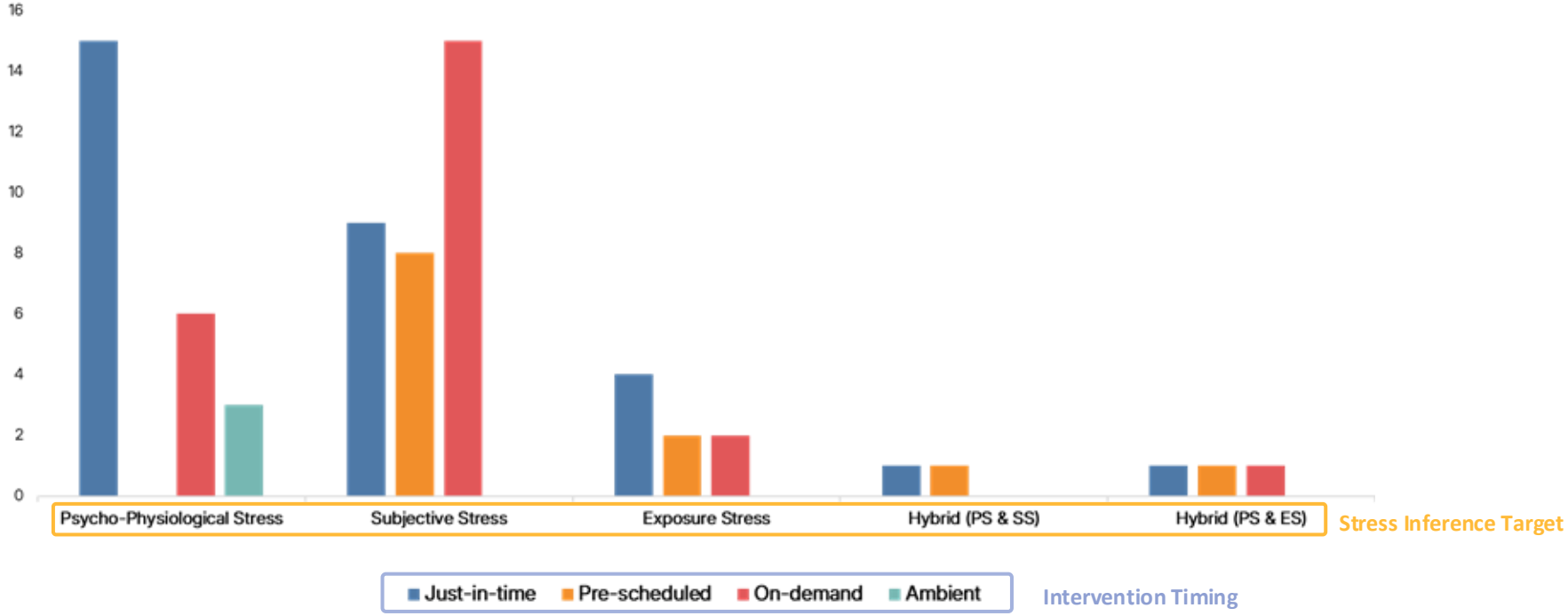
Findings for RQ2. When Were Interventions Delivered?

Interventions were delivered in **four timing strategies**
→ **Just-in-time (JIT)** is the most prevalent delivery strategy

Timing	Definition	# of Studies
Just-in-time	triggered by real-time stress detection	30
On-demand	accessed by users when needed	24
Pre-scheduled	delivered at fixed times or sessions	12
Ambient	always visible in the periphery	3

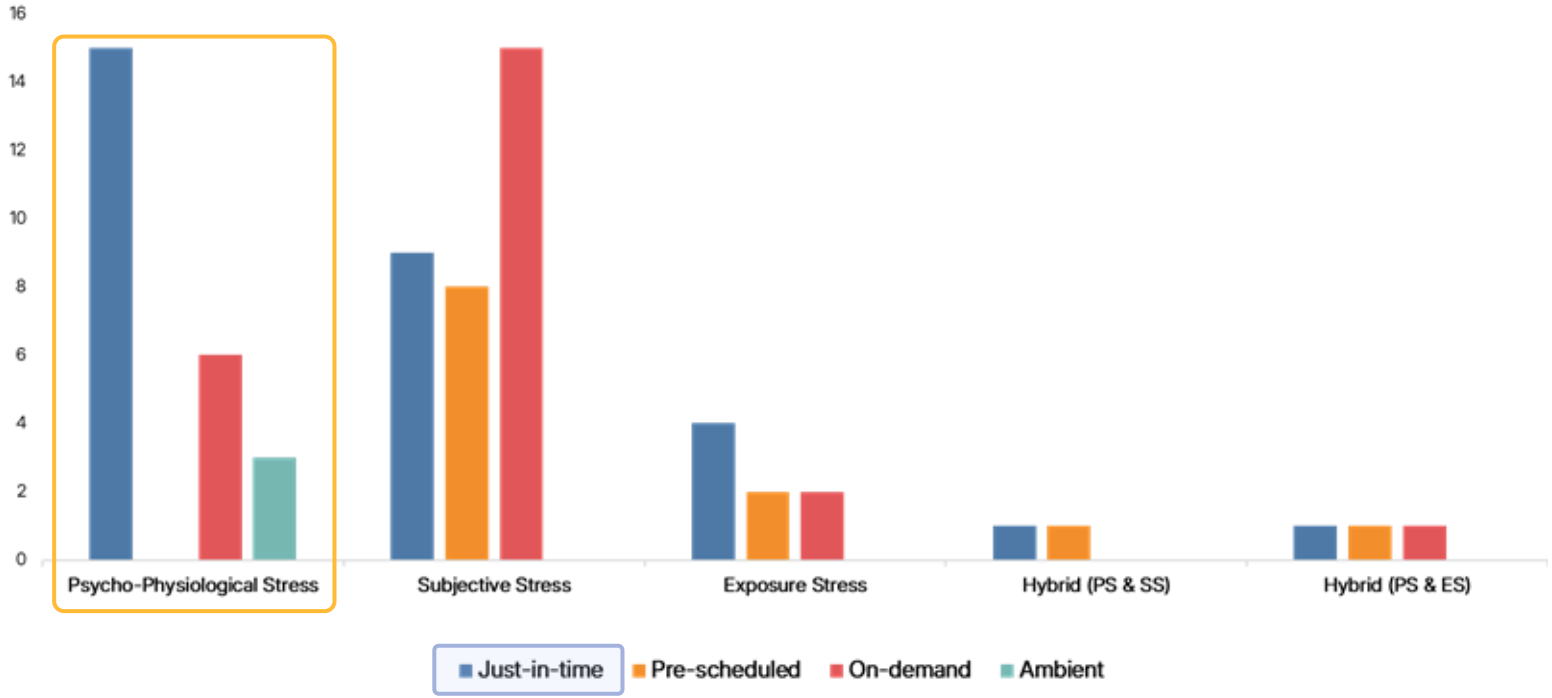
Findings for RQ2. Timing by Inference Target

Stress inference shapes not only content but also **timing of intervention**



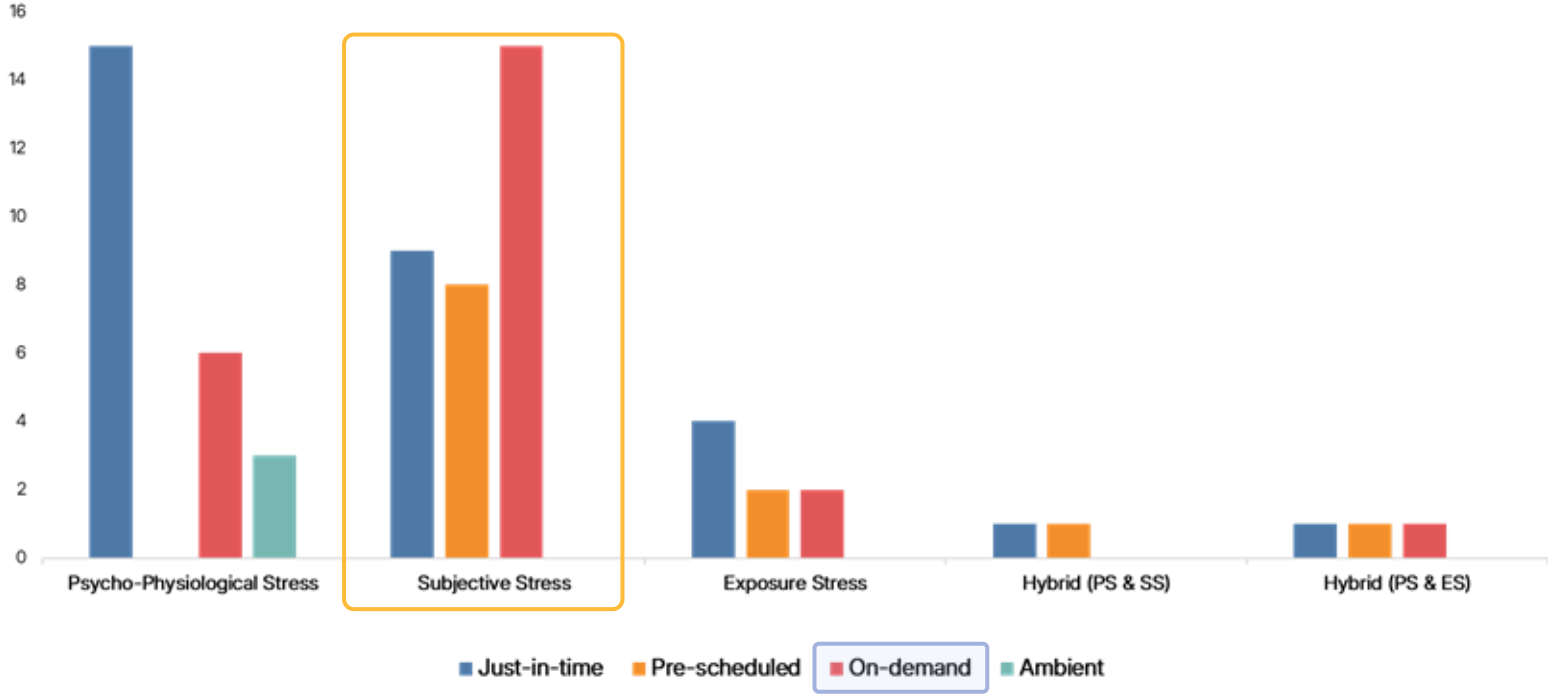
Findings for RQ2. Timing by Inference Target

Psycho-physiological stress systems used **just-in-time delivery**



Findings for RQ2. Timing by Inference Target

Subjective stress systems relied more on **on-demand** access for user-driven reflection



Findings for RQ3. How Were Systems Evaluated?

We analyzed evaluation practices across four aspects:
study design, participants, duration, and **metrics**

→ Most studies were conducted in **field settings** (N=28) with **students and workers**
→ **Mid-term (1 week–2 months)** was the most common duration (N=24)
→ Evaluation relied on **psychological scales**(e.g., PSS), **usability**(e.g., SUS) and **qualitative interviews**

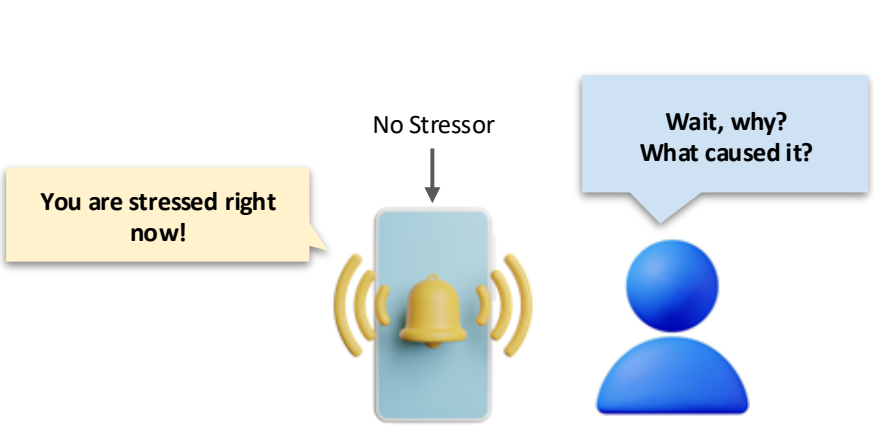
Findings for RQ3. How Were Systems Evaluated?

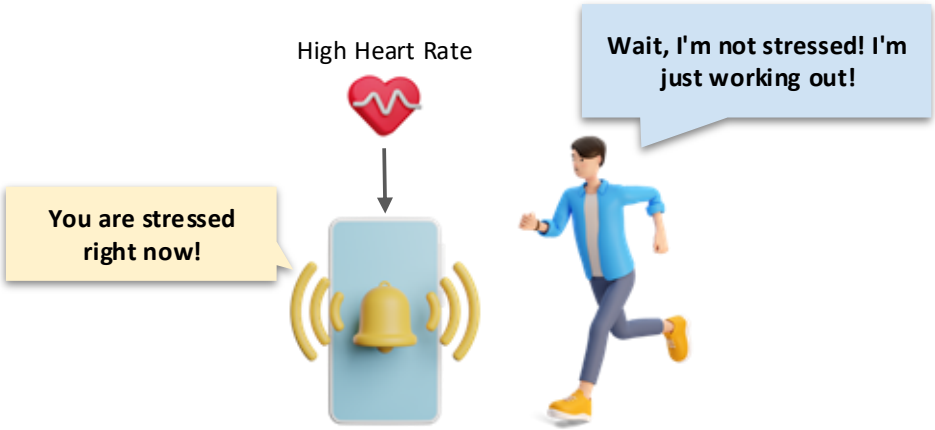
We analyzed evaluation practices across four aspects:
study design, participants, duration, and **metrics**

⚠ **45% of studies used non-comparative designs**
⚠ **Only 11% exceeded 8 weeks**

Stress Tracking: Current Limitations

49 out of 52 studies focused on a **single stress inference target**





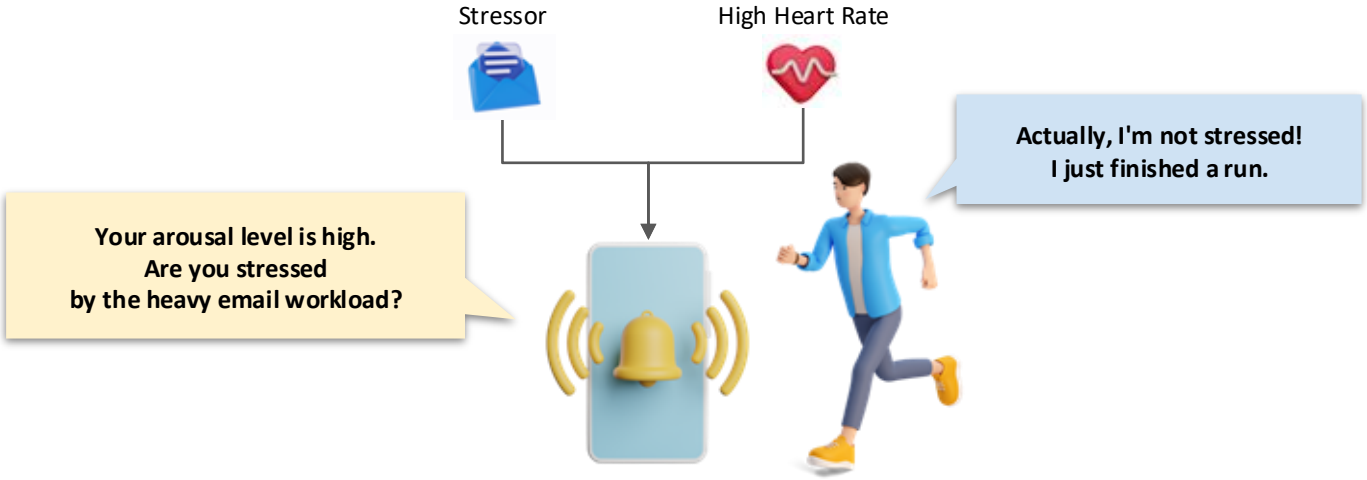
Context Loss
Systems detect "what" happened but not "why" it occurred
→ sensing model acts as a black box

Perceptual Mismatch
User feels excited, system flags it as stress
→ distrust or over-reliance

Stress Tracking: Future Directions

Capture the Full Stress Process:
Move beyond single inference target tracking (Stressor & Appraisal & Response)
➜ Help users understand not just "what" but "why" they are stressed

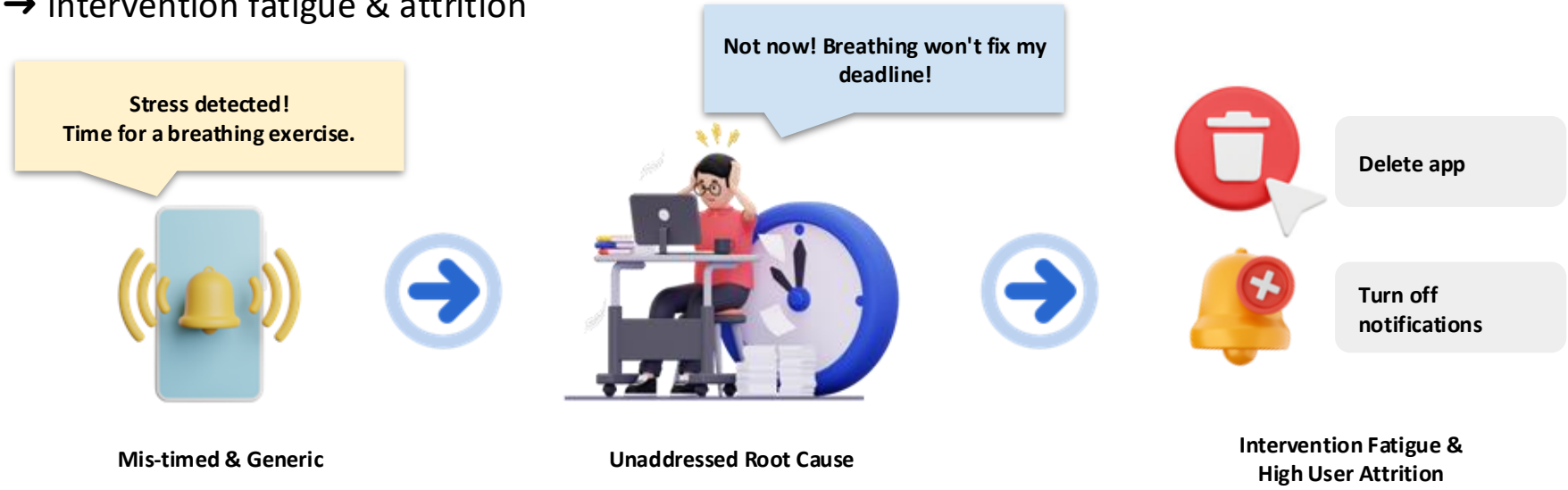
Human-in-the-loop calibration:
Users provide feedback on detected stress states
➜ System personalizes over time



Intervention: Current Limitations

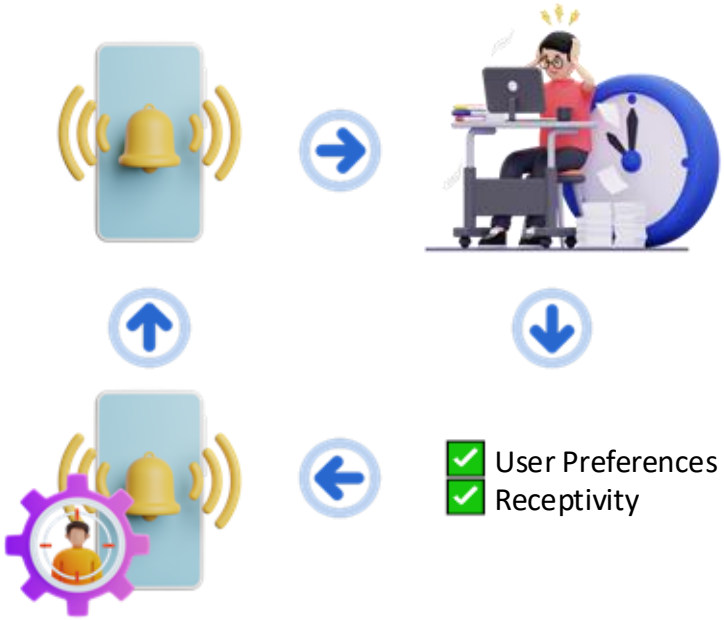
Most interventions are **symptom-oriented without addressing root causes**
➜ users become dependent on temporary relief

Most studies used **just-in-time delivery**
➜ interventions at unwanted moments
➜ intervention fatigue & attrition



Intervention: Future Directions

Closed-loop Adaptation:
Learn from user feedback to adapt both content and timing
→ from symptom relief to root-cause problem solving



Evaluation: Current Limitations

Study Design

45% used non-comparative designs
→ efficacy remains unvalidated

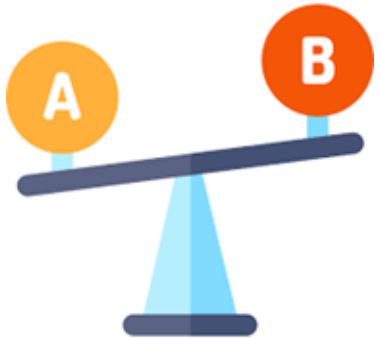
Only 11% exceeded 8 weeks
→ long-term effects remain unclear

Evaluation Metrics

Focused on efficacy & usability
→ how users actually experience systems remains underexplored

Evaluation: Future Directions

Study Design



Prioritize longitudinal RCTs*
→ Validate **long-term efficacy**

Evaluation Metrics

Go beyond efficacy metrics
→ **Mixed-methods** to understand **how users experience systems**

*Randomized Controlled Trials

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Take-away Message

- **Stress management should move beyond detection**
  → Consider the full stress process (stressor–appraisal–response)

- **Stress inference should guide intervention design**
  → Adapt both content and timing through closed-loop systems

- **Evaluation should reflect real-world impact**
  → Longitudinal and mixed-method evaluation

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