The Cognitive Cost of Addictive Design: A Mechanistic Framework for Supra-Additive Extraneous Load in Persuasive Interfaces

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Digital interfaces capture attention through combinations of persuasive elements, yet no framework explains why those combinations produce supra-additive cognitive load or characterizes the magnitude of excess. This study integrates three independently validated theories into a mechanistic account of that compounding. Psychophysical summation frames interface elements as combined visual stimuli entering a nonlinear perceptual system, where responses are predicted to exceed additive contributions when design primitives function as non-independent stimulation inputs. Fogg's behavioral model characterizes these inputs as targeting distinct motivational, ability, and prompt components simultaneously, theorized to modulate a multiplicative behavioral function differentially by primitive. Cognitive load theory locates this pressure at the sensory-to-working memory transition, where stimulation is theorized to bypass conscious filtering, entering working memory as extraneous load reducing processing capacity and schema formation. A 24 full-factorial experiment varied four interface primitives (infinite scroll, autoplay, social proof, and notification badges) within a controlled prototype. Cognitive load operationalized via NASA-TLX and dual-task arithmetic response time demonstrated convergent validity (r=0.68). The control condition produced a mean NASA-TLX of 38.1 against 72.4 at maximum exposure, consistent with non-additive compounding. The autoplay-social proof interaction exceeded prediction by 1.34x (largest effect), supporting non-independent compounding (sampling toward N=480 ongoing). Results offer an empirical characterization of interface-driven cognitive cost, supplementing subjective accounts of addictive design with metrics legible to regulators and consumers.

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