A Comparative Study of The Fragmented Mind: Task-Switching, Notification Frequency, and Sustained Attention in Knowledge Workers

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Abstract

Contemporary knowledge work unfolds inside a near-continuous stream of digital interruptions, yet controlled comparisons of how different notification frequencies shape sustained attention remain scarce. The present study proposes and reports a between-groups comparative design testing how four levels of notification exposure (high-frequency/relevant, high-frequency/irrelevant, low-frequency, and a no-notification control) shape performance on a sustained-attention task among knowledge workers, and further examines trait mindfulness as an individual-difference moderator of this relationship. Drawing on attention residue theory (Leroy, 2009), the endogenous/exogenous interruption distinction from the smartphone-cognition literature (Canale et al., 2019), and field evidence that workplace interruptions recur roughly every eleven minutes and cost up to twenty-five minutes of recovery time (Mark et al., 2008), the study predicted a monotonic decline in attention performance as notification frequency rose, with the heaviest-notification group faring worst and the notification-free control group faring best. Sixty-four knowledge workers were randomly assigned across the four conditions while completing a 30-minute sustained attention to response task (SART) alongside a trait mindfulness measure. As predicted, both accuracy and reaction-time variability were poorest under high-frequency/relevant notifications and best under the no-notification control, with the remaining two conditions falling in between; task-irrelevant notifications produced smaller decrements than equally frequent task-relevant ones, and trait mindfulness buffered performance loss specifically under heavy interruption load. Together, these findings extend attention residue theory into a controlled comparative paradigm and point toward concrete levers, at both the organizational and individual level, for protecting focus in digitally saturated work environments. The reported results are illustrative, built to mirror the directional patterns the empirical literature consistently supports, and are offered as a template for researchers who wish to run this comparison with genuine participant data.

Keywords: notifications, task-switching, sustained attention, attention residue, trait Mindfulness, knowledge workers, comparative study

Introduction

Knowledge work, work that depends on sustained cognitive effort, judgment, and problem-solving rather than routine physical output, now unfolds largely inside digital environments crowded with competing demands for attention. Email, chat platforms, calendar alerts, and mobile notifications draw continuously on attentional resources that earlier generations of workers could devote to a single task without interruption. In a foundational field study, Mark, Gudith, and Klocke (2008) found that knowledge workers are interrupted roughly every eleven minutes and need as long as twenty-five minutes to fully regain their prior level of focus after such a disruption. More recent industry figures indicate the problem has only grown: workers now toggle between screens or applications hundreds of times daily, and a single interruption can now cost upward of twenty-three minutes of lost focus (University of California, Irvine, as cited in Institute of Organizational Science and Mindfulness [IOSM], 2025). Reports further suggest that many knowledge workers cycle through nine or ten separate applications in a given day and that a sizable share never once experience thirty consecutive minutes of uninterrupted work (Cannelevate, 2025) — evidence that fragmentation has become less an occasional hazard than a default condition of digital-era work.

Two theoretical accounts underpin the comparison tested here. Attention residue theory (Leroy, 2009) holds that switching from an unfinished Task A to a new Task B leaves behind a residue of attention still tied to Task A, which then degrades performance on Task B; because interruptions triggered externally, as notifications are, arrive without any natural stopping point, they are thought to generate more residue than switches an individual initiates voluntarily. A second account, cognitive load theory, holds that every switch between tasks carries a measurable "switch cost", a burst of slower responding and more errors as the cognitive system disengages from one task set and reconfigures for the next (Pashler, 1994). When switching is frequent and unpredictable, as under a high-notification regime, these costs are theorized to accumulate across a work session into measurable mental fatigue (Kaplan & Berman, 2010). A further distinction, borrowed from research on smartphone-related cognitive interference, separates endogenous interruptions, self-generated drifts of attention toward one's phone driven by boredom or a craving for more engaging stimulation, from exogenous interruptions, attentional pulls triggered by an outside cue such as an incoming alert, a buzz, or a flash of light on a screen (Canale et al., 2019). This distinction is directly relevant here because notifications are inherently exogenous: even when a person never touches the device, the mere occurrence of a phone notification measurably disrupts performance on sustained-attention tasks (Canale et al., 2019; Stothart et al., 2015). Complementary "brain drain" findings show that a smartphone's passive presence nearby, with no notification at all, already draws down available working-memory and attentional capacity, implying that notification effects likely add to, rather than fully account for, the broader cognitive cost smartphones impose (Ward et al., 2017).

Field and laboratory evidence broadly converges with these theoretical claims. Frequent micro-switching under conditions of continuous partial attention has been linked to markedly higher error rates and weaker working-memory accuracy in controlled tracking studies (MIT Attention Lab, as cited in IOSM, 2025). Much of this evidence, however, comes from observational or self-report sources rather than experiments that directly manipulate notification frequency, a gap the present comparative design is intended to close.

Not every notification is equally disruptive. Notifications tied to a person's actual work, an incoming email, a Slack message about a live project, are expected to interfere more than notifications unrelated to work, since relevant content is more likely to provoke lingering rumination and a stronger urge to abandon the current task altogether, whereas irrelevant content, while still momentarily distracting, tends to be dismissed more easily. This reasoning is why the present design includes both a reduced-frequency group and a frequency-matched but content-irrelevant group, allowing frequency and relevance to be examined somewhat independently of one another.

Individual differences likely also shape how vulnerable a given person is to notification-driven distraction. Trait mindfulness, a stable disposition toward sustained, non-judgmental awareness of the present moment, has been found to weaken the pull that environmental smartphone cues exert on problematic checking behavior, with more mindful individuals showing less automatic vigilance toward their devices (Lu et al., 2019; Zhang & Wang, 2022). A related line of work shows that trait mindfulness dampens the connection between habitual social-media use at work and burnout (Charoensukmongkol, 2016). Together, this suggests any comparative test of notification frequency should ideally account for variation in trait mindfulness, since two employees facing an identical notification schedule may end up with quite different attentional outcomes depending on this trait.

The behavioral costs of switching attention between tasks rest on an identifiable neural foundation. Event-related fMRI work consistently shows that shifting from one task to another engages a fronto-parietal control network, spanning lateral prefrontal cortex, the inferior frontal junction, and intraparietal sulcus, that stays comparatively quiet during simple task repetition; this extra engagement reflects the top-down reconfiguration needed to drop one task set and stand up another (Dove et al., 2000; Braver et al., 2003). Individual variation in how strongly this network is functionally connected at rest has itself been linked to the size of a person's behavioral switch costs, implying that identical interruptions may impose different cognitive tolls on different people depending on their underlying control-network architecture (Yin et al., 2015). This neuroscientific work reinforces attention residue theory and cognitive load theory from a different angle, suggesting that notification-driven switching is not simply an inconvenience but a biologically grounded reconfiguration cost paid every time attention is redirected.

The Present Study

The present study used a between-groups comparative design to test how four levels of notification exposure shape sustained attention among knowledge workers, while also treating trait mindfulness as a potential individual-difference moderator of that relationship. Designs of this kind, in which separate groups each receive a different level of a manipulated variable and are then compared on a shared outcome, are well suited to isolating a variable's causal effect apart from the many confounds, differences in job role, workload, or baseline attentional capacity chief among them, that limit what purely correlational workplace research can establish.

Five hypotheses guided the study: (H1) participants in the high-frequency notification condition would show weaker sustained attention than participants in every other condition; (H2) attention performance would decline in a dose-dependent fashion as notification frequency rose; (H3) participants exposed to frequent but task-irrelevant notifications would outperform those exposed to equally frequent task-relevant notifications; (H4) the no-notification control group would outperform every notification-exposed group; and (H5) trait mindfulness would moderate the effect of notification condition on sustained attention, with more mindful participants showing smaller performance losses under high-frequency conditions than less mindful participants.

Method

Participants

Sixty-four adult knowledge workers (e.g., analysts, administrators, software developers, and consultants) were recruited from a mid-sized metropolitan labor market of halol city and randomly assigned to one of four conditions (n = 16 per group). Eligibility required current full-time knowledge-work employment, normal or corrected-to-normal vision, and regular use of a smartphone or desktop notification system in daily work. Participants were pre-screened and excluded for a self-reported diagnosis of attention-deficit/hyperactivity disorder to reduce unmeasured individual-difference variance unrelated to the experimental manipulation.

Design

The study used a between-groups comparative experimental design with one manipulated factor (notification condition: high-frequency/relevant, low-frequency/relevant, high-frequency/irrelevant, no-notification control) and one primary continuous outcome (sustained attention performance). This design allows direct comparison of group means across notification frequency (H1, H2, H4) and, via the high-frequency/irrelevant group, comparison of frequency versus content relevance (H3).

Materials and Measures

Sustained attention was measured using a 30-minute computerized Sustained Attention to Response Task (SART), a well-validated go/no-go paradigm in which participants respond to frequent "go" stimuli and withhold responses to infrequent "no-go" stimuli. Two indices were derived: response accuracy (percentage of correct go and no-go trials) and reaction-time variability (the within-person standard deviation of correct-trial reaction times), a common marker of attentional lapses. Perceived mental fatigue was additionally assessed post-task using a brief self-report visual analogue scale. Trait mindfulness was assessed prior to the task using a short-form version of the Mindful Attention Awareness Scale (MAAS), enabling participants to be classified into higher- and lower-trait-mindfulness subgroups via a median split for the planned moderation analysis (H5).

Procedure

After providing informed consent, participants completed the MAAS and a brief demographic questionnaire, then were seated at a standardized workstation and began the 30-minute SART. Depending on assigned condition, participants received simulated push notifications on a secondary device positioned within their peripheral vision: every 1 minute (high-frequency/relevant, containing simulated work-relevant content such as emails and calendar alerts), every 5 minutes (low-frequency/relevant), every 1 minute with content unrelated to work tasks (high-frequency/irrelevant, e.g., weather or general news alerts), or no notifications at all (control). Notifications were visible but participants were not required to respond to them, mirroring naturalistic workplace notification exposure in which many exogenous cues disrupt attention without requiring direct interaction with the device (Stothart et al., 2015). Following the task, participants completed the fatigue scale and were debriefed.
A brief pilot phase (n = 8, not included in the main analysis) preceded full data collection to confirm that the notification schedules were reliably delivered, that the secondary device's placement produced consistent peripheral visibility across participants, and that the 30-minute task duration was sufficient to produce a measurable vigilance decrement in the control condition, consistent with typical SART performance curves.

Analytic Approach

Group differences in accuracy, reaction-time variability, and self-reported fatigue were analyzed using one-way between-groups analysis of variance (ANOVA), with planned pairwise comparisons (Tukey HSD) conducted to test the specific directional hypotheses (H1–H4). Effect sizes are reported as eta-squared (η^2) for omnibus tests and Cohen's d for pairwise comparisons. To test H5, a 4 (notification condition) × 2 (trait mindfulness: higher vs. lower) between-groups factorial ANOVA was conducted on SART accuracy, with the interaction term used to evaluate whether trait mindfulness buffered the effect of notification condition.

Results

The results reported in this section are illustrative values constructed to match the directional pattern consistently reported in the empirical literature on notifications, task-switching, and sustained attention (e.g., Mark et al., 2008; Leroy, 2009; Pashler, 1994); they are presented as a template of how findings from this design would be reported, rather than as data collected from an actual completed sample, and should be replaced with real analyzed data before submission or publication.

A one-way ANOVA revealed a significant effect of notification condition on SART accuracy, $F(3, 60) = 12.16$, $p < .001$, $\eta^2 = .38$. Consistent with H1 and H4, planned comparisons indicated that the high-frequency/relevant group (M = 74.6%, SD = 7.2) performed significantly worse than the no-notification control group (M = 91.8%, SD = 4.9), $t(30) = 8.02$, $p < .001$, $d = 2.83$. The low-frequency/relevant group (M = 84.3%, SD = 6.0) and the high-frequency/irrelevant group (M = 80.5%, SD = 6.4) fell between these extremes, supporting a dose-dependent pattern consistent with H2.

Supporting H3, the high-frequency/irrelevant group outperformed the high-frequency/relevant group despite equivalent notification frequency, $t(30) = 2.41$, $p = .022$, $d = 0.85$, indicating that content relevance, not frequency alone, contributes independently to attentional disruption. Reaction-time variability showed the same ordinal pattern across groups, $F(3, 60) = 10.04$, $p < .001$, $\eta^2 = .33$, with the high-frequency/relevant group showing the greatest within-person variability (M = 203 ms, SD = 38) and the control group the least (M = 101 ms, SD = 24).

Self-reported mental fatigue mirrored the objective performance data, $F(3, 60) = 8.77$, $p < .001$, $\eta^2 = .30$, with the high-frequency/relevant group reporting the highest fatigue (M = 7.2 on a 10-point scale, SD = 1.3) and the control group the lowest (M = 2.8, SD = 1.1). Table 1 summarizes group means across all outcome measures.

Table 1

Group Means (and Standard Deviations) for Sustained Attention Outcomes by Notification Condition

Condition	SART Accuracy (%)	RT Variability (ms)	Fatigue (0–10)
High-frequency / relevant	74.6 (7.2)	203 (38)	7.2 (1.3)
High-frequency / irrelevant	80.5 (6.4)	179 (33)	6.1 (1.4)
Low-frequency / relevant	84.3 (6.0)	155 (29)	5.3 (1.4)
No-notification control	91.8 (4.9)	101 (24)	2.8 (1.1)

Note. Illustrative values constructed to match directionally consistent patterns reported in the empirical literature; not derived from an actually collected dataset. N = 16 per group.

Moderation by Trait Mindfulness

The 4 × 2 factorial ANOVA testing H5 revealed a significant main effect of trait mindfulness on SART accuracy, $F(1, 56) = 7.35$, $p = .009$, $\eta^2 = .12$, such that higher-trait-mindfulness participants outperformed lower-trait-mindfulness participants overall. This main effect was qualified by a significant Notification Condition × Trait Mindfulness interaction, $F(3, 56) = 4.62$, $p = .006$, $\eta^2 = .20$. Simple-effects decomposition indicated that the gap between higher- and lower-mindfulness participants was largest in the high-frequency/relevant condition (Ms = 79.1% vs. 69.8%, respectively) and negligible in the no-notification control condition (Ms = 92.4% vs. 91.1%), consistent with H5 and suggesting that trait mindfulness functions as a protective buffer specifically under conditions of high interruption load rather than uniformly across all conditions.

Discussion

This comparative study set out to test how four levels of notification exposure shape sustained attention among knowledge workers. The modeled pattern supported all five hypotheses: attention declined as notification frequency rose (H1, H2), the no-notification control group came out ahead of every notification-exposed group (H4), and notifications unrelated to work produced smaller performance losses than equally frequent work-relevant ones (H3). This pattern extends attention residue theory (Leroy, 2009) into a controlled comparative setting: because externally triggered switches have no natural stopping point, they appear to exact a greater cognitive toll than frequency alone would predict, especially when the interrupting content is work-relevant and therefore likely to trigger lingering task-related rumination as a person returns to what they were doing.

These findings carry clear implications for organizations. Field data already show that a single workplace interruption can cost up to twenty-five minutes of recovery time (Mark et al., 2008), and that many knowledge workers never get a full thirty uninterrupted minutes across an entire workday (Cannelevate, 2025). The comparative pattern reported here suggests that policies aimed at reducing notification frequency, particularly work-relevant interruptions during periods set aside for focused work, could meaningfully protect sustained attention, in line with evidence that protected no-meeting blocks are tied to measurable gains in completion rates and team satisfaction (Cannelevate, 2025).

The finding that irrelevant notifications caused less disruption than relevant ones at the same frequency (H3) is a distinctive contribution of this design relative to the largely correlational field literature, which has rarely manipulated content relevance independently of frequency. Practically, this implies that notification management should not treat every interruption as interchangeable: silencing or batching work-relevant channels, email and work chat in particular, during focused stretches may protect attention more effectively than a blanket notification blackout that also removes low-cost, easily ignored alerts.

The Role of Trait Mindfulness

The modeled moderation result (H5) points to trait mindfulness as a possible protective buffer against notification-driven attentional decline, one that matters most specifically when interruption load is high rather than across the board. This fits with prior work showing that trait mindfulness weakens the pull of environmental smartphone cues on checking behavior (Lu et al., 2019; Zhang & Wang, 2022) and softens the link between habitual digital engagement and workplace burnout (Charoensukmongkol, 2016). One plausible explanation is that people higher in trait mindfulness can register an interruption cue without their attention automatically snapping toward it, consistent with mindfulness research's broader emphasis on noticing present-moment stimuli without reacting to them. Should this pattern hold up under real data collection, it would suggest brief mindfulness training could complement organization-level notification policy, particularly for employees whose roles carry an unavoidably high interruption load.

Theoretical Implications

Assuming these modeled results were to be confirmed empirically, they would extend attention residue theory (Leroy, 2009) in two respects. First, directly comparing several frequency levels within one controlled design would supply experimental, rather than purely correlational, support for the dose-dependent character of attention residue, a relationship inferred until now largely from field survey data (Mark et al., 2008). Second, showing that content relevance affects outcomes independently of frequency would suggest the theory needs a relevance parameter alongside frequency and voluntariness, rather than treating every involuntary interruption as functionally equivalent. That refinement would also link attention residue theory more directly to the endogenous/exogenous distinction from the smartphone-cognition literature (Canale et al., 2019), a promising point of contact between two currently separate research traditions. It would likewise sit comfortably alongside neuroimaging evidence that task-switching engages a fronto-parietal control network whose activation, and whose resting-state connectivity strength, predicts the size of behavioral switch costs (Dove et al., 2000; Yin et al., 2015), giving the behavioral comparison reported here a plausible neural mechanism rather than leaving switch cost as a purely descriptive label.

Practical Implications

For organizations, this pattern of findings points to a layered set of practical levers. At the policy level, protecting focus blocks by suppressing work-relevant notifications specifically, rather than silencing every digital alert without distinction, may strike the best balance between preserving sustained attention and keeping the degree of low-cost connectivity many employees and employers are unwilling to give up entirely. That balance fits with field evidence that structural steps such as no-meeting blocks and clear norms around channel response times are tied to real gains in completion rates, output quality, and team satisfaction (Cannelevate, 2025). At the individual level, employees lower in trait mindfulness, who in this modeled dataset showed the sharpest performance drops under heavy interruption load, may stand to benefit disproportionately from brief mindfulness training or from concrete environmental supports, such as device-free zones during periods set aside for deep work.

Limitations

As presented, this paper reports illustrative rather than empirically collected results, and the specific means, standard deviations, and inferential statistics reported here are constructed to match literature-consistent directional patterns rather than derived from actual data collection; a genuine test of these hypotheses requires running the described protocol with a real sample. Beyond this, the proposed design itself has limitations that would apply to a real implementation: a 30-minute laboratory SART, however well validated, does not fully capture the extended, multi-hour attentional demands of a genuine knowledge-work day; the sample size ($n = 16$ per group; $n = 32$ per mindfulness subgroup for the moderation analysis) is adequate for detecting large effects but underpowered for smaller, more realistic real-world effect sizes; and the single-session design cannot capture cumulative, multi-day attention residue effects that field research suggests may compound over time (Cannelevate, 2025). The use of a median split to classify trait mindfulness, while common in applied comparative designs, discards continuous variance and is statistically less powerful than treating mindfulness as a continuous moderator in a regression-based framework; a real implementation should prefer the latter approach.

Future Directions

A genuine implementation of this design should recruit a larger, occupationally diverse sample, extend the task duration or use ecological momentary assessment across a full workday, and consider a longitudinal or crossover extension in which the same participants experience multiple notification conditions across separate sessions to control for individual differences in baseline attentional capacity. Future comparative work could also manipulate notification modality (visual vs. auditory vs. haptic), test whether brief mindfulness-based training causally reduces notification-driven attentional decline rather than merely correlating with it, and examine whether other self-regulatory individual differences, such as self-reported smartphone dependency or attentional impulsivity, similarly moderate vulnerability to notification-driven attentional decline (Zhang & Wang, 2022).

Conclusion

This study modeled a controlled comparative test of how notification frequency and content relevance jointly affect sustained attention in knowledge workers, finding a dose-dependent pattern of attentional degradation consistent with attention residue theory and existing field research. Pending replication with real collected data, the pattern suggests that both reducing notification frequency and prioritizing which notifications are relevant to ongoing work may be independently useful levers for protecting sustained attention in digitally saturated knowledge-work environments.

References

1. Braver, T. S., Reynolds, J. R., & Donaldson, D. I. (2003). Neural mechanisms of transient and sustained cognitive control during task switching. Neuron, 39(4), 713–726.
2. Canale, N., Vieno, A., Doro, M., Rosa Mineo, E., Marino, C., & Billieux, J. (2019). Emotion-related impulsivity moderates the cognitive interference effect of smartphone availability on working memory. Scientific Reports, 9, Article 18519.
3. Cannelevate. (2025). How context switching reduces workplace productivity [Report]. Cannelevate.
4. Charoensukmongkol, P. (2016). Mindful Facebooking: The moderating role of mindfulness on the relationship between social media use intensity at work and burnout. Journal of Health Psychology, 21(9), 1966–1980.
5. Dove, A., Pollmann, S., Schubert, T., Wiggins, C. J., & von Cramon, D. Y. (2000). Prefrontal cortex activation in task switching: An event-related fMRI study. Cognitive Brain Research, 9(1), 103–109.
6. Institute of Organizational Science and Mindfulness. (2025). Attention is today's productivity gap: What the new science says.
7. Kaplan, S., & Berman, M. G. (2010). Directed attention as a common resource for executive functioning and self-regulation. Perspectives on Psychological Science, 5(1), 43–57.
8. Leroy, S. (2009). Why is it so hard to do my work? The challenge of attention residue when switching between work tasks. Organizational Behavior and Human Decision Processes, 109(2), 168–181.

9. Lu, X., Zhang, R., & Wu, W. (2019). Trait mindfulness and problematic smartphone use. Personality and Individual Differences, 145, 33–37.
10. Mark, G., Gudith, D., & Klocke, U. (2008). The cost of interrupted work: More speed and stress. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 107–110.
11. Pashler, H. (1994). Dual-task interference in simple tasks: Data and theory. Psychological Bulletin, 116(2), 220–244.
12. PsychUniverse. (2025). The cognitive cost of notifications and 5 important strategies to reclaim attention.
13. Rosen, L. D., Carrier, L. M., & Cheever, N. A. (2013). Facebook and texting made me do it: Media-induced task-switching while studying. Computers in Human Behavior, 29(3), 948–958.
14. Stothart, C., Mitchum, A., & Yehnert, C. (2015). The attentional cost of receiving a cell phone notification. Journal of Experimental Psychology: Human Perception and Performance, 41(4), 893–897.
15. Ward, A. F., Duke, K., Gneezy, A., & Bos, M. W. (2017). Brain drain: The mere presence of one's own smartphone reduces available cognitive capacity. Journal of the Association for Consumer Research, 2(2), 140–154.
16. Yin, S., Bi, T., Chen, A., & Egner, T. (2015). Task-switching cost and intrinsic functional connectivity in the human brain: Toward understanding individual differences in cognitive flexibility. PLOS ONE, 10(12), Article e0145826.
17. Zhang, J., & Wang, E. (2022). Indulging in smartphones in times of stress: A moderated mediation model of experiential avoidance and trait mindfulness. Behavioral Sciences, 12(12), Article 485.