

# **ATTENTION REGULATION IN DIGITAL CONTEXTS: FLOW DIMENSIONS AS PATHWAYS TO MINDFULNESS AND BOREDOM PRONENESS**

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## **Abstract**

Contemporary scholarship has focused more and more on the dynamic between regulatory mechanisms of attention, engagement, and utilisation of digital media. However, a definitive synthesis to understand the relationship between proneness to boredom, experiential flow, and dispositional mindfulness across the lifespan of habitual usage of technologies remains elusive. The current cross-sectional study has investigated direct and indirect relationships between boredom proneness, the eight canonical dimensions of flow, trait mindfulness, and two separate indices of technology use (smartphone and social media) in a sample of 480 adults. Data were collected through standardised psychometric instruments and structural equation modelling was used for data analysis.

The results challenged the current theoretical-conceptual models by showing a positive correlation between boredom proneness and the trait mindfulness ( $r = .311, p < .001$ ). Path analytic results showed that two particular flow dimensions - action-awareness and time-transformation - explained 16.8 percent of variance in openness to flow experiences. Furthermore, mindfulness was found to be a positive predictor of internal and external boredom proneness, which indicates that the temporal and awareness-based aspects of flow play a substantial role in predicting boredom through indirect mechanisms. Conversely, goal oriented dimensions of flow like clear goals and a sense of control had modest negative effects on mindfulness, presumably because of the emphasis they place on performance as opposed to pure awareness.

Surprisingly, there was no significant association between boredom or mindfulness and technology use, which contrasts with frameworks that assume digital devices are major compensatory mechanisms. While internal boredom proneness was found to be broadly associated with all dimensions of flow, external boredom was selectively associated with

awareness and time-transformation. These results hint at a subtle view on digital attention: frequent flow experiences might lead to increased mindfulness levels, but increased mindfulness might also result in a complete overstimulation on an individual's sensitivity towards environmental under-stimulation. The study ends with discussions of the implications of these findings for the theoretical and practical approaches to strategies targeting digital well-being.

**Keywords:** *boredom proneness, flow experience, mindfulness, digital engagement, path analysis, attention regulation*

## Introduction

Boredom represents a complex and frequently paradoxical concept within the modern psychology. It is generally defined as a state of weariness that occurs when insufficient engagement with stimuli present in the environment occurs (Vanden Bos, 2007). Situated at the extreme of a continuum that includes the states of absorption, interest, and purposeful involvement, boredom is nevertheless, remarkably, permeating. Sundberg (1994) has suggested that boredom is felt not in lack of stimulation, but in subjective inability to see available stimulation as meaningful or interesting. Similarly, Fisher (1993) also located boredom as a part of the regulatory domain, treating it as an outcome when an increase of directed attentional effort is required by a task in which there is no intrinsic reward. Consequently, boredom proneness has been conceptualised as the tendency to experience such states frequently and intensely with implications beyond discomfort to predict academic underachievement, absenteeism and dropout (Goetz et al., 2013; Wegner et al., 2008). It is regularly linked to poor psychological and physical health outcomes (Sommers & Vodanovich, 2000). With the near universal use of digital devices, boredom has also been implicated as a proximal cause of problematic smartphone and social media use (Elhai et al., 2018; Wolniewicz et al., 2020).

Despite this, boredom is not a unitary construct. Farmer and Sundberg (1986) made a distinction between an internal dimension, which was defined as endogenous difficulty in generating or maintaining self-directed mental engagement, and the external dimension, defined as the attribution of monotony to the surrounding environment. These subtypes have different implications in terms of thinking, emotional control and behaviour. A study of undergraduate students of a north Indian university showed the Arts students to score significantly higher than Commerce students on overall boredom proneness and its internal and external subscales (Parthi & Gupta, 2017a). Arts students had more academic boredom and were better at mood labeling. Mood-labelling refers to the capacity to accurately label one's emotional states, and was found to be negatively related to boredom proneness, adding to the argument of Swinkels and Giuliano (1995) that both boredom and mood awareness are based on attentional self-regulation. The systematic distinctions among the academically different streams indicate that the internal-external distinction has behavioural and educational meaning and is not merely a manifestation of general negative affect. Tam et al. (2021) further stated that the individual differences in boredom proneness are a product of both endogenous regulatory capacity and exogenous environmental fitness, thus emphasizing the need to investigate these two dimensions simultaneously.

### ***Cognitive Failure and Boredom***

Boredom proneness can create a negative impact on everyday thinking ability. Broadbent, et al (1982) coined the term "cognitive failures" to describe small but disruptive breaks in perception, memory and motor sequencing. Although seemingly trivial, such errors have the potential to lead to non-optimal flow of normal goal-directed action resulting in inaccurate outcomes, which in turn compound to impact performance, safety, and self-regulatory confidence. Parthi and Gupta (2017b) identified three dimensions of state boredom viz. inattention ( $\beta = .483$ ,  $t = 2.58$ ,  $p < .01$ ), dysphoric affect ( $\beta = .443$ ,  $t = 2.02$ ,  $p < .05$ ), and time perception ( $\beta = .483$ ,  $t = 2.58$ ,  $p < .01$ ) as significant independent for cognitive failure proneness having variance approximately 14%. This is in accordance with attentional models

of boredom, which suggest that prolonged attention to unrewarding material imposes a demand regulatory capacity, which in turn, degrades the accuracy of cognitive operations in progress and leads to higher levels of error (Fisher, 1993; Hamilton et al., 1984).

### ***The Role of Mindfulness and Flow***

Mindfulness has been defined as the maintenance of an open, non-evaluative attention to present moment experiences (Brown & Ryan, 2003). It has been suggested that mindfulness is a natural protection factor against chronic boredom and the increase of digital consumption. Mechanistically, mindfulness is hypothesised to increase top down control of attention and increase tolerance for under stimulating conditions (Bishop et al., 2004). Paradoxically, more often than not, empirical evidence shows positive correlations rather than negative correlations between boredom proneness and trait mindfulness. There have been two non-mutually exclusive explanations. A motivational account proposes that boredom serves as an antecedent of heightened levels of mindfulness because chronic under stimulations encourage individuals to seek out attentional regulation strategies (Kiken et al., 2020). Alternatively, a perceptual sensitivity account argues that enhanced interoceptive awareness provides better calibrating mindful people compared to less mindful people with a superior capacity to detect and label under-stimulation. Good et al. (2024) similarly found that trait mindfulness increased rather than decreased the relationship between situational anxiety and loneliness during the Covid-19 crisis; their reasoning being that increasing present moment sensitivity resulted in increased awareness of aversive states. The same mechanism that makes us pay more attention to anxiety may make us pay more attention to boredom.

Flow is a construct introduced by Csikszentmihalyi (1990) to indicate a holistic experiential state of complete absorption which is a consequence of an optimal fit between perceived competence and task demands. It provides a theoretically compelling antecedent of both mindfulness and boredom. Reid (2011) wrote flow and mindfulness represent phenomenologically adjacent modes of engaged presence with differences in structural composition: Both involve being present and absorbed in an activity, but flow involves the dissolution of the meta-cognitive layer, whereas mindfulness specifically involves the cultivation of the meta-cognitive layer. Compensatory Internet Use Theory (Kardefelt - Winther, 2014) predicts that constructs that reduce boredom should reduce technology use, yet Fendel et al. (2024) found contradictory results following a meta - analysis of 39 mindfulness intervention studies, with large effect sizes ( $g = -1.67$ ), low evidence quality, and

publication bias, making downstream effects of mindfulness on technology use empirically uncertain.

### ***Contextualizing Technology Use***

Meier and Reinecke (2021) noted that technology usage frequency is a poor proxy for its psychological importance, and there needs to be a movement toward more quality and purpose-based measures. This is especially pertinent for the present study because boredom-prone individuals might use smartphones mostly for structured or skill-based activities that produce flow; the positive flow-smartphone relationship reported in some studies may be adaptive in nature and not compensatory. Wilcockson et al. (2019) emphasised the diversity of smartphone activities, and called for differentiated measure between habitual, automatic checking behaviour, and purposive, engaged use.

### ***The Present Study***

Building upon this theoretical context, the present investigation utilizes path analysis to explore how dimensions of flow predict mindfulness, and how mindfulness, in turn, mediates the relationship between flow and boredom. The study also examines how both and mindfulness predict technology use through two parallel models *viz.* internal vs. external boredom

The research focuses on three key questions:

- How do internal and external boredom differ in their relationships with mindfulness and dispositional flow?
- Which dimension of flow directly predicted mindfulness, and are there any indirect effects on boredom?
- To what extent do boredom and mindfulness predict technology use?

## **Method**

### ***Participants and Procedure***

A cross-sectional convenience sample of 480 college students were involved in the study from 2023 till 2024. To be eligible, the participants had to use both a smartphone and a social media platform regularly. All study subjects gave voluntary informed consent and were given information about their right to withdraw at any time without penalty. Missing data were

minimal ( $< 3\%$ ) and dealt with using list wise deletion for correlational analyses and maximum likelihood estimation for path models.

### ***Measures***

Boredom proneness was measured by means of the Boredom Proneness Scale (BPS; Farmer and Sundberg, 1986), a 28-item scale that produces two 14-item subscales. The internal subscale measures difficulty in maintaining self-regulated attentional engagement; the external subscale measures perceived monotony of the environment. Items are rated on a 7-point Likert scale, with a two-factor structure being replicated from diverse samples (Struk et al., 2017; Parthi and Gupta, 2017; Vodanovich et al., 2005).

Trait mindfulness was assessed using the Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003), a 15 - item unidimensional measure of dispositional attention to and awareness of present moment experience. Respondents rate their activity of mindful versus automatic states on a six point scale. Increasing scores reflect increasing mindfulness. MacKillop and Anderson (2007) confirmed that items related to inattention and automatic functioning have the highest load, suggesting that the scale mostly measures the dispositional lack of mindfulness rather than the development of positive mindfulness.

Flow experience was assessed with the Dispositional Flow Scale - 2 (DFS - 2; Jackson & Eklund, 2002), for each of the 9 canonical flow dimensions - challenge - skill balance, action - awareness merging, clear goals, unambiguous feedback, concentration on the task at hand, sense of control, loss of self - consciousness, time transformation, and autotelic experience. Items were scored on a five-point Likert scale, with the higher the values the more dispositional experiencing of the specific dimension.

Technology use was indexed, using the Media and Technology Usage and Attitudes Scale (MTUAS; Rosen et al., 2013), the Smartphone Usage subscale (18 items) and the Social Media Usage subscale (8 items). Both subscales have been shown to have adequate reliability and criterion validity in previous studies (Rosen et al., 2013).

## **Results**

### ***Descriptive Statistics***

Table 1 gives means, SD, and distributional indices for all variables. Skewness value and kurtosis value are within acceptable range and parametric suitability is confirmed. The

sample also had moderate levels of both internal and external boredom proneness and moderate dispositional mindfulness, consistent with a non-clinical population. Flow dimensions were relatively balanced with slightly higher mean scores for autotelic experience as compared to time transformation. Technology usage patterns showed significantly greater overall use of smartphones relative to social media use as a reflection of the more general functional scope of smartphone use.

**Table 1: Descriptive Statistics for Study Variables (N=480)**

| Variable             | N   | Mean    | SD     | Skewness | Kurtosis | Minimum | Maximum |
|----------------------|-----|---------|--------|----------|----------|---------|---------|
| Internal             | 480 | 62.967  | 8.704  | -.040    | .488     | 34.00   | 89.00   |
| External             | 480 | 59.790  | 10.119 | -.191    | -.059    | 26.00   | 89.00   |
| Total Boredom        | 480 | 122.76  | 16.45  | -.31     | .54      | 62.00   | 178.00  |
| Smartphone           | 480 | 192.423 | 36.431 | .155     | 1.051    | 7.00    | 309.00  |
| Social Media         | 480 | 42.142  | 15.162 | .408     | 1.418    | 8.00    | 114.00  |
| Mindfulness          | 480 | 3.926   | 0.867  | .293     | .667     | 1.47    | 7.53    |
| Challenge            | 480 | 14.275  | 2.934  | -.305    | -.355    | 6.00    | 21.00   |
| Awareness            | 480 | 13.225  | 2.617  | .066     | .068     | 5.00    | 20.00   |
| Clear goals          | 480 | 14.323  | 3.080  | -.283    | -.201    | 4.00    | 20.00   |
| Unambiguous feedback | 480 | 14.181  | 2.780  | -.230    | -.072    | 5.00    | 20.00   |
| Concentration        | 480 | 13.823  | 2.741  | -.054    | -.114    | 5.00    | 20.00   |
| Control              | 480 | 13.608  | 2.939  | -.074    | -.350    | 5.00    | 20.00   |
| Consciousness        | 480 | 13.285  | 3.034  | -.274    | .137     | 4.00    | 20.00   |
| Time                 | 480 | 13.254  | 2.553  | -.016    | .143     | 6.00    | 20.00   |
| Autotelic            | 480 | 14.854  | 2.847  | -.108    | -.528    | 7.00    | 20.00   |

### ***Correlation Analysis***

Several theoretically meaningful patterns emerged from the correlational analysis as can be observed in Table 2. Correlational analyses showed significant positive correlations between all three dimensions of boredom proneness with the trait of mindfulness: internal boredom,  $r=.242$ ,  $p<.001$ , external boredom,  $r=.298$ ,  $p<.001$  and total boredom,  $r=.311$ ,  $p<.001$ . These modest coefficients were statistically robust and in the same direction of effect in dimensions of boredom.

Internal boredom was positively and significantly related to all the nine dimensions of flow including a balance of challenge and skill level ( $r = .230$ ,  $p < .001$ ), merging of action and awareness ( $r = .101$ ,  $p = .027$ ), presence of clear goals ( $r = .145$ ,  $p = .001$ ), presence of

unambiguous feedback ( $r = .158$ ,  $p = .001$ ), concentration ( $r = .169$ ,  $p < .001$ ), feeling of control ( $r = .183$ ,  $p < .0$ ). External boredom was significantly associated only with action-awareness merging ( $r = .129$ ,  $p = .005$ ), and time transformation ( $r = .168$ ,  $p < .001$ ), with all other associations between negligible and near-zero ( $r = -.043$  to  $.076$ , all  $p < .09$ ).

**Table 2 :Pearson Correlation Among Study Variables (N=480)**

| Variable                | 1      | 2      | 3      | 4      | 5      | 6      | 7      | 8      | 9      | 10     | 11     | 12     | 13     | 14     | 15 |
|-------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----|
| 1. Internal             | -      |        |        |        |        |        |        |        |        |        |        |        |        |        |    |
| 2. External             | .525** | -      |        |        |        |        |        |        |        |        |        |        |        |        |    |
| 3. Total Boredom        | .852** | .893** | -      |        |        |        |        |        |        |        |        |        |        |        |    |
| 4. Mindfulness          | .242** | .298** | .311** | -      |        |        |        |        |        |        |        |        |        |        |    |
| 5. Challenge            | .230** | .076   | .169** | .091*  | -      |        |        |        |        |        |        |        |        |        |    |
| 6. Awareness            | .101*  | .129** | .133** | .315** | .354** | -      |        |        |        |        |        |        |        |        |    |
| 7. Clear goals          | .145** | -.043  | .050   | -.017  | .533** | .243** | -      |        |        |        |        |        |        |        |    |
| 8. Unambiguous feedback | .158** | .005   | .087   | .070   | .546** | .365** | .608** | -      |        |        |        |        |        |        |    |
| 9. Concentration        | .169** | .024   | .104*  | .030   | .509** | .296** | .593** | .587** | -      |        |        |        |        |        |    |
| 10. Control             | .183** | -.010  | .091*  | .017   | .516** | .281** | .572** | .633** | .619** | -      |        |        |        |        |    |
| 11. Consciousness       | .106*  | -.003  | .054   | .096*  | .286** | .290** | .378** | .424** | .409** | .400** | -      |        |        |        |    |
| 12. Time                | .167** | .168** | .192** | .295** | .356** | .338** | .213** | .241** | .341** | .320** | .284** | -      |        |        |    |
| 13. Autotelic           | .144** | .010   | .082   | .070   | .583** | .316** | .506** | .538** | .507** | .487** | .399** | .236** | -      |        |    |
| 14. Smartphone          | .133** | .016   | .080   | .161** | .297** | .310** | .359** | .324** | .365** | .379** | .337** | .245** | .326** | -      |    |
| 15. Social Media        | .099*  | .011   | .059   | .152** | .068   | .117*  | .056   | .041   | .065   | .111*  | .106*  | .103*  | .062   | .536** | -  |

Values are Pearson's  $r$ . \* $p < .05$ . \*\* $p < .01$  (two-tailed)

Mindfulness was most correlated with the two factors of action-awareness merging ( $r = .315$ ,  $p = .005$ ) and time transformation ( $r = .168$ ,  $p < .001$ ). Smaller significant associations were apparent for challenge-skill balance ( $r = 0.091$ ,  $p = .047$ ) and loss of self-consciousness ( $r = 0.096$ ,  $p = .036$ ). Correlations with clear goals ( $r = -0.017$ ), unambiguous feedback ( $r = .070$ ), concentration ( $r = .030$ ), sense of control ( $r = .017$ ), and autotelic experience ( $r = .070$ ) were not significant.

Internal boredom was found to be positively related to smartphone ( $r = .133$ ,  $p = .003$ ) and social media ( $r = .099$ ,  $p = .029$ ) use. External boredom had negligible associations with both measures of technology (smartphone:  $r = .016$ ,  $p = .731$ ; social media:  $r = .011$ ,  $p = .814$ ). Mindfulness was significantly associated with both smartphone use ( $r = .161$ ,  $p < .001$ ) and social media use ( $r = .152$ ,  $p = .001$ ). Flow dimensions showed a greater level of correlation

with smartphone use ( $r = .245$  to  $.379$ , all  $p < .001$ ). Significant associations were found between social media use and only a few dimensions of flow: action-awareness merging ( $r = .117$ ,  $p = .010$ ), sense of control ( $r = .111$ ,  $p = .015$ ), loss of self-consciousness ( $r = .106$ ,  $p = .021$ ) and time transformation ( $r = .103$ ,  $p = .024$ ).

#### ***Path Analysis: Internal Boredom Model***

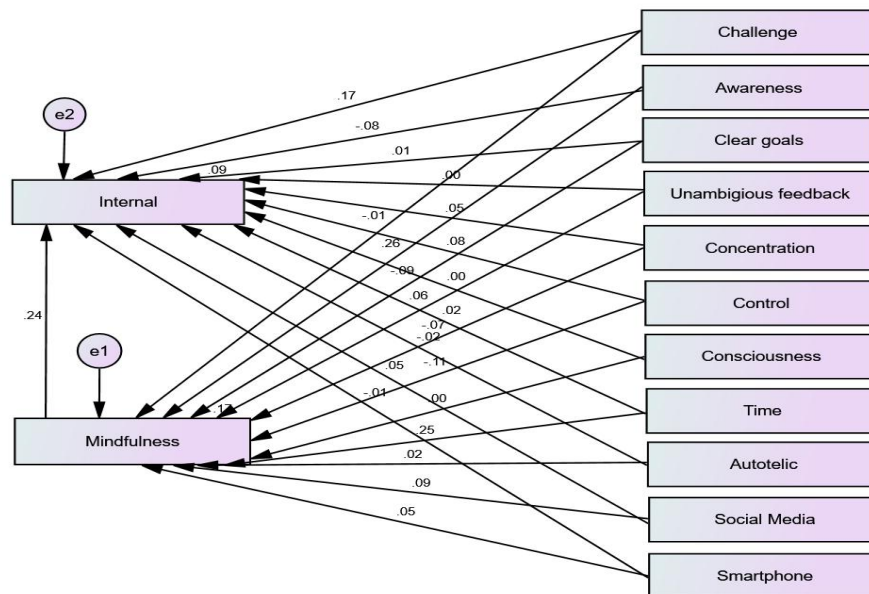
Action awareness merging was the strongest direct predictor of mindfulness ( $\beta = .255$ ,  $p < .001$ ) closely followed by time transformation ( $\beta = .252$ ,  $p < .001$ ). Two other dimensions had significant negative direct impacts on mindfulness, namely sense of control ( $\beta = -.107$ ,  $p = .010$ ) and clear goals ( $\beta = -.090$ ,  $p = .032$ ). Social media use also had a small but significant positive direct effect on mindfulness ( $\beta = .087$ ,  $p = .037$ ); smartphone use did not ( $\beta = .053$ ,  $p = .203$ ). No other flow dimension was significant when modelled at the same time as the other predictors (see Table 3).

**Table 3: Structural Effects in the Internal and External Boredom Mediation Models**

| Outcome variable        | Predictor variable | B     | $\beta$ | t        | LLCI  | ULCI  |
|-------------------------|--------------------|-------|---------|----------|-------|-------|
| <b>Internal boredom</b> | Challenge          | .503  | .172    | 3.947*** | .254  | .752  |
|                         | Mindfulness        | 2.371 | .238    | 4.992*** | 1.440 | 3.302 |
| <b>External boredom</b> | Time               | .351  | .088    | 1.976*   | .004  | .698  |
|                         | Mindfulness        | 3.092 | .263    | 5.572*** | 2.004 | 4.180 |
| <b>Mindfulness</b>      | Awareness          | .084  | .014    | 6.123*** | .057  | .111  |
|                         | Time               | .085  | .014    | 6.049*** | .058  | .112  |
|                         | Control            | -.032 | .012    | -2.576** | -.055 | -.009 |
|                         | Clear goals        | -.025 | .012    | -2.150*  | -.048 | -.002 |
|                         | Social media       | .005  | .002    | 2.088*   | .000  | .009  |

**Note.** B = unstandardized coefficient;  $\beta$  = standardized coefficient

**Figure 1: Structural Equation Model Depicting the Mediation Pathways Predicting Internal Boredom**



Within the internal boredom equation, mindfulness was the most positive predictor (beta= .238,  $p < .001$ ). Challenge-skill balance, as the only other direct significant predictor (beta= .172,  $p < .001$ ). No other flow dimension, nor either technology, as a direct predictor of internal boredom, was of significance in the multivariate context.

Action-awareness merging had an important positive indirect effect on internal boredom through mindfulness (standardised indirect effect =.061,  $p=.009$ ). Time transformation showed an equivalent indirect effect (beta= .060;  $p=.009$ ). Sense of control had a negative indirect relationship with internal boredom via mindfulness (standardised indirect effect = -0.026,  $p = .058$ ). With regard to total effects only challenge-skill balance was significant (standardised total effect=0.169,  $p=0.026$ ). There were no significant total or indirect effects of internal boredom or mindfulness on technology use. The explained variance of the endogenous variables in both models is presented in Table 4.

**Table 4: Explained Variance of Endogenous Variables**

| Outcome     | R <sup>2</sup> |
|-------------|----------------|
| Mindfulness | .168           |
| Internal    | .092           |
| External    | .113           |

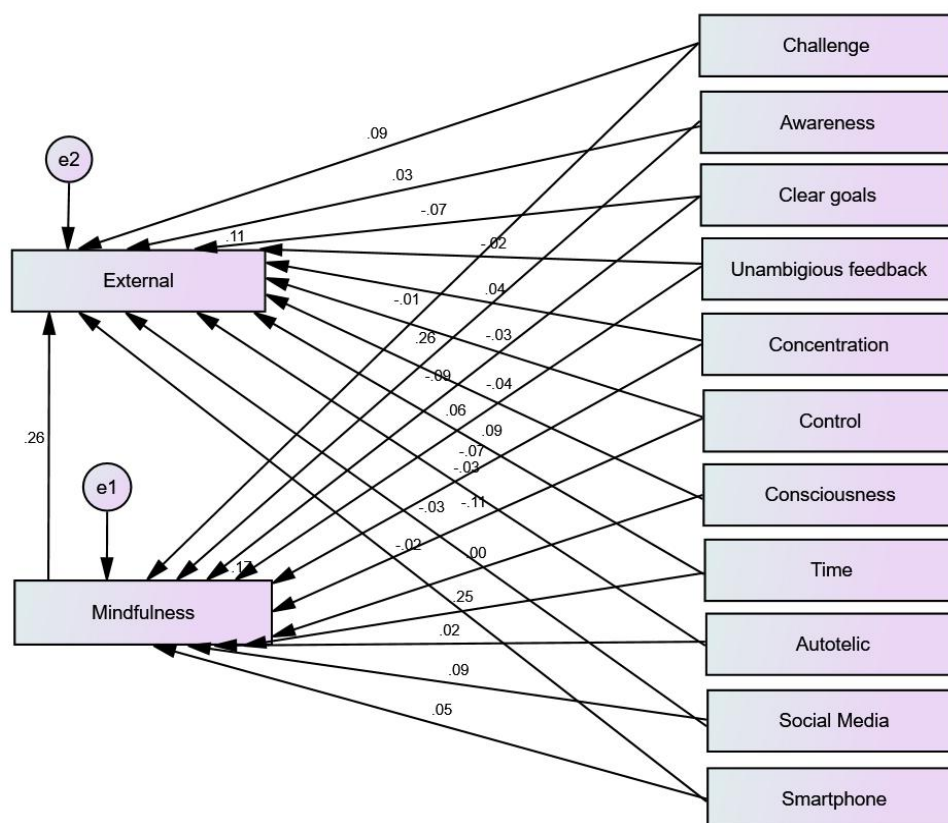
#### *Path Analysis: External Boredom Model*

Action awareness merging was the strongest direct predictor of mindfulness ( $\beta = .255$ ,  $p < .001$ ) closely followed by time transformation ( $\beta = .252$ ,  $p < .001$ ). Two other dimensions had significant negative direct impacts on mindfulness, namely sense of control ( $\beta = -.107$ ,  $p = .010$ ) and clear goals ( $\beta = -.090$ ,  $p = .032$ ). Social media use also had a small but significant positive direct effect on mindfulness ( $\beta = 0.087$ ,  $p = .037$ ); smartphone use did not ( $\beta = 0.053$ ,  $p = .203$ ). No other flow dimension was significant when modelled at the same time as the other predictors.

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**Figure 2: Structural Equation Model Depicting the Mediation Pathways Predicting External Boredom**



## Discussion

The current study investigated the topic of attention regulation in digital environments by using path analysis to explain the relationships among internal and external boredom proneness, trait mindfulness, nine flow dimensions, and two indices of technology use in a sample of 480 college students. The findings deviate from basic assumptions on a number of fronts and are in favor of a reoriented theoretical account. Specifically, experiential involvement in flow-inducing activities seem to increase mindfulness over time; however, the resultant mindfulness might increase rather than decrease awareness of under-stimulation. The following section breaks down each of these findings in detail.

### *Positive Boredom-Mindfulness Association*

The correlation of  $r=311$ ,  $p<.001$ , between total boredom proneness and trait mindfulness is the most salient finding. It contradicts current theoretical models that should see mindfulness increase present moment tolerance and reduce boredom frequency and intensity (Li, 2025). The positive association observed, which was robust in both subscales, indicates that people who report greater boredom proneness also report greater dispositional mindfulness.

Path analysis clarifies the directionality: mindfulness positively predicts both internal ( $\beta = .238$ ) and external ( $\beta = .263$ ) boredom proneness even after controlling for flow dimensions. Two explanations can be put forward to explain this pattern. First, a motivational account suggests that chronic under-stimulation encourages individuals to develop mindfulness as a regulatory resource, meaning that boredom comes before the development of mindfulness. Second, a perceptual sensitivity account suggests that by having an increased interoceptive awareness, mindful people better recognize and refer to under-stimulation, which has been shown to be associated with mindfulness and an increased present-moment awareness of aversive states (Good et al., 2024). Both explanations have very interesting practical consequences for designing interventions.

### ***Flow Dimensions as Antecedents of Mindfulness***

The most structurally novel result is that action-awareness and time-transformation dimensions of dispositional flow are the strongest direct antecedents of trait mindfulness, which jointly account for 16.8% variance of trait mindfulness. This is a reversal of conventional ordering of causes. In his article in the 120th journal of Psychology of General and Physiological Psychology, Reid (2011) suggested that both action-awareness and time-transformation involve the dissolution of self-referential mental activity; repeated practice of these states may train the attentional system in a present-focused, non-self-referential awareness similar to mindfulness. Neuroimaging evidence (Huskey et al., 2021) provides further support for overlap between neural substrates that underlie intrinsic reward during flow and those underlying processes of attention regulation related to mindfulness.

Negative direct effects of sense of control ( $\beta = -0.107$ ) and clear goals ( $\beta = -0.090$ ) on mindfulness highlight the theoretical tension between performance-oriented flow dimensions and the non-evaluative nature of mindfulness (Sheldon et al, 2015). These results indicate that absorptive, present-centered aspects of flow support mindfulness, while aspects that are goal-oriented may hinder development of mindfulness.

### ***Differential Profiles for Internal and External Boredom***

The unique correlation profiles of internal and external boredom are consistent with the conceptual attentional characteristics. The internal boredom correlated positively with all the flow dimensions while the external boredom showed correlation only with the action-awareness merging and time transformation. This pattern is consistent with the proposal made

by Danckert (2018) that internal boredom is an indicator of chronic difficulties in self-regulation, whereby individuals are sensitive to features in their environment that promote stimulation. External boredom, selective for immersive absorption, is an indication of a preference for vivid engagements over structured goal-oriented experiences.

In the path models, both the dimensions of boredom showed similar indirect effects via mindfulness mediated by action-awareness merging and time transformation. This convergence could be a reflection of multi-collinearity of the flow predictors. The slightly higher  $R^2$  for external boredom (11.3%) suggests a better measurement capacity of activity variables to measure environmental sources of boredom than the internal self-regulatory difficulties underlying internal boredom ( $R^2 = 9.2$ ).

### ***The Null Effects on Technology Use: Theoretical Recalibration***

The lack of significant direct and indirect effects of boredom dimensions on technology use and mindfulness on technology use was unexpected. While bivariate correlations showed positive associations between internal boredom and smartphone use ( $r = .133$ ) and mindfulness and smartphone use ( $r = .161$ ), these associations disappeared in the multivariate analyses that controlled for flow dimensions and other variables. This pattern means, evidenced associations at the trait level may be due to shared variance with third variables rather than causal pathways. Potential explanations include the state versus trait level of influence of boredom on momentary digital media switching (Johannes et al., 2021) versus weaker trait level effects on overall usage. Moreover, compensation mechanisms might operate at an instance level, that are not manifested at the trait level.

Additionally, Fendel et al. (2024) noted that there were large mean effect sizes for mindfulness interventions on problematic internet use, but low evidence quality and publication bias warned against generalising these results. Our null results suggest that the effects of mindfulness-based interventions on technology use may be mediated by other mechanisms than by decreasing trait boredom, such as increasing metacognitive awareness of habitual checking or increasing self-regulatory control.

### **Limitations and Future Directions**

The cross section design which limits causal inference; path models, although based on theory, are compatible with bidirectional reciprocity. Longitudinal or experimental designs with manipulation of flow or mindfulness would be required to make directional claims. Self

report measures are subject to bias, particularly in the case of mindfulness and technology utilisation. The positively valenced items of the MAAS may produce socially desirable reactions, which biases variance at the high end. Objective logging through screen time APIs combined with experience sampling protocols on the state of momentary boredom and flow would provide more accurate estimates. Finally, modest explained variances (16.8% for mindfulness, 9.2% and 11.3% for internal and external boredom, respectively) suggest that there are additional covariates (personality traits, executive function, contextual demands of life) that are not accounted for.

## Conclusion

This investigation presented a path analytic model of attention regulation in digital contexts that challenges current theoretical assumptions. The results suggest that specific flow dimensions, especially action awareness and time transformation, are a function of upstream antecedents of trait mindfulness in that they promote greater present-moment awareness through repetitive absorptive engagement. The positive relation between boredom proneness and mindfulness through these flow dimensions discovers an indirect relationship, perhaps reflecting either motivational consequence of chronic under-stimulation or perceptual sensitivity associated with dispositional mindfulness.

Importantly, the continued lack of significant effects of boredom and mindfulness on technology use discredits simplified accounts of the compensatory effects of technology use. Future research should consider momentary processes and qualitative differences in use in place of overall frequency. Practically, interventions that focus on improving digital well-being should focus on opportunities for absorptive, flow-inducing activities in the workplace, leisure and educational settings, which may be a more ecologically-valid route to improving mindfulness and attentional regulation than formal meditation programmes alone.

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### **Ethical Approval**

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institution.

### **Informed Consent**

Informed consent was obtained from all individual participants included in the study. Participants were informed of their right to withdraw from the research at any time without penalty.

### **Use of AI and AI-Assisted Technologies**

During the preparation of this work, the authors used Consensus and Semantic Scholar in order to perform a comprehensive literature search and identify relevant academic citations. Grammarly was used to provide grammar, spelling, and punctuation checks to improve the readability of the text. After using these tools, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

### **Data Availability Statement**

*Type 1: Data available on request*

The datasets generated during and/or analyzed during the current study are not publicly available due to the privacy and confidentiality agreements established during the informed consent process. However, the data are available from the corresponding author on reasonable request.