Facets of a Wandering Mind: A Meta-Analysis of Task-Related Interference and Learning

Authors: Daniel Ebbert, Andrew Zamecnik, Natasha Wilson, Srecko Joksimovic, Negin Mirriahi, and Shane Dawson

Abstract

During learning, learners experience both task-related and unrelated thoughts. While previous research has primarily focused on task-unrelated thoughts (TUT or mind wandering), off-task thoughts sometimes also have some connection to the task (task-related interference, TRI). This meta-analysis aimed to determine the occurrence of TRI and TUT combined these into an overall frequency of off-task thoughts, and examined their relationship with learning outcomes. The meta-analysis analysed 28 samples, employing meta-analysis of single means to determine frequency and a mixed-effects model to investigate correlations. Results show that TRI occurs 23% of the time and shows no correlation with learning outcomes. TUTs occur 29% of the time and negatively correlate with learning outcomes. An additional meta-analysis indicates that off-task thoughts collectively occur 51% of the time and are negatively correlated with learning outcomes. These results highlight the importance of considering TRI when studying off-task thoughts, as unlike TUTs, they do not appear to influence the learning process negatively. The result is that learners engage in off-task thoughts for 51% of their learning time, which has significant implications for educational practices.

Extended Summary

It is not uncommon for individuals to experience thoughts unrelated to their current task while learning. These off-task thoughts signify a shift in attention from the external task to an internal thought stream, which can hinder the processing of task-related information (Kam et al., 2011). The cascade model of inattention (Smallwood et al., 2007) suggests that this shift from external to internal focus disrupts the processing of pertinent information, thereby reducing learning effectiveness (Smallwood, 2011). However, the content of these off-task thoughts could influence whether they interfere with processing task-relevant information.

Off-task thoughts can be categorised into two distinct types: task-unrelated thoughts (TUTs or mind wandering), such as thinking about dinner or sports, and task-related interference (TRI), which involves thoughts related to evaluating the task (Smallwood et al., 2003, 2004). TRI represents a hybrid concept between task-related and task-unrelated thoughts (McVay & Kane, 2012; Welhaf et al., 2020), as the content of these thoughts is not directly related to the current task but maintains some level of relatedness. For instance, while studying mathematics, a learner might think about how to apply the newly acquired knowledge to their work.

Both TUTs and TRI have been the subject of prior research in educational settings. A recent meta-analysis by Wong et al. (2022) showed that TUTs occur approximately 30% of the time during learning, indicating that learners frequently engage in internal thought streams unrelated

to the task, thus disrupting the processing of task-relevant information. Two separate meta-analyses by Bonifacci et al. (2023) and Wong et al. (2022) confirmed the negative association between TUTs and learning outcomes, underscoring the detrimental impact of this internal thought stream on learning. While the negative influence of TUTs on learning outcomes has been established, the relationship between TRI and learning outcomes has not been extensively investigated.

This meta-analysis aims to determine the frequency of TRI, TUTs, and overall off-task thoughts during educational activities and assess their association with learning outcomes. We systematically searched for records examining TRI in an educational context to achieve this. Our search yielded a total of 2240 records from databases and previous meta-analyses. After removing duplicates, we screened 1069 titles and abstracts, resulting in the full-text screening of 104 records. Of these, 12 records met the inclusion criteria. An additional record was obtained through an open call for data. These 13 records encompassed data from 28 samples.

We conducted two meta-analyses for TRI, TUTs, and overall off-task thoughts. First, a meta-analysis of single means was performed to ascertain the frequency of occurrence of these thoughts. Second, a mixed-effects model meta-analysis was conducted to determine the correlation between these thought types and learning outcomes. The results indicated that TRI occurred 23.18% of the time, while TUTs occurred 29.14% of the time. The overarching category of off-task thoughts occurred 51.06% of the time. No significant correlation was found between TRI and learning outcomes ($\beta = 0.0255$, $p = 0.4316$). However, TUTs ($\beta = -0.3276$, $p < .0001$) and the overarching category of off-task thoughts ($\beta = -0.2301$, $p < .0001$) exhibited significant negative correlations with learning outcomes.

These findings underscore the importance of considering both TUTs and TRI when investigating off-task thoughts. Focusing solely on TUTs is insufficient, as TRI constitutes a substantial part of a student's learning experience. We encourage future researchers to measure TRI alongside TUTs in their studies. Finally, the results of our meta-analysis showed that off-task thoughts (TRI + TUTs) occur 51% of the time during learning and negatively impact learning outcomes. These findings have implications for educational practice, such as exploring effective learning designs or incorporating practices that support learners in self-identifying and responding to off-task thoughts.

References

Bonifacci, P., Viroli, C., Vassura, C., Colombini, E., & Desideri, L. (2023). The relationship between mind wandering and reading comprehension: A meta-analysis. Psychonomic Bulletin & Review, 30(1), 40–59. https://doi.org/10.3758/s13423-022-02141-w

Kam, J. W. Y., Dao, E., Farley, J., Fitzpatrick, K., Smallwood, J., Schooler, J. W., & Handy, T. C. (2011). Slow Fluctuations in Attentional Control of Sensory Cortex. Journal of Cognitive Neuroscience, 23(2), 460–470. https://doi.org/10.1162/jocn.2010.21443

McVay, J. C., & Kane, M. J. (2012). Why does working memory capacity predict variation in reading comprehension? On the influence of mind wandering and executive attention. Journal of Experimental Psychology: General, 141(2), 302–320. https://doi.org/10.1037/a0025250

Smallwood, J. (2011). Mind-wandering While Reading: Attentional Decoupling, Mindless Reading and the Cascade Model of Inattention. Language and Linguistics Compass, 5(2), 63–77. https://doi.org/10.1111/j.1749-818X.2010.00263.x

Smallwood, J., Davies, J. B., Heim, D., Finnigan, F., Sudberry, M., O'Connor, R., & Obonsawin, M. (2004). Subjective experience and the attentional lapse: Task engagement and disengagement during sustained attention. Consciousness and Cognition, 13(4), 657–690. https://doi.org/10.1016/j.concog.2004.06.003

Smallwood, J., Fishman, D. J., & Schooler, J. W. (2007). Counting the cost of an absent mind: Mind wandering as an underrecognised influence on educational performance. Psychonomic Bulletin & Review, 14(2), 230–236. https://doi.org/10.3758/BF03194057

Smallwood, J., Obonsawin, M., & Heim, D. (2003). Task unrelated thought: The role of distributed processing. Consciousness and Cognition, 12(2), 169–189. https://doi.org/10.1016/S1053-8100(02)00003-X

Welhaf, M. S., Smeekens, B. A., Gazzia, N. C., Perkins, J. B., Silvia, P. J., Meier, M. E., Kwapil, T. R., & Kane, M. J. (2020). An exploratory analysis of individual differences in mind wandering content and consistency. Psychology of Consciousness: Theory, Research, and Practice, 7(2), 103–125. https://doi.org/10.1037/cns0000180

Wong, A. Y., Smith, S. L., McGrath, C. A., Flynn, L. E., & Mills, C. (2022). Task-unrelated thought during educational activities: A meta-analysis of its occurrence and relationship with learning. Contemporary Educational Psychology, 71, 102098. https://doi.org/10.1016/j.cedpsych.2022.102098