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EDITORIAL

Emerging perspectives on distraction and task interruptions: metacognition, cognitive control and facilitation - part I

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Modern technology allows for the control of learning and work environments to an unprecedented degree. Therefore, the focus of research shifts from how learning and work performance are passively affected by environmental factors to how people actively shape their own learning and work experiences. This includes task-irrelevant stimuli and task interruptions. For instance, modern headphones allow one to switch between two modes: Active noise cancelling eliminates all background sounds while acoustic transparency allows certain signals to pass through the headphones, creating a customisable audio space. Modern devices also allow us to plan certain task interruptions (for example, by email alerts) in advance. This gives users unprecedented autonomy over their learning and work environments. However, increased control does not necessarily imply that these environments are free of distraction and interruptions. In fact, quite the opposite is true: Modern-day digital learning and work environments are full of distractions and interruptions. With users' increased control over their learning and work environments, new research questions arise that emphasise the active role of the individual in shaping their own learning and work experiences:

- Are people capable of distinguishing between harmful and helpful task-irrelevant stimuli and activities?
- Can the harmful aspects of distractions and interruptions be brought under cognitive control?
- Are distraction and task interruptions always harmful or are they sometimes helpful?

Within this Special Issue, we primarily focus on the following emerging trends in distraction and attention.

Metacognition

Modern technology gives us control over our environments, and this may imply that people have to make decisions about whether they accept, prevent or even actively create certain types of distraction and task interruptions. This leads to the question of whether people have metacognitive insight into the degree to which distraction and task interruptions have positive or negative effects on their cognitive performance. An emerging topic in auditory-distraction research is thus whether people can correctly assess the disruptive or helpful effects of task-irrelevant stimuli and activities on their performance and thereafter act upon these evaluations. The metacognition of auditory distraction is not yet fully understood, as findings currently paint a mixed picture of the degree to which people are metacognitively aware of the effects of distractions and interruptions (Ball et al., 2018; Beaman et al., 2014; Bell et al., 2022, 2023; Ellermeier & Zimmer, 1997; Hanczakowski

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et al., 2017, 2018; Kattner & Bryce, 2022; Röer et al., 2017b). While some studies indicate that people are well aware of the effects of changing auditory stimuli on their performance (Bell et al., 2022), others seem to indicate that they nevertheless fail to exert appropriate metacognitive control to combat distraction (Beaman et al., 2014; Hanczakowski et al., 2018; Kattner & Bryce, 2022). More research, especially basic, is needed to understand the underpinnings of distraction and how people metacognitively monitor the effects of distractions and interruptions on their performance.

Cognitive control

Linked to the question of the metacognitive monitoring of distraction is another, namely to what degree the realisation that distractions and interruptions hurt performance results in efforts to compensate for the negative performance effects of distractions and interruptions. Is it possible to counteract the negative effects of distractions and interruptions with increased cognitive control? In recent years this question has been the subject of considerable attention and debate (Bell et al., 2021b; Hughes et al., 2013; Körner et al., 2017; Marsh et al., 2015, 2020; Parmentier & Hebrero, 2013; Röer et al., 2015). More research is necessary to understand the inconsistent findings and to gain theoretical and practical insights into how unwanted effects of distractions and interruptions can be brought under cognitive control. In this context, basic research is required to gain theoretical insight and pave the way for a fuller practical insight to be gleaned from a more applied research approach.

Inhibition and facilitation

Acoustic alarms that alert us to important changes in the environment highlight that distraction is not a fault of the cognitive system. Instead, distraction has the important adaptive function of processing ignored information to such an extent that the cognitive system is able to respond to important changes in the environment, such as the sound of an approaching jaguar in evolutionary times or a supervisor's email in modern times. For decades, however, research has only focused on the negative aspects of distraction. Only recently, the positive aspects have come to light. Positive aspects of distraction have, as yet, been most exhaustively explored in relation to the semantic processing of the distractors. For example, the semantic processing of nominally task-irrelevant distractors can have immediate (Hanczakowski et al., 2017) and delayed (Richardson et al., 2023; Röer et al., 2017a) advantages on later tasks through semantic facilitation. Distraction and task interruptions can help to overcome cognitive blockades in creative problem solving (Ball et al., 2015) and increase creativity (Carpenter et al., 2020; Yang et al., 2022). Older adults, in particular, can benefit from an increased semantic processing of task-irrelevant information because of their broader attentional focus (Kim et al., 2007; Weeks & Hasher, 2014). Distraction could also help interrupt unwanted behaviours or unwanted cognitions (Lin & Wicker, 2007; Masuda et al., 2010), or can alert us to important changes in the auditory environment, which is relevant for the design of auditory alarms (e.g. Ljungberg & Parmentier, 2012; Schlesinger et al., 2018). Moreover, interrupting secondary tasks may be relevant for heightening vigilance decrements (Hockey, 2003). The foregoing offers the possibility of integrating planned interruptions into modern work processes to regenerate cognitive performance (e.g. Ariga & Lleras, 2011). However, important aspects remain unexplored. In order to be able to use distractions and interruptions in a targeted manner, more basic research is needed that focuses on the potential positive side effects of distraction and interruptions.

Emerging perspectives on distraction and task interruptions, Part 1: controllability versus automaticity

A noteworthy aspect of this Special Issue is that it will be published in three parts. Part 1 focuses broadly on the controllability versus automaticity of distraction. Within the auditory distraction research space there is some controversy in relation to whether phenomena of auditory distraction can be fractionated into those that result from non-controllable, automatic and preattentive processes (Jones et al., 1992; Jones & Tremblay, 2000) and controllable forms that result from the capture or diversion of attention away from the concurrent mental task (Hughes et al., 2005, 2007). For example, the duplex account (Hughes, 2014) proposes a differentiation between a variety of distraction that reflects the legacy of preattentive processing that is applied automatically to the auditory stream whose operation and effects (i.e. the distraction produced) are beyond the conscious inspection and cognitive

control of the individual, and a cognitively controllable form of distraction that occurs because a sound captures attention away from focal task processing. Due to the link with attentional processing, the duplex account proposes the disruption produced by the latter should be amenable to conscious awareness. While some previous research supports the duplex account by demonstrating dichotomies and dissociations in the effects produced by different auditory distractors (e.g. Campbell et al., 2007; Hughes et al., 2013; Hughes & Marsh, 2020; Marois et al., 2019, 2020; Marois & Vachon, 2023; Marsh et al., 2020; Sörqvist, 2010; Sörqvist et al., 2013), other studies have either failed to find evidence of such dichotomies or have observed that dissociations in cognitive control are often caused by external factors (Bell et al., 2010, 2021b, 2022; Körner et al., 2017; Röer et al., 2015), suggesting that the findings should be integrated within a unitary framework (Bell et al., 2021a). To resolve these key issues, it is essential to deepen our insights into auditory distraction, while also expanding the focus to include a wider range of associated sensory and cognitive phenomena.

In Part 1 of this Special Issue, we present eight articles that broaden the empirical foundation of theories on distraction by investigating internal and external distractions, different sensory modalities and populations.

Bell et al. (2024) examined the distracting effect of Mozart's music on immediate serial recall and found that Mozart's music consistently disrupted serial recall even though this disruptive effect decreased over time if the coherent presentation of the music in its original sequence facilitated developing a predictive model of the unfolding auditory input. Despite the robust distraction caused by Mozart's music on performance, participants who liked Mozart music retrospectively judged that it aided their performance when in fact the distracting effects of music were unrelated to the liking of the music, in line with a metacognitive illusion in people's judgements about the effects of music on performance (Bell et al., 2023).

Kattner et al. (2024) conducted a study on auditory distraction in blind, visually impaired and sighted individuals. Their findings provide evidence in favour of more efficient control over auditory distraction by certain types of speech in blind and visually impaired in comparison to sighted individuals. Furthermore, the study revealed that emotional prosody differentially modulated distraction across these groups. These differences among blind, visually impaired and sighted individuals may be attributed to a reorganisation of the auditory processing system as the result of prolonged visual deprivation, resulting in more efficient filtering of task-irrelevant auditory information.

Zhang et al. (2024) undertook a study investigating the controllability of disruption produced by emotive auditory distractors (i.e. negative and positive distractor words). Consistent with the notion that the disruption produced by emotive speech is amenable to cognitive control, the disruption produced by negative word distractors over neutral word distractors diminished across blocks of trials during the course of the experiment. Repeated exposure to negative distractors, but not to neutral distractors thus resulted in habituation. The findings are consistent with the notion that the disruption produced by emotive distractor words is underpinned by attentional shifts that can be tempered via cognitive control, but the acoustic effects (i.e. disruption produced by neutral distractor words) cannot be modulated by such control mechanisms.

Rettie et al. (2024) consider the disruption produced by taboo word distractors (profanities, vulgarities and sexual terms). Their study demonstrates that taboo word distractors produce disruption over and above that produced by valence against neutral word distractors, suggesting that the taboo-distractor effect is not simply a valence effect and is likely attributable to another property such as the offensiveness or arousal produced by taboo words. The study also revealed that the disruptive effect of taboo word distractors was eliminated by providing participants with foreknowledge but the effect of neutral word distractors was undiminished. This demonstrates that the taboo-distractor effect is underpinned by an attentional diversion mechanism that is amenable to cognitive control, and is qualitatively distinct from the disruption produced by the automatic processing of any acoustically-changing sound.

Marsh et al. (2024) report a disruptive effect of vibrotactile distractors. They demonstrate that a vibrotactile sequence that alternates between hands (i.e. right, left, right, left …) produces more disruption than when the sequence is delivered to one hand (e.g. left, left, left, left …), and produces comparable disruption to an alternating sequence of auditory distractors (e.g. a, b, a, b …), against a non-alternating sequence (e.g. a, a, a, a …). Further, they demonstrate that the disruption produced by changing vibrotactile sequences is not

observed on a task on which attentional capture forms of distraction are typically revealed. Further, the predictability of the hand of presentation did not influence the disruptive effect. The lack of an effect of predictability and the insensitivity of the missing-item task to disruption, converge to suggest that the disruption produced by changing vibrotactile sequences are not underpinned by a cognitively controllable attentional diversion effect, but rather reflect impacts related to their non-controllable, automatic processing.

Linklater et al. (2024) examined the impact of different properties of distractor songs on performance of a range of novel (melody retrieval, lyric retrieval) and commonly used short-term memory tasks. The nature of the primary task dictated which qualities of distractor songs (lyrics, melody, familiarity) impaired performance. The findings are at odds with the notion that particular properties of sound produce cognitively controllable attentional diversion, since the same property of sound should be empowered with disruptive potential regardless of task properties. Rather, the interdependency between the nature of the focal task and the potentially distracting sound fits better with the view that such disruption occurs as the result of automatic processing. Nevertheless, the authors report a task-insensitive disruptive effect of melody familiarity, suggestive of a controllable, attentional diversion effect that requires additional exploration.

Vasilev et al. (2024) undertook a study that required participants to perform a self-paced reading task in the presence of quiet, instrumental music and lyrical music. Overall, regardless of familiarity, lyrical music prolonged reading times, suggesting that it reduces the efficiency of reading. However, no effects were determined on text passage comprehension. The findings are consistent with the notion that the automatic, obligatory processing of language disrupts the focal reading task. However, lyrics were presented in the participant's mother tongue, whether the disruption is attributable to automatic phonological or semantic processing could not be determined.

Rummel et al. (2024) focused on the interaction between internal distraction by task-irrelevant thoughts and external distraction by task-irrelevant speech, employing a thought-probing method. While the presence of task-irrelevant speech predictably increased the perception of external distraction, the perception of internal distraction decreased, suggesting that participants increased their task engagement when faced with external distraction. These findings highlight the mutual interdependence of internal and external distractions, underscoring the importance of considering both to foster a comprehensive understanding of distractibility.

In summary, the articles included in the first part of the Special Issue enrich the literature by providing valuable insights regarding important everyday distractions such as music (Bell et al., 2024; Linklater et al., 2024; Vasilev et al., 2024), background speech (Kattner et al., 2024; Rettie et al., 2024; Rummel et al., 2024; Zhang et al., 2024) and mind wandering (Rummel et al., 2024). They also extend theories on auditory distraction to novel paradigms (Linklater et al., 2024; Marsh et al., 2024), and blind as well as visually impaired individuals (Kattner et al., 2024), thereby promoting a deeper understanding of distraction across different modalities and diverse groups.

To preview, in Parts 2 and 3 the scope of the Special Issue will be broadened to include additional topics such as individual differences in the susceptibility to auditory and visual distraction. Included articles may investigate neuroatypical populations and their responses to the emotive nature of potentially distracting stimuli. Further articles may examine the influence of the eccentricity between visual target and visual distracter, or the ear of presentation of auditory distracters, on the magnitude of distraction. Other articles may focus on manipulating the semantic and/or non-semantic (e.g. phonological) relationship between task-relevant and task-irrelevant material to investigate whether a clash between similar processes applied to to-be-ignored and focal stimuli governs disruption. Understanding the conditions central to performance alteration due to interruption or task-switching will form another strand, while some studies will focus on potentially facilitatory effects of to-be-ignored sound on task performance. Together, these parts will provide a rich empirical foundation for advancing our understanding of distraction and its interplay with other types of sensory and cognitive processing. This will further theoretical development and provide key insights on how to effectively control distractions in work and learning environments.

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