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Distractor or Noise?
The Influence of Different Sounds on Cognitive Performance in Inattentive and Attentive Children

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1. Introduction

It is a well known and certified fact that noise under most circumstances interfere with cognitive processing of various kinds, e.g. vigilance (e.g. Broadbent, 1951), arithmetic’s (Broadbent, 1958), and response speed (Broadbent, 1957). This effect is assumed to be due to the competition of attentional resources between the target and the distracting stimuli. This finding is often replicated and found valid among different tasks and participant populations (Belleville, Rouleau, Van der Linden, & Collette, 2003; Boman, 2004; Klatte, Meis, Sukowski, & Schick, 2007; Rouleau & Belleville, 1996). Most research since Broadbent’s days has dealt with the negative effects of noise and different kinds of auditory distraction. In line with this earlier research has demonstrated that inattentive persons, such as children with ADHD (attention deficit /hyperactivity disorder) are even more susceptible to distraction as compared with their attentive peers. This has been shown in numerous of studies (e.g. Corbett & Stanczak, 1999; Geffner, Lucker, & Koch, 1996; Rickman, 2001).

However, in contrast to the main body of evidence, there have been a few reports of contradictory findings. Specifically, it has been shown that under certain circumstances, children with attentional problems, rather than being distracted, actually benefit from environmental noise presented with the concurrent target task. Until recently, this facilitating effect of non-task related environmental auditory stimulation has been limited to the effects of background music on arithmetic task performance by children with ADHD (Abikoff, Courtney, Szeibel, & Koplewicz, 1996; Gerjets, Graw, Heise, Westermann, & Rothenberger, 2002). In addition, road traffic noise was found to improve episodic memory among children from households with low socio-economic status, a group that is likely to be distinguished by attentional problems and academic under-achievement (Matheson et al., 2010; Stansfeld et al., 2005). However, these studies have not provided a satisfactory theoretical account for why noise, under certain circumstances, can be beneficial for cognitive performance.
There are some early studies that provide a theoretical account for noise enhancement. In these studies, hyperactive children improved their performance in demanding attention tasks where noise was introduced by visual stimulation (Zentall, 1986; Zentall & Dwyer, 1989; Zentall, Falkenberg, & Smith, 1985), or auditory stimulation (Zentall & Shaw, 1980). In these experiments the positive effect was attributed to a general increase of arousal, formulated in a theoretical framework named “the optimal stimulation theory” (Zentall & Zentall, 1983). However, this optimal stimulation theory has not been explored or developed further.

The aim with the present chapter is to present a plausible theoretical explanation as to why, when, and how noise can improve executive functions and cognitive performance in various tasks. Our research has recently extended these findings and for the first time will here be suggested a theoretical framework for understanding which conditions are necessary for noise induced cognitive enhancement to occur. We have shown that auditory noise has different effects on the memory performance of children with an ADHD diagnosis compared to normally developed children (Söderlund, Sikström, & Smart, 2007). These effects have been replicated, and found valid in further studies comprising sub-clinical, inattentive participants (Söderlund, Marklund, & Lacerda, 2009; Söderlund, Sikström, Loftesnes, & Sonuga-Barke, 2010). In the following section we introduce a model and findings that demonstrate a link between noise stimulation and cognitive performance. This has been named the Moderate Brain Arousal (MBA) model (Sikström & Söderlund, 2007), which suggests a link between attention, dopamine transmission, and external auditory noise (white noise) stimulation.

2. The phenomenon of Stochastic Resonance

Perceptual stochastic resonance (SR) is the counterintuitive phenomenon by which weak sensory signals that cannot be detected because they are presented below the detection threshold, become detectable when additional random (stochastic) noise is added (Moss, Ward, & Sannita, 2004). Signaling in the brain is characterized by noisy inputs and outputs. The crucial task of the central nervous system is to distinguish between the signal, the information-carrying component, and noise that constitute meaningless neural inputs. The paradox is that the brain can actually use noise to differentiate the signal in the targeted stimuli from noise, so noise actually improves or increases the signal-to-noise ratio. The requirement for this phenomenon to occur is the introduction of non-linearity in the response, for example through a threshold function. This is shown in Figure 1, where the noise and the signal interact. The noise adds to the signal and brings the neuron over the activation threshold, and elicits a neural response (action potential), giving the auditory system a representation of the signal (a sinus tone).

SR is well established across a range of settings, and exists in any threshold-based system. The concept of SR was originally introduced to explain climate changes (Benzi, Parisi, Sutera, & Vulpiani, 1982), but has been identified in a number of naturally occurring phenomena, some examples are: in bi-stable optical systems (Gammaitoni, Hänggi, Jung, & Marchesoni, 1998); in mechanoreceptors of the crayfish (Douglass, Wilkens, Fantazoulou, & Moss, 1993); and in the feeding behavior of the paddlefish (Russell, Wilkens, & Moss, 1999). SR is in particular found in the nervous system, distinguished by its all-or-none nature of action potentials.
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Fig. 1. Stochastic resonance where a weak sinusoidal signal goes undetected as it does not bring the neuron over its activation threshold. With added noise, the same signal results in action potentials.

In humans SR has been found in different modalities: in touch, where tactile random stimulation made skin receptors more sensitive (Wells, Ward, Chua, & Timothy Inglis, 2005); in audition, where white noise improves auditory detection in a group with normal hearing (Zeng, Fu, & Morse, 2000), and in participants with cochlear implants (Behnam & Zeng, 2003); in vision, where visual (flickering) noise improved detection of weak signals (Simonotto et al., 1999). Interestingly, cross modal SR has been found, where weak visual signals became detectable when participants where exposed to loud auditory white noise (Manjarrez, Mendez, Martinez, Flores, & Mirasso, 2007). SR can improve motor control and balance as well. Elderly, diabetics, and Parkinson patients’ performance was enhanced through stochastic noise transmitted by vibrating soles (Novak & Novak, 2006; Priplata, Niemi, Harry, Lipsitz, & Collins, 2003; Priplata et al., 2006). In neurodegenerative disorders galvanic stimulation of the vestibular organs improved motor control considerably (Pan, Soma, Kwak, & Yamamoto, 2008; Yamamoto, Struzik, Soma, Ohashi, & Kwak, 2005). To sum up, SR is present in the entire nervous system in all modalities, and it seems that the nervous system can take advantage of noise both in sensory discrimination and motor control. SR is usually quantified by plotting detection of a weak signal, or cognitive performance, as a function of noise intensity. This relation exhibits an inverted U-curve, where performance peaks at a moderate noise level. That is, moderate noise is beneficial for performance, whereas too much, or too little noise attenuates performance.

While less known, empirical evidence also suggest that SR improves central processing in the brain and thus improves cognitive performance. For example a facilitating effect of cognitive SR has been found where auditory noise improved the speed of arithmetic computations in a normal group of school pupils (Usher & Feingold, 2000). In a visual task, face recognition, response times got shorter when the vestibular organs where stimulated by a weak stochastic galvanic current (Wilkinson, Nicholls, Pattenden, Kilduff, & Milberg, 2008) finally, figure copying became more accurate when exposed to galvanic stimulation.


Sörqvist, P. (2010a). High working memory capacity attenuates the deviation effect but not the changing-state effect: further support for the duplex-mechanism account of auditory distraction. [Research Support, Non-U.S. Gov’t]. *Memory & cognition, 38*(5), 651-658. doi: 10.3758/MC.38.5.651


The treatment of Attention Deficit Hyperactivity Disorder is a matter of ongoing research and debate, with considerable data supporting both psychopharmacological and behavioral approaches. Researchers continue to search for new interventions to be used in conjunction with or in place of the more traditional approaches. These interventions run the gamut from social skills training to cognitive behavioral interventions to meditation to neuropsychologically-based techniques. The goal of this volume is to explore the state-of-the-art in considerations in the treatment of ADHD around the world. This broad survey covers issues related to comorbidity that affect the treatment choices that are made, the effects of psychopharmacology, and non-medication treatments, with a special section devoted to the controversial new treatment, neurofeedback. There is something in this volume for everyone interested in the treatment of ADHD, from students examining the topic for the first time to researchers and practitioners looking for inspiration for new research questions or potential interventions.

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