The effects of auditory stimuli on the central executive

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Abstract:

The experiment was conducted in order to examine the effects of auditory stimuli on the central executive. A group of 16 subjects was presented with an attention shifting task (a card sorting task), while listening to four auditory stimuli conditions (verbal music, instrumental music, noise and control) one at a time. It was hypothesised that performance would be best in the control condition and worst in the verbal music condition. The prediction made, was not supported by the collected data, nevertheless alternative explanations are provided.

Introduction:

In primary school we are all told that our homework is important, and that we should not allow ourselves to be distracted whilst doing them, the cardinal sin being to work with music in the background. At the same time, several guides to more effective l earning suggest that certain kinds of music are beneficial to the learning process, especially classical music, and could well be used to our advantage. In order to determine which is the best strategy for learning, we need to know how the learning proces s works, and how music (and what kinds of music) affects it. In 1989, Salamé and Baddeley found that vocal music significantly impaired performance on an immediate recall task for visually presented verbal memory, whereas instrumental music only disrupted recall to a far lesser extent (Salamé & Baddeley, 1989). These findings could tell us something about how music affects our ability to learn new information, based on Baddeley's widely accepted model of working memory. Instead of focusing on the structur es involved in memory, the working memory model focuses on the processes involved, and consists of three parts (Fig. 1): The phonological loop, the visuo-spatial sketchpad, and the central executive.

1) The phonological loop (PL) processes and stores verbal material, and consists of two parts, a subvocal rehearsal loop (SRL) and a phonological short-term store (P-STS) (Fig. 2), and whereas speech inputs have obligatory access to the phonological STS, nonspeech verbal information, such as written text, first enters the SRL where it is recoded into subvocal speech. As the P-STS is time limited, the SRL also serves to rehearse decaying information in the P-STS.

2) The visuo-spatial sketchpad (VSSP) processes and stores visual and spatial information, and also verbal information which is stored in the form of imagery. 3) The central executive (CE) coordinates activity within working memory (i.e. between the two s ubsystems 1 & 2), and between working memory and other parts of the cognitive system, such as retrieval of information from long-term memory. Its function is primarily one of regulation (Baddeley, 1986).

Salamé and Baddeley were more concerned with exploring the details of the phonological loop than how music was processed, and the conclusions we can draw from their study are merely that vocal music, containing phonological information, disrupts the p honological loop through its obligatory access, and thus interferes with the verbal information from the text book simultaneously trying to enter our memory. However, they found that instrumental music does create some interference, even though it contain s no phonological information, and the fact is that we quite obviously have a memory for melody and rhythm, which is not in the phonological loop, and not in the visuo-spatial sketchpad. This leaves one alternative: If Baddeley's (1986) model of working m emory is to be accepted as it stands, music must be processed through the central executive. What then happens when we perform a task known to go through the central executive? Extrapolating on Baddeley's model, this should be equally disrupted by instrum ental and vocal music, as both would disrupt central executive functioning. Alternatively, Berz (1995) suggested that music does not fit into any of the three existing components of the working memory model, and adds two more loops: A Music Memory Loop an d Multiple Sensory Loops (the latter to cover sensory sensations not explained by the original model, such as touch, heat, pain, and so forth). (Fig. 3).

If Berz' model is correct, there should be no difference in performance on the task of central executive functioning whether the music is vocal or instrumental, as the instrumental, and the instrumental element of the vocal music, should be processed by t he music memory loop, and the phonological element of the vocal music should be processed by the phonological loop. In order to establish which is the case, whether music is processed in the central executive of Baddeley's original model, or somewhere else, such as in Berz' model, we designed the following experiment. Our interest lies in trying to discover the effects of auditory stimuli on the central executive. We used an attention shifting task, a card sorting task with four different auditory stimuli conditions: 1) vocal music, 2)instrumental music, 3)noise and 4)s ilence control. We hypothesised that performance will improve from condition one to condition four.

METHOD:

SUBJECTS

Subjects were sixteen undergraduate psychology students at St Andrews University. Approximately equal numbers of male and female subjects volunteered, they were of average to above average intelligence, and were aged 17 to 22. These subjects were volunt eers and were not offered any form of payment.

MATERIALS

Four types of auditory stimuli were used. The main criteria for the music which was selected was that it was unusual enough for subjects to have no prior knowledge of it. Tracks were selected which were judged to best represent their category, for examp le English Language A Capella was judged to be most suitable for the vocal music condition. For the non-vocal condition Pan Pipe music was selected and for the noise condition the sound of splashing water was used.

The packs of cards which were used had been complied for the purpose by the experimenters. Each set contained eighty cards with an equal number of each suit, and no picture cards which were judged to be too distracting.

The music was played to the subjects over headphones, as this was judged to be imposing enough to cause the desired effect. The volume level was set across all trials.

DESIGN

The independent variables in this experiment were the four types of music presented. The dependent variable was the time taken, in seconds, for the subject to sort through eighty cards. This was a within subjects design, where the conditions were partia lly randomised so that the different types of auditory stimuli were presented to the subjects in four different orders.

PROCEDURE

The experiment was run in small cubicles where the experimenter and the subject carried out the task on a one on one basis. The subjects were instructed to first of all sort the cards into two piles with respect to colour, and then into piles of four su its, changing between the two ways of sorting whenever tapped on the shoulder. The subjects were tapped every time they had completed sorting ten cards. After one practise run there were four experimental trials, one run through the pack for each of the d ifferent types of auditory stimulus. For the sake of consistency the subjects were instructed to keep their headphones on throughout the experiment, even during the silent condition. Experimenters talked to the subjects as little as possible between the t rials; and indeed attempted to conduct the experiment without speaking at all between the initial instructions and the final debriefing. The time it took for the subjects to sort the eighty cards was recorded for each of the conditions.

RESULTS

Table 1:

CONDITION	MEAN SCORES (secs)	STANDARD DEVIATIONS
Silence	90.94	10.08
Noise	89.56	6.67
Instrumental	90.38	7.23
Vocal	88.44	7.25

As can be seen from the above, the means for all conditions were very similar, and the range of results and standard deviation was also very small. To ascertain if there were any significant differences between conditions, a multivariate ANOVA was perf ormed. No significant differences were found.

- Discussion:

From the data collected and unlike predicted, we accepted the null hypothesis. There was no significant difference found between the four different condition. We hypothesised that verbal music would interfere more with central executive functioning than i nstrumental music, noise or a silence condition.

There are varies which could have effected the outcome of the study. Firstly we had a very small sample of 16 subjects to collect our data from. For this reason we chose to use a within- subject design. Unfortunately this meant that all the subjects had to participate in all four conditions. From the debriefing session we are aware that some of the subjects found it hard to concentrate for all four conditions. Furthermore we considered that a practice effect might have taken place. To avoid this we provided the subjects with a practice run and also rearranged the order of the four conditions.

Implications and suggestions for further research

Our confirmation of the null hypothesis that the central executive does not play a role within music processing leads researchers back to the earlier models of Salamé and Baddeley (1989,) or of Berz (1995,) illustrated in figures 1 and 2. This backwar ds step is unsatisfactory and contains unaddressed issues including considerations of possible evolutionary development and model complexity.

Both models fail to consider an evolutionary approach to the subject. Whilst sound-processing has been an essential survival strategy since before the development of the first hominids, phonemic processing is only necessary for the understanding of language and must have developed from general sound processing. It can be assumed that music developed at an even later stage than language within human evolutionary history.

With this in mind are Salamé and Baddeley (1989) correct in only providing a loop capable of processing phonological stimuli? Their results could be equally explained by a general audio-processing loop that has in recent hominid history become par tially specialized to phonemic qualities under the particular selection constraints of a developing linguistic tradition. In consideration of the evolution of phonemic specialization within a wider audio-processing system the two systems need not be rende red asunder, but rather integrated under a new title - the passive audio-processing loop, (figure 3.)

Figure 3: A suggested model of working memory incorporating music processing within an audio-processing loop

Berz's (1995) critique argues against a single audio-loop by drawing together references from a number of studies suggesting specialization in a number of musical qualities e.g. rhythm, pitch, and timbre. Having shown the independent processing invo lved in each of these characteristics he subsequently re-combines them into a new processing system - the music-memory loop. This approach is contradictory and arbitrary; either each individual characteristic is processed separately, (and thereby vastly complicating the current model and involving the abandonment of all current processing models including the music-memory loop in favour of individual stimuli processor organized by a central unit analogous to the central executive, or the supervisory atte ntion system (e.g. Shallice & Burgess, 1993,)) or the combination of auditory inputs classified as music belong to a more inclusive system of auditory stimuli.1 The suggested model (figure 3) takes the simpler of these two options, with an evolutionary content providing

hierarchies within the stimuli processing loops.

And finally... this experiment may not be defined a success due to a lack of evidence to support the experimental hypothesis. It was however not a failure; an area of possible confusion, the potential role of the central executive in music processing, has been refuted. Further studies within this field should concentrate upon the validity of Salamé and Baddeley's original model, and upon the issue of single or multiple processing units for auditory stimuli.

- References:

Berz, (1995), Working Memory: A Theoretical Model, *Music Perception*, Vol.12, pp.353-364.

Shallice & Burgess, (1989), Supervisory Control of Action and Thought Selection, in (eds.) Baddeley & Weiskrantz, (1993), *Attention: Selection, Awareness and Control*, Clarendon Press, Oxford, pp171-187.

Salame & Baddeley, (1989), Effects of Background Music of Phonological Short-Term Memory, *The Quarterly Journal of Experimental Psychology*, Vol.41a, pp.107-122.

1 An argument perhaps furthered from the non-traditional musical qualities of many modern and modernist compositions