Background noise means process interference in counting performance

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ABSTRACT

The present paper examined the effects of different background sounds on counting performance. Two experiments were carried out to test how counting performance was affected by four background noise conditions: spoken numbers, numbers played backwards, names of occupations and a silent control condition. The hypothesis was that the condition with spoken number noise should have strongest negative effect on counting performance. The results from Experiment 1 gave no support for the hypothesis, since no significant difference between conditions was found. Experiment 2 used a more complex counting task and a faster presentation rate of the background sounds. The condition with spoken number noise showed largest effect on counting performance, and performance in the control condition was better than all background sound conditions. The results are in line with the theory of *interference by process.*

Keywords: Noise, Counting, Interference by process.

INTRODUCTION

What kind of background sound is most disruptive for counting processing, and thereby affects mathematical performance? In order to find optimal learning conditions in schools, we need information about the cognitive nature of distraction. If the overall noise level is the main issue for disruption, we should minimize the number of noise sources and mount a big amount of absorbing panels. But if irrelevant speech affects performance perhaps classrooms with smaller cells could be a more effective solution. Thus, to design a classroom with acoustic characteristics that offers good learning conditions we need more information about cognitive disruption.

A common research paradigm to explore and find answers about our cognitive higher order functions is to give participants in the experiment a main cognitive task and present auditory distraction at the same time (Sörqvist et al. 2010; Beaman & Jones 1998; Hygge et al. 2003). Numerous experiments with such a paradigm have demonstrated many interesting phenomena. Jones with collegues showed that serial recall performance was more impaired by changing state sounds (like a, r, s, p, k, t, a, t) compared to steady state sounds (like a, a, a, a, a, a, a, a, a); this finding is known as the changing-state effect and is restricted to serial processing performance (Jones & Macken 1993). A changing state sound is not more disruptive than a steady state sound then the main task is free recall. Thus, when the main task involves processing of order, background sounds with ordered information (changing state) affect performance to a greater extent than continuous sounds.

A similar phenomenon in the field of auditory distraction is related to the semantic content of the background sound. When participants are told to recall visually presented items from the one semantic category (e.g. fruits), performance drops when the background sound contains words from the same semantic category (e.g. other fruits) compared to a sound that contains words from another semantic category (e.g. tools) (Neely & LeCompte 1999). This semantic effect is shown in free recall of the to-be-remembered words, but the semantic information gives no extra power to the distraction on serial recall performance (Jones & Macken 1993). Thus, when the main task is free recall, background sounds with semantic information from the same category as the to-be-remembered items affects performance to a greater extent than words from other semantic categories.

Many studies have explored cognitive functions like learning and memory (e.g. free recall, serial recall, recognition), proof reading, reading comprehension, reading speed etc. (Sörqvist 2010; Evans & Lepore 1993). Studies about counting are more infrequent, but there are some exceptions. Buchner et al. (1998) performed a series of four experiments where participants were instructed to count visually presented dots in four different experimental auditory conditions. In the four experimental conditions, an irrelevant auditory item was presented simultaneously with each visual dot (Irrelevant words, random number, distant numbers, and adjacent numbers). In the distant number condition the auditory distracting number were -20, -10, +10 or +20 from the current running total. In the adjacent number condition the distracting number was -2, -1 +1 or +2 from the current running total. They showed that performance in silence was significantly better than all experimental conditions but no significant difference between the experimental conditions was found. However, Buchner's experimental design has some weaknesses. The number of distracting items was equal to the number of dots, and the participant therefore could theoretically just count the distracting sounds to reach the correct answer.

The present paper describes two experiments on the topic of distracting sound during counting processing. Experiment 1 is basically a replication of Buchner et al. (1998). The approach in Experiment 2 was somewhat different, instead of presenting dots one after the other at a certain interval, all dots were presented at the same time. The benefits with such approach are that counting speed is not restricted to a certain interval, and number of distracting sounds is not related number of dots.

EXPERIMENT 1

The purpose in Experiment 1 was to examine whether counting performance was affected by background noise. Three background noise conditions were used; spoken numbers, spoken numbers played backwards, occupations and silence as a fourth control condition.

METHOD

Participants

The experiment involved 32 subjects aged 18-34 years with a mean age of 25 years, 21 women and 11 males. The participants were recruited from the University of Gävle and received a cinema ticket in reward.

Focal task

The counting task in the experiment was to count visually presented dots on a computer screen. The dots were presented one at a time with a presentation time of 700 ms for each dot and a 1.5 second pause between each dot.

Background sounds

The spoken number background sound was two-digit numbers read by a male voice, the same sound files were played backwards in the backward number condition. In the third condition the same male read occupation words. All sound files were mixed in Audacity software.

Design

The experiment had a within-participants design with one factor: "Background Sound Condition" which had four levels: spoken numbers, spoken numbers played backwards, occupations, and quiet. Each participant performed 15 counting trials in each condition, i.e. a total of 60 trials. The 60 trials were randomized. To control for potential order effects, the order of the sound conditions was counterbalanced across participants.

Procedure

Each participant performed the test individually in front of a laptop and wore headphones throughout the whole experiment. Before they started the experimenter gave basic information about the experiment. Participants were instructed to ignore any sound that they heard in the headphones and were told that they would not be tested on its content. The written instruction in the beginning of the test, informed the participants that they would see a number on the screen (e.g. 34) which would be followed by a series of presented dots. Their task was to start from the presented number and keep on counting the following dots (for example, if the number 34 appeared on the screen, the first following dot were 35 and so on, if 10 dots were presented after number 34, the correct answer was 44, which should be typed on the keyboard). The experiment lasted approximately 30 min.

RESULTS AND DISCUSSION

The results from Experiment 1 showed no significant effect of background sound, $F(3.31) = 1.48$, $p > .05$ (Figure 1). These results were in line with earlier studier with similar experimental paradigm (Buchner et al. 1998).

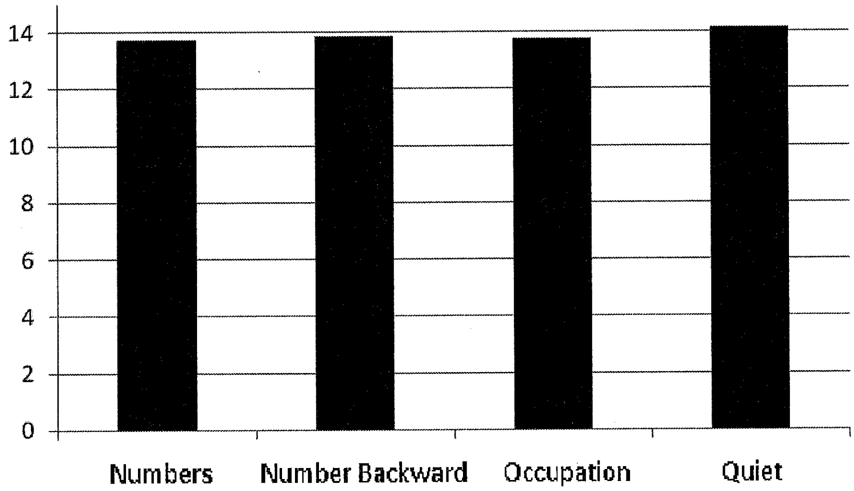

Figure 1: Mean number of correct counting results in the three experimental conditions and control (quiet). There was no significant difference between the conditions.

Counting performance has been shown to be unaffected by background noise in many studies. From a cognitive point of view the absence of effect of seems strange, since it's shown that other cognitive processes are affected by background noise with interfering content (e.g. semantic tasks as reading comprehension is negatively affected by background noise with semantic content, and serial processing is affected if the background noise contains ordering information). One possible reason to the absence of effect could the nature of the background noise. The counting task in Experiment 1 required the participants to count at a certain interval, which gave a counting rhythm. The background noise items were presented at the same rate so the actual rhythm could have been helpful for the counting. This interpretation could explain the absence of effect in Buchner et al's studies as well.

EXPERIMENT 2

Experiment 2 was designed to separate counting speed from presentation rate of the background noise. When the rhythm of counting and the disturbing background sound is disconnected the counting process should be more vulnerable to the semantic information (numbers) in the disturbing background sound.

METHOD

Participants

Experiment 2 involved 32 subjects aged 18-32 years with a mean age of 23 years, 24 women and 8 males. The participants were recruited from the University of Gävle and received a cinema ticket in reward.

Focal task

An image with dots was presented on a computer screen, the participants' task was to count the number of dots. The number of points in each image varied between 16 and 20. Each participant performed 15 counting trials in each condition, a total of 60 trials.

Background sounds. See Experiment 1

Design. See Experiment 1

Procedure

Each subject performed the test individually in room in front of a laptop wearing headphones during the entire experiment. At the outset the participants were told about the experiment. Before they started the test program they read an instruction about the procedure. The written instruction in the beginning of the test, informed the participants that they would see a number on the screen (e.g. 34) which would be followed by an image with dots. Participant's task was to start from the presented number and keep on counting the dots on the image (for example, if the number 34 appeared on the screen, and there were 18 dots on the image, the correct answer was 52, which should be typed on the keyboard). The experiment lasted approximately 30 min.

RESULTS AND DISCUSSION

The results showed a significant effect of background noise condition $F(3.31) = 7.49$, $p<0.01$, $\eta^2 = .195$ (Figure 2). Counting performance in the control condition was significantly better compared to all experiment conditions, Control vs. Occupations $t(31) = 2.35$, $p<0.05$; Control vs. Numbers $t(31) = 3.90$, $p<0.01$; Control vs. $t(31) = 2.56$, $p<0.05$. The Number condition differed significantly from control condition and occupation condition $t(31) = 2.66$, $p<0.05$, but did not differ significantly from the backward number condition $t(31) = 2.35$, $p<0.05$. Neither did the backward number condition and the occupation condition differ significantly $t<1$.

These results are in line with the hypothesis that counting processing is affected by interference from irrelevant stimuli with number (or counting) information. These results give further evidence to the view of *interference by process*.

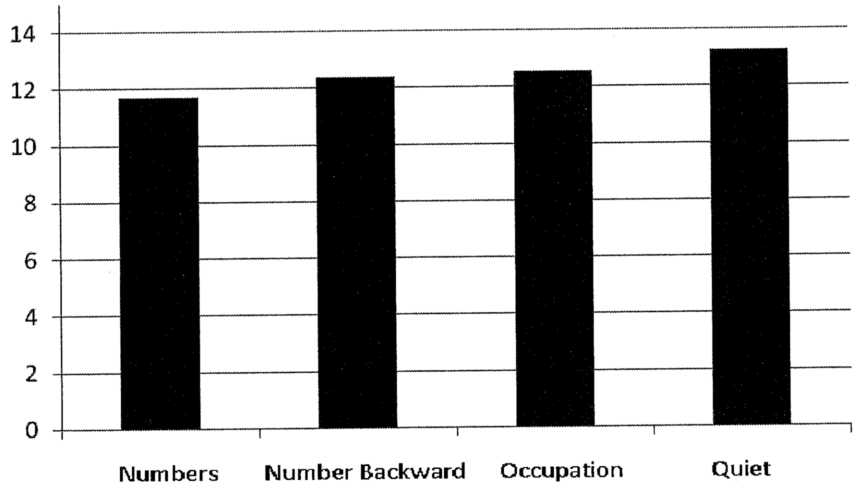

Figure 2: Mean number of correct counting results in the three experimental conditions and control (quiet)

GENERAL DISCUSSION

This paper examined how different kinds of background noise conditions affect counting performance. When counting stimuli were presented one after another, no effect of sound condition was shown (Experiment 1). In experiment 2 another paradigm was chosen, all counting stimuli were presented at the same time in the same sound environmental settings. The result showed a significant effect of sound condition. All sound conditions had negative effect on counting performance compared to the quiet control condition. The spoken number background noise condition showed strongest effect, which was in line with the hypothesis.

Buchner et al. (1998) reported four experiments with different settings to examine the effect of background noise. They did not find any significant effect between the different background noise conditions in their studies. All four studies had more or less the same paradigm; they presented the counting stimuli one after another.

It has been shown that memory of serial order is effected by background noise, if the noise contains order information (Jones & Macken 1993). This kind of effect has also been shown for free recall performance when background noise contained words taken from similar semantic category (Neely & LeCompte 1999; Marsh et al. 2008).

Jones with coworkers has published more detailed evidence and discussions about the interference by process view (Marsh et al. 2009). Experiment 2 in the present paper gives further evidence to the process view, thus this view is applicable to counting performance as well as other cognitive tasks.

The reason that Experiment 1 in the present paper and Buchner et al. (1998) showed no significant differences between the background noise conditions on the counting performance, can be interpreted in terms of rhythm. Since the counting pace was equal as the pace of presented background speech stimuli no interference were occurred, and thus counting performance was unaffected.

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