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REORGANIZATION OF TEMPORAL LOCAL/GLOBAL PROCESSING WITH AUDITORY SALIENCE

Baptiste Bouvier [1*] **Emmanuel Ponsot** [1] **Patrick Susini** [1]
[1] STMS IRCAM, Sorbonne Université, CNRS, Ministère de la Culture, 75004 Paris, France

ABSTRACT

The so-called ”forest before the trees” phenomenon refers to the perceptual processing of the global information before the fine-grained analysis in vision. This advantage can be reversed by the presence of local salience. The same advantage for processing global temporal information is found in audition, but not for musical experts. Here, we ask whether and how salience modifies the local/global temporal auditory processing. To do so, participants (13 non-musicians, 7 expert-musicians) had to search, within melodic sequences of 9 notes organized in 3 triplets, for local or global modification applied to one triplet. In some conditions, these sequences were further manipulated in timbre (brightness) to make one of the triplets salient. Results show that the advantage for processing global information was substantially decreased with salience, regardless of its congruence with the modification to detect. Furthermore, the performance to find a local modification was improved for non-musicians when salience was congruent with that modification. We conclude that salience draws attention to local information, and that once at the local level, attention is directed by salience to the locally modified information. This re-organization of local/global temporal auditory processing with salience appears to be more efficient for non-musicians than for expert musicians.

Keywords: *attention, auditory perception, local/global*

1. INTRODUCTION

Perception is a complex process involving the integration of sensory information at different scales to form a coherent perceptual experience. In the visual modality, studies using Navons’s paradigm [1] revealed that the processing of the global information took priority over the local processing [2]. Similarly, in hearing, an advantage of the global processing of information has been revealed through studies using an adaptation of the visual paradigm [3, 4]. The ability to process local vs. global information has since been shown to be influenced by top-down processes shaped by musical expertise [5, 6]. More precisely, the advantage for processing the global information was found in non-musicians, and, on the contrary, a local advantage was revealed for expert-musicians [6].

An important bottom-up process in perception is the salience of physical features. It has been shown to modulate attention and perception in both visual and auditory modalities [2, 7]. In the auditory domain, salience can be modulated by features such as loudness, pitch or timbre [8-11]. Thus, in an orchestra, for example, a trumpet's clarion may be salient because of its level and brightness, but a musician could still be able – more than a non-musician - to pay attention to other instruments if he wishes.

In this study, we aim to investigate the effect of bottom-up salience on auditory local-global processing. As this processing depends on musical expertise, we selected non-musicians and expert-musicians to observe how salience affects the global and local advantage respectively. We hypothesize that salience will affect these processing hierarchies differently for musicians and non-musicians due to top-down processes modulated by musical expertise.

Specifically, we will use a modified version of the auditory local-global paradigm [12] to investigate how the salience of auditory features influences the local/global processing, in musicians and non-musicians.

[*] ***Corresponding author***: baptiste.bouvier@ircam.fr.

2. MATERIALS AND METHODS

2.1 Participants and Setup

Twenty volunteer participants took part in the experiment: 13 non-musicians (4 women, mean age: 31.4 ± 11.0 year) and 7 expert-musicians (1 woman, mean age: 41.4 ± 15.9 year).
Sounds were presented to listeners through a Beyerdynamic DT-770 PRO headset (Heilbronn, Germany) and a Focusrite Scarlett 2i2 soundcard at a level of 70 dB SPL. The sound level was measured with the sound level meter type 2250-S of Bruel & Kjær. Participants were tested in a double-walled Industrial Acoustics Company (IAC) sound-insulated booth. The test interface was coded with Max (v8) (https://cycling74.com/products/max) on a Mac Mini.

2.2 Stimuli

Stimuli construction were based on Susini et al., 2020 [5]: they were pairs of melodies made of 9 notes segmented into 3 triplets. The local level was defined as the pitch structure within the triplets, and the global level was defined as the pitch structure formed by the mean pitch of the three triplets. In the present study, the rising and falling pitch profiles were kept. Stimuli were presented as pairs of melodies: a target and a comparison, separated by a 500 ms silence. Four types of modifications could distinguish the pitch profile of the target and the comparison melodies: no modification, a local modification, a global modification, or both local and global modifications (hereafter called Condition No, Condition L, Condition G and Condition L + G, respectively). Local variations were changes in the pitch of one note within one triplet, while global variations were changes in the mean pitch of an entire triplet.
All notes followed the harmonic structure of Bouvier et al., 2023 [11]: each note with a fundamental frequency f_0 had n harmonics, the n^{th} harmonic f_n having a frequency $n*f_0$ and a weight $1/n^{\alpha}$. Thus, varying α changed the sound spectral centroid (SC), and therefore its perceived brightness. For the ordinary notes, $\alpha = 5$. For the so-called bright notes, $\alpha = 1.5$. The stimulus pair could be affected or not by a salience manipulation (2/3 of all the trials containing a salience manipulation). If yes, in the congruent salience condition (1/3 of all trials), the modified triplet consisted of bright notes, both in the target and the comparison stimulus. In the non-congruent salience condition (1/3 of all trials), one of the other two triplets was made salient with equal probability.

2.3 Procedure

Participants took part in two separate attention-directed tasks in separate sessions: a "local" and a "global" session. They were asked to perform a "similar/different" discrimination task by focusing on the local or global scale depending on the session. In the local task, they had to determine whether the pitch profiles of the three triplets were similar or different in the target and the comparison stimuli, irrespective of the global profile. In the global task, they had to determine whether the global profile was identical or not, irrespective of the local profiles of each triplet. Each session was divided into 5 blocks of 96 trials and lasted approximately 1h30.

3. RESULTS

3.1 Analyses

Within the framework of SDT (Signal Detection Theory), we computed confusion matrices to derive sensitivity (d') and decision criterion (c) values for each participant, in each task, as a function of the modalities of the different factors. Analyses followed those proposed by Susini et al. (2020). This experiment is based on a 2 × [2 × 2 × 4 × 2 × 3] factorial design: one between-factor "Group" (musicians|non-musicians) and five within-factors "Task" (Local|Global) × "Profile" (R|F) × "Condition" (No|L|G|L + G) × "Position" (First|Last) × "Salience" (No|Congruent|Incongruent).

3.2 Results

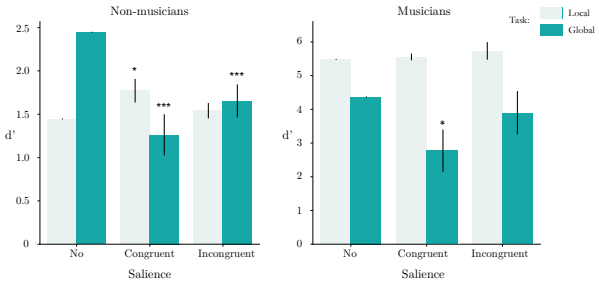

Figure 1. Sensitivity (d') in the local and the global task for non-musicians (left) and expert-musicians (right) depending on the salience condition. Error bars: standard error of the distribution of participants' paired scores between each condition and the No-Salience condition.

Results reveal a global advantage for non-musicians in the No Salience condition: these participants are better in the global task (d' = 2.45) than the local task (d' = 1.45). A t-

test revealed that this advantage in the global task compared to the local one was significant ($T(10) = 3.38$, $p = .007$, cohen-d = 1.02, power = 0.86). The expert-musicians, on the contrary, are better in the local (d' = 5.48) than in the global task (d' = 4.37). A t-test revealed that this advantage in the local task compared to the global one was significant ($T(5) = 3.24$, $p = .02$, cohen-d = 1.32, power = 0.74).

When salience is congruent with the modification to find, the pattern is changed: non-musicians no longer show a global advantage but, on the contrary, a better performance in the local task (d' = 1.77 for the local task, d' = 1.26 for the global one). This inversion is due to a significant increase in performance in the local task ($T(10) = 2.39$, $p = .019$, cohen-d = 0.72, power = 0.72) combined with a significant decrease in the global task ($T(10) = 4.99$, $p < .001$, cohen-d = 1.51, power = 1.0). For expert-musicians, the local advantage is mainly reinforced because of a significant degradation of performance in the global task ($T(5) = 2.54$, $p = 0.026$, cohen-d = 1.04, power = 0.70).

When salience is incongruent, a significant degradation of the performance in the global task is still observed for non-musicians (d' = 1.66) ($T(10) = 4.65$, $p<.001$, cohen-d = 1.4, power = 0.99).

4. DISCUSSION

A global advantage was found for non-musicians when they have to detect modifications in melodies at a local or global scale. Indeed, in the No-salience condition, they performed better in the global task than in the local one. This effect does not stand for expert-musicians, which is in line with Susini et al. [6].

More importantly, the results with salience manipulations show that the global advantage is reversed in non-musicians when salience is congruent with a local change. In this condition, they become better at detecting local changes. Furthermore, the global information processing is always disrupted when information is locally salient, regardless of the salience congruence.

In sum, salience disrupts the global advantage by systematically degrading performance in the global task, and by enhancing performance in the local task when it is congruent. This result is in line with the results found in vision: Mevorach et al. [2] showed that the presence of local salience degraded performance in the global identification task.

The same pattern could be true for expert-musicians: the local advantage is increased when salience is congruent with the modification to detect. But their performance in the local task reveals a ceiling effect and does not allow a perfectly reliable observation. However, their performance in the global task is also degraded by the presence of local salience. This re-organization of the local/global auditory processing appears to be less efficient than for non-musicians.

5. CONCLUSION

In summary, local/global information processing is re-organized because of salience. The re-organization seems to be more pronounced in non-musicians.

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