The two faces of masking vs. the general picture of the hearing system selectivity

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1.Introduction

The fundamental characteristic of the auditory system is its action as a frequency analyser. This action is revealed by our ability to "hear out" the individual partials, or harmonics, of complex sounds. More generally, our ability to hear one sound in the presence of other sounds depends crucially on frequency resolution also known as frequency selectivity; I will use the latter term.

It seems likely that frequency selectivity depends to a large extent on the filtering that takes place in the cochlea. Frequency selectivity is most often quantified by masking which may be regarded as reflecting the limits of frequency analysis; by measuring when one sound is just masked by another, it is possible to characterize the frequency analysis capabilities of the auditory system.

The problem facing the auditory system is in fact much more complicated. In many everyday situations our auditory system is presented with an acoustic waveform made up from a mixture of sounds originating from a variety of sources. The role of the system is to interpret this complex waveform as sound-producing events.

The problem of interpreting sound in terms of separate events is closely related to the visual problem of interpreting, in terms of three-dimensional objects. This is the case that assigning the different frequency components in the sound to the appropriate sources is called the separation of auditory objects or the identification of sound sources. Our ability to do this is greater than we might expect from simple studies of masking hence the mechanism involved in this action should take into consideration not only what is happen in the cochlea, on the basilar membrane. This mechanism is called "perceptual grouping" or "stream formation" and - unlike filtering on the basilar membrane which is peripheral one – perceptual grouping belongs to central or cognitive processes in hearing. Perceptual grouping may be a very useful tool to construct the "auditory scene" and build the most general picture of selectivity of the hearing system. This form of selectivity has to be connected with both peripheral and central processes in hearing.

Now our task is to find out effects which could carry information about this high degree of selectivity of auditory system. I suggest that everything what is known about comodulation masking release (CMR) and modulation detection/discrimination interference (MDI) can contribute to the formation of auditory objects. CMR and MDI because of their nature play the role of bridging peripheral and central auditory processes [1] and *ipso facta* take the important place in the general picture of the hearing system selectivity.

2. The role of CMR and MDI on the construction of the picture of the hearing system selectivity

The construction of the general picture of the hearing system selectivity needs the contribution of peripheral and central processes in hearing. The phenomena exploration of which could be of interest in creation this picture should be instrumental in bridging the both aspects of hearing: peripheral and central.

If an aspect of auditory perception can be explained entirely by consideration of processes occurring within one frequency channel, then that aspect might reflect mainly peripheral processing. However, if an aspect of auditory perception can only be explained by processes that involve comparing or combining information across frequency channels, then those processes must occur relatively centrally, at a level higher than the auditory nerve.

The phenomena known under acronyms CMR and MDI may be very useful in illustrating these aspects of peripheral and central processing in hearing.

In the phenomenon of comodulation masking release, the outputs of auditory filters tuned away from the signal frequency can be used to enhance signal detection. CMR occurs when the task is to detect a signal centred in a narrow-band masker that is amplitude modulated in some way. The addition of other components to the masker (the on-frequency band), remote from the signal frequency, can enhance signal detection, provided the extra components have a similar pattern of modulation to the on-frequency band. CMR is usually assumed to reflect a relatively central across-channel process.

In the phenomenon of modulation detection/discrimination interference, the outputs of auditory filters tuned away from the signal frequency degrade signal detection. This degradation seems to happen mainly when the task of the observer is to discriminate changes in modulation depth of the signal or to detect a change in the modulation pattern of the signal. The ability to discriminate/detect these changes is adversely affected by the presence of other modulated sounds (also called flankers), even when those sounds have centre frequencies well away from that of the target. Again, MDI is usually assumed to reflect a relatively central across-channel process.

In many ways, the conditions in which CMR and MDI occur are only a little different. MDI resembles CMR, except that the remote components enhance detection in CMR and degrade it in MDI. Jorasz and Moore [2] suggest that the both effects are the two faces of the same phenomenon: the auditory masking. It is very important and "comfortable" because we can illustrate the nature of the both phenomena showing results of measurements for one of them (CMR or MDI).

The necessity of involving of central processes is the elementary feature of CMR and MDI, their "to be or not to be". But if the paradigm used to measure the detection of the signal had previously been associated with highly successful within-channel explanation that was based upon peripheral auditory processes we could expect that peripheral, within-channel mechanisms contribute to CMR and MDI [1]. Additionally Moore and Jorasz [3] demonstrated that perceptual grouping- closely connected with the identification of the sound sources - play a role in the amount of MDI.

3. Conclusions

Fig.1 illustrates the conclusions of our speculation about general picture of the hearing system selectivity. Our ability to hear out one sound in the presence of other sounds (left side of the graph) or – more generally- our dealing with mixtures of sounds effecting the identification of sound sources (right side of the graph) is the basic problem facing the auditory system.

The full picture of the hearing system selectivity should take into consideration not only the filtering on the basilar membrane inside the cochlea (1), i.e. peripheral mechanism, but also the perceptual mechanism called perceptual grouping (2), i.e.central mechanism, involved in this action of the hearing system.

Exploration of CMR and MDI, the effects which demonstrate the two faces of auditory masking, could take an important place in the picture of the hearing system selectivity. The relative importance of within-channel and across-channel processes in CMR and MDI may shed light on the peripheral versus central nature of these processes contribution of whom is irremissible for understanding the selectivity of the hearing system. The overlapping of the graphs- CMR and MDI- reflects a delicate balance between mechanisms producing MDI and those producing CMR [3, 2].

References

[1] U. Jorasz, B.C.J. Moore, Peripheral and central processes in hearing, Archives of Acoustics 25, 4, 433-439 (2000).
[2] U. Jorasz, B.C.J. Moore, The two faces of auditory masking, ibid. 423-431 (2000).
[3] B.C.J. Moore, U. Jorasz, Detection of changes in modulation depth of a target sound in the presence of other modulated sounds, J.Acoust.Soc.Am. 91, 1051-1061 (1992).

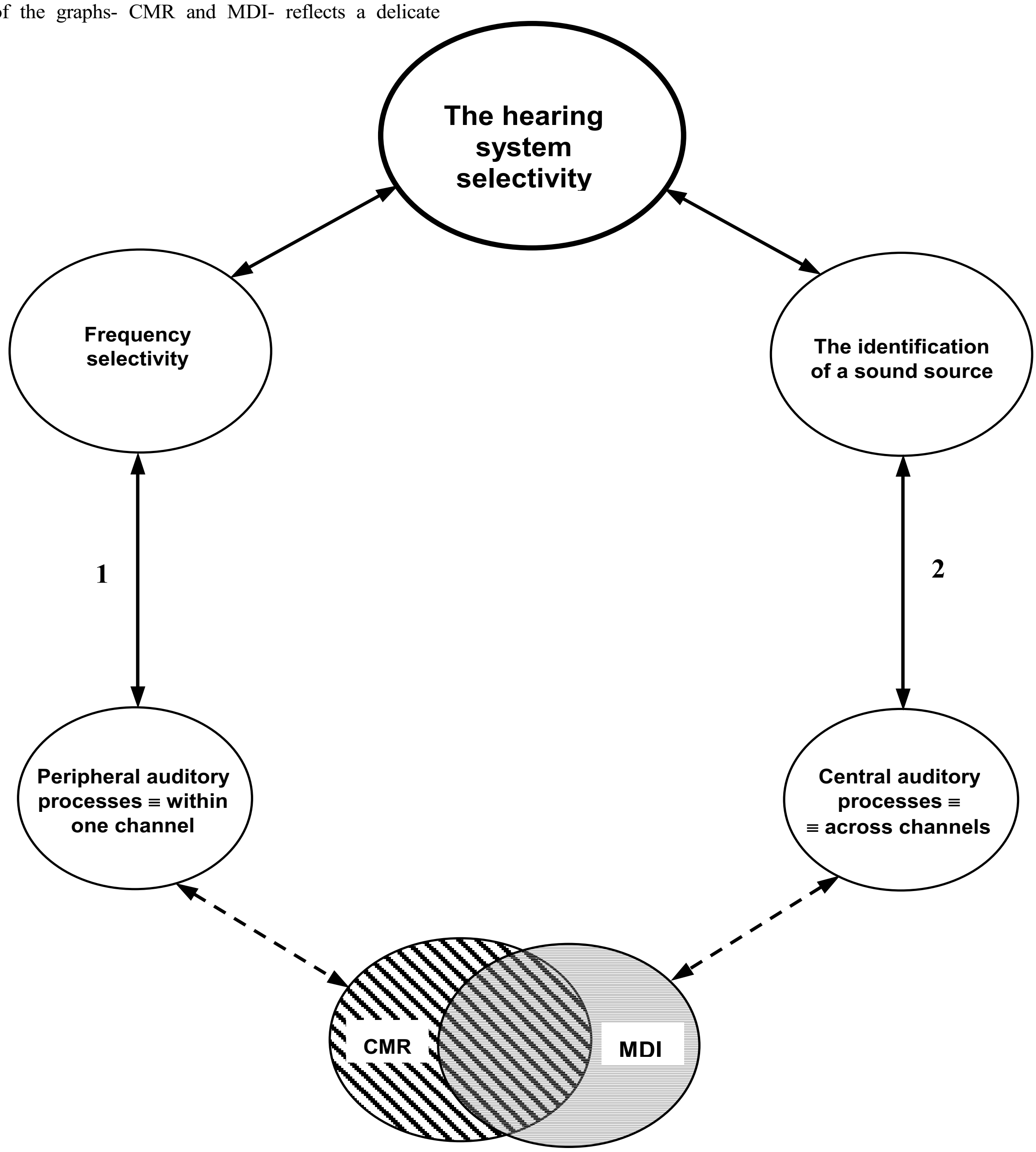

Fig. 1. The general picture of the hearing system selectivity
1-frequency analysis on BM 2-perceptual grouping