Neuroscience Letters 628 (2016) 167–170

Contents lists available at ScienceDirect

Neuroscience Letters

journal homepage: www.elsevier.com/locate/neulet

Research article

# Short-term visual deprivation can enhance spatial release from masking

Sara Pagé [a,b], Andréanne Sharp [a,b], Simon P. Landry [a,b], François Champoux [a,b,*]

[a] Centre de recherche interdisciplinaire en réadaptation du Montréal métropolitain, Institut Raymond-Dewar, Montreal, Quebec, Canada
[b] École d'orthophonie et d'audiologie, Université de Montréal, Montreal, Quebec, Canada

## HIGHLIGHTS

- Brief visual deprivation transiently enhances auditory perception.
- 90 min of visual deprivation boosts out-of-phase competing noise detection.
- Auditory ability returns to baseline after 90 min of light exposure.

ARTICLE INFO

*Article history:*
Received 19 May 2016
Received in revised form 14 June 2016
Accepted 17 June 2016
Available online 18 June 2016

*Keywords:*
Binaural interaction
Masking level difference
Sensory deprivation
Spatial release from masking

ABSTRACT

This research aims to study the effect of short-term visual deprivation on spatial release from masking, a major component of the cocktail party effect that allows people to detect an auditory target in noise. The Masking Level Difference (MLD) test was administered on healthy individuals over three sessions: before (I) and after 90 min of visual deprivation (II), and after 90 min of re-exposure to light (III). A non-deprived control group performed the same tests, but remained sighted between sessions I and II. The non-deprived control group displayed constant results across sessions. However, performance in the MLD test was improved following short-term visual deprivation and performance returned to pre-deprivation values after light re-exposure. This study finds that short-term visual deprivation transiently enhances the spatial release from masking. These data suggest the significant potential for enhancing a process involved in the cocktail party effect in normally developing individuals and adds to an emerging literature on the potential to enhance auditory ability after only a brief period of visual deprivation.


## 1. Introduction

Several investigations on the blind have reported significant improvements to a number of auditory abilities [e.g. 1–3]. However, little is known regarding the rapidity of these sensory changes following sensory deprivation. Some investigations have shed light on the mechanisms underlying the relative swiftness of this plasticity. For instance, auditory steady-state responses were found to be altered in some individuals following only 6 h of visual deprivation [4] and most recently, Meng et al. [5] found that one week of dark exposure could alter animal primary auditory cortex connectivity. Investigations on the impact of short-term visual deprivation for behavioral auditory processes in human have revealed increased loudness and pitch discrimination [6], reduced sound localization inaccuracies [7], and improved detection of mistuned harmonics [8]. However, further research is required to better understand the specific auditory abilities that can be enhanced within such a short timeframe.

The ability to isolate a target signal from background noise is a major enabling factor in the cocktail effect [e.g. 9,10]. This improvement of sound source segregation when the target and competing acoustic information are spatially separated is called the 'spatial release from masking' [for reviews,see 11,12]. Spatial release from masking resulting from binaural interaction can be evaluated using a Masking Level Difference (MLD: [13,14]) test. For this, a target signal is presented binaurally simultaneously with a competing noise. An interaural phase difference of either the target signal or the masking noise is then introduced. This shift in phase produces a perceptual distinction between the spatial locations of the acoustics stimuli, which in turn facilitate the detection of the target signal. The MLD has received significant research interest and has been shown to be highly stable and reproducible [e.g. 15].

* Corresponding author at: Université de Montréal, Faculté de Médecine, 7077 avenue du Parc, Quebec, H3N 1X7, Canada.
*E-mail address:* francois.champoux@umontreal.ca (F. Champoux).

http://dx.doi.org/10.1016/j.neulet.2016.06.033
0304-3940/

In this present study, we investigate the impact of short-term visual deprivation on the MLD test. Previous data have suggested that 90 min of visual deprivation can transiently enhance the perception of auditory cues in non-competing listening situations. Here, we hypothesize that this short-term visual deprivation will lead to an improvement in a competing auditory condition evaluated by the MLD test.

### *1.1. Material and methods*

#### *1.1.1. Participants*

Twenty-six healthy individuals (14 females, 12 males; 20–32 years of age; mean age: 24) participated in the study. All participants gave their written informed consent and research approval was obtained from the Institutional Review Board of the Faculty of Medicine at the Université de Montréal. All participants reported normal or corrected-to-normal vision. Pure-tone detection thresholds at octave frequencies ranging from 250 to 8000 kHz were within normal limits in both ears for all participants.

#### *1.1.2. Procedure, stimuli, and design*

The MLD test was administered [13,14]. A 500 Hz pure-tone signal and a narrow-band noise were simultaneously presented binaurally. Detection thresholds were measured in three conditions. In the first condition, the pure tone and the masking noise were presented binaurally in-phase (homophasic condition: S0N0). In the second condition, the pure tone was presented 180° out-of-phase while the masking noise remained in-phase (antiphasic condition: SπN0). Finally, in the third condition, the pure tone was presented in-phase whereas the masking noise is presented 180° out-of-phase (antiphasic condition: S0Nπ). Detection thresholds were determined using a 3-down/1-up adaptive staircase procedure [for further description,see 16,17] with 1 dB increments. Participants were asked to indicate the detection of the signal by pressing a button. Thresholds were identified when three identical ascending responses were reported. The MLD was calculated from the difference in the binaural detection thresholds between the homophasic and either antiphasic condition (i.e. S0N0 − SπN0; S0N0 − S0Nπ). All participants were blindfolded during the MLD test (Mindfold, Mindfold Incorporated, Tucson, AZ, USA) and no feedback about the correctness of the responses was given to the participants at any time. The stimuli were generated using an Interacoustics AC40 audiometer (Interacoustics, Assens, Denmark) and were presented binaurally through ER 3A insert earphones (Etymotic Research, Elk Grove, California, USA). The output of the acoustic system was calibrated using a sound level meter (model 824, Larson Davis, Provo, Utah) and artificial ear (6 cc coupler, model 4152, Brüel and Kjaër, Denmark).

Participants were separated into two age and gender matched groups. After the first administration of the MLD test (session I), one group (n = 13; visually deprived) kept their blindfold while the other (n = 13; controls) had their blindfolds removed (for an explicit detailing of the visual deprivation procedure, see [8]). Participants were asked to view or listen to a movie during a period of 90 min. The examiner who remained in the room during this time monitored participants. After 90 min, the MLD test was again administered (session II). After the second session, all participants had their blindfolds removed and waited another 90 min. Participants were asked to view a movie during this period. Their thresholds were measured a third time (session III) after this second 90-min period. Each administration of the MLD test lasted approximately 15 min during which the three MLD test conditions (S0N0; SπN0; S0Nπ) were administrated in pseudo-random order.

## 2. Results

Data in the two conditions of the MLD are presented in Fig. 1. The performance of control participants remained constant across evaluation (Fig. 1A), whereas the visually deprived participants had an improvement for the S0Nπ condition during their second discrimination test (Fig. 1B). A 2 × 3 ANOVA was performed for each of the two different MLD conditions (SπN0; S0Nπ) with *Group* (non-visually deprived; visually deprived) as between-subjects factor and *Session* (Session I; Session II; Session III) as a within-subject factor. The interaction between factors was not significant in the SπN0 condition ($F(2, 48) = 0.438$, $p = 0.648$). However, it was significant in the S0Nπ condition ($F(2, 48) = 5.212$, $p = 0.009$), reflecting group-specific changes across the different sessions in this particular condition of the MLD test. Post hoc tests with Bonferroni correction (alpha value = 0.017) for the S0Nπ condition revealed no significant difference for the control group across the different sessions ($p > 0.05$). However, detection thresholds in session II were significantly different from session I ($t(12) = -3.323$; $p = 0.006$) and session III ($t(12) = -3.092$; $p = 0.009$) for the visually deprived. There was no significant difference between sessions I and III ($t(12) = -0.671$; $p = 0.515$). Threshold in the S0N0 condition did not change across sessions and were comparable across groups ($p > 0.05$).

## 3. Discussion

In this study, we aimed to evaluate the impact of short-term visual deprivation on spatial release from masking as measured by performance on the MLD test. The MLD test was administered over three sessions to two groups of participants. One group was blindfolded for 90 min between the first and second test sessions and the other (control) was not. The visually deprived group displayed an increased detection only for the out-of-phase competing noise condition (S0Nπ). The specificity of the result eliminates the possibility of a response bias from the participants, as this would have been reflected in a measured improvement in both conditions. Experimental group participants had their blindfolds removed after the second evaluation and the improvement disappeared in the third evaluation. Control group participants who remained sighted between sessions displayed constant results across evaluations. These results suggest that short-term visual deprivation transiently enhance the spatial release from masking, providing insight on the reported enhanced cocktail party effect in blind individual [3,18].

Sensory improvements following short-term visual deprivation are consistent with a metamodal model of cortical organization [19]. It is increasingly acknowledged that primary sensory cortices are not limited to the processing of unimodal sensory information (e.g., [20–23]). According to the metamodal model, sensory dominance in a cortical region occurs because it is more efficient at processing a specific modality's sensory characteristics. However, if a primary input is removed, the coexisting sensory inputs that were previously not significantly processed may quickly garner the recently freed cortical resources [24]. To date, this model has been used to explain the rapid and transient auditory or tactile enhancement observed following short-term visual deprivation [8,25,26]. Instances of rapid auditory [4,5] and tactile [27,28] cortical changes following a short period of visual deprivation have been reported. A number of studies have attempted to corroborate the effects of short-term visual deprivation on perception with mixed results. Studies in the auditory domain have reported the most constant improvements including increased loudness and pitch discrimination after 3 h of visual deprivation [6], reduced sound localization inaccuracies [7], and improved discrimination of mistuned harmonics after 90 min of visual deprivation [8]. Reweighing of audiovisual perception after 3 h of visual deprivation was found