Hemispheric Differences in the Recognition of Environmental Sounds

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ABSTRACT

In the visual domain, Marsolek and colleagues have found evidence for two dissociable and parallel neural subsystems underlying abstract and specific recognition: an abstract-category subsystem that operates more effectively in the LH and is less sensitive to specific stimulus characteristics, and a specific-exemplar subsystem that operates more effectively in the RH and is more sensitive to specific stimulus characteristics.

In the present study, we tested this hypothesis in the auditory domain by conducting two long-term repetition-priming experiments on the recognition of environmental sounds. Participants attempted to identify target sounds from an initial 750 ms sound presented monaurally. Target stems were primed by either an identical or a different exemplar sound (e.g., the same or different tokens of an exemplar category). When noise was simultaneously presented to the opposite ear, this priming was reduced in the different-exemplar condition (i.e., specificity) when sounds were presented to the left ear (LH), but not when sounds were presented to the right ear (RH), consistent with Marsolek’s framework.

In the visual domain, Marsolek and colleagues have found evidence for their claim that two dissociable and parallel neural subsystems underlie abstract and specific recognition of objects (Burgund & Marsolek, 2000; Marsolek, 1999; Marsolek & Burgund, 2003), word forms, pseudowords, and letters. According to their theory, an abstract-category subsystem operates more effectively in the left hemisphere (LH) and is less sensitive to the specific surface characteristics of the stimuli, whereas a specific-exemplar subsystem operates more effectively in the right hemisphere (RH) and is more sensitive to specific stimulus characteristics.

The strongest support for the two-systems hypothesis comes from studies using the long-term repetition-priming paradigm, in which participants must respond to an initial block of stimuli. After a short distractor task, participants are presented with a second block of stimuli, in which some of the stimuli from the first block are repeated. Typically, performance for repeated stimuli is better than performance for new stimuli (priming effect). However, if the first and second presentations (prime and target, respectively) mismatch on some dimension, the priming effect may be attenuated, and this attenuation is referred to as specificity (or a specificity effect).

Marsolek (1999) has reported distinct patterns of specificity in the two cerebral hemispheres for object recognition. Participants named objects (e.g., piano) presented in either the left (RH) or right (LH) visual field during a test phase after having viewed centrally presented same-exemplar or different-exemplar objects (e.g., different exemplars of a piano) during an initial encoding phase. Equivalent priming was obtained in the same- and different-exemplar conditions when test objects were presented to the LH, but priming was reduced in the different-exemplar condition (i.e., specificity) when test objects were presented to the RH. A similar pattern of hemispheric differences has also been obtained for the recognition of objects previously primed by a same or different depth-orientation view (Burgund & Marsolek, 2000).

In the present study, we tested Marsolek’s hypothesis in the auditory domain by performing two long-term repetition-priming experiments on the recognition of environmental sounds. There are reasons to believe that two dissociable neural subsystems underlying abstract and specific perception may not be limited to the visual domain. Indeed, we recently obtained hemispheric differences in specificity effects in object word recognition (González & McLennan, 2007) in line with the Marsolek’s data in visual word recognition.

EXPERIMENT 1

Method

Participants: A total of 24 participants (7 men) were recruited from the University Jaume I of Castellón (Spain) for course credit. All participants were right-handed (Edinburgh Handedness Inventory, Oldfield, 1971).

Materials: The stimuli consisted of 24 digitized target sounds selected from the database of acoustic objects at the University of British Columbia (1999). The database comprises a variety of acoustic events, such as sounds produced by entities, people, musical instruments, animals, and machines. The sounds were digitized at 48000 Hz, 16-bit resolution, and all sounds were long enough for the identification and classification of the stimuli.

Design: A within-participant design was used, with the reaction time as the dependent variable. The experimental design was a 3 x 2 factorial design with prime type (same-exemplar, different-exemplar, unprimed) and the ears of sound stem presentation (left, right) results in six within-participant conditions.

Experimental Procedure: The setup was identical to Experiment 1, with the following exceptions: (a) all 24 target sounds were presented, (b) the 750 ms target sound was presented monaurally while noise was presented binaurally, and (c) the noise was white noise filtered to 11020 Hz and digitized at an sampling rate of 22050 Hz. The RMS amplitude was set to 0.68 below the level of the sound files. On each trial during the second block of trials, participants were presented with a sound stem monaurally and binaurally with the noise in the opposite ear.

RESULTS AND CONCLUSIONS

Exp. 1: Crucially, the difference between the same-exemplar and different-exemplar conditions (0.64 and 0.57, respectively) was not significant when the target stems were presented to the left ear (t(23) = 1.19, p = .24, d = 0.25). In contrast, the difference was significant (0.67 and 0.55) when the target stems were presented to the right ear (t(23) = 2.78, p = .009, d = 0.68).

Exp. 2: Crucially, the difference between the same-exemplar and different-exemplar conditions (0.68 and 0.58, respectively) was significant when the target stems were presented to the left ear (t(23) = 2.74, p = .005, d = 0.68), but not when the target stems were presented to the right ear (t(23) = 1.23, p = .22).

These results are consistent with the predictions based on Marsolek’s results in the visual domain: in particular, specificity effects emerged when the target stimuli were presented to the left ear (RH), but not when the target stimuli were presented to the right ear (LH).

EXPERIMENT 2

Method

Participants: Twenty-four participants (7 men) were recruited from the University Jaume I of Castellón (Spain) for course credit. All participants were right-handed (Edinburgh Handedness Inventory, Oldfield, 1971).

Materials: The stimuli consisted of 24 digitized target sounds selected from the database of acoustic objects at the University of British Columbia (1999). The database comprises a variety of acoustic events, such as sounds produced by entities, people, musical instruments, animals, and machines. The sounds were digitized at 48000 Hz, 16-bit resolution, and all sounds were long enough for the identification and classification of the stimuli.

Design: A within-participant design was used, with the reaction time as the dependent variable. The experimental design was a 3 x 2 factorial design with prime type (same-exemplar, different-exemplar, unprimed) and the ears of sound stem presentation (left, right) results in six within-participant conditions.

Results: The same-exemplar and different-exemplar conditions were not significant when the target stems were presented to the left ear (t(23) = 1.19, p = .24, d = 0.25). In contrast, the difference was significant (0.67 and 0.55) when the target stems were presented to the right ear (t(23) = 2.78, p = .009, d = 0.68).

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References


