Are Vision and Touch Equivalent for Natural Textures Perception? Studies from Cross-Modal Transfer and Matching Tasks

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Abstract. The present study examines the extent to which vision and touch are perceptually equivalent for natural textures perception. The natural textures used as material were automotive seat fabrics. The textures differed with regard to two main aspects: they presented either a high or a low degree of cross-modal similarity between vision and touch, and they presented either a high or a low degree of visuo-haptic dissimilarity with their distracter within a pair. We explored the respective impact of the two stimuli characteristics upon cross-modal performances, using a matching and a transfer procedure.

1 Introduction

Gibson (1966) has proposed a partial equivalence between vision and touch ([2]). Perceptual equivalence can be defined in two different manners ([4]). In the first definition, perceptual equivalence involves that vision and touch function in a similar way, so that the same type of information can be derived from the touch and from the vision of an object. In the second definition of perceptual equivalence, both modalities function similarly so that information derived from one sense can be communicated or transferred to the other. Equivalence of the first definition can be assessed using cross-modal matching tasks in which subjects are exposed simultaneously to a target stimulus in one modality and to test stimuli in another modality: they have to recognize the target stimulus among the test stimuli. Equivalence of the second definition can be assessed using cross-modal transfer tasks, in which subjects are first exposed to a target stimulus in one modality, and then must recognize, in another modality, the target stimulus among test stimuli.

In the present study, we explored the extent to which vision and touch were perceptually equivalent for natural textures perception, using both cross-modal matching

and transfer tasks. Natural textures used as material were automotive seat fabrics. We took care of measuring their degree of cross-modal equivalence, using Garbin's method ([1]). The Euclidean distance between the visual and the haptic positions of individual stimuli in visual and haptic multidimensional spaces was taken as a measure of cross-modal dissimilarity (the greater the distance, the lower the similarity). A measure of bi-modal dissimilarity between the target and the distracter stimuli pairs was also introduced. A visuo-haptic multidimensional space was used for this measurement: the Euclidean distance between two stimuli was taken as a measure of their degree of bi-modal dissimilarity (the greater the distance, the greater the dissimilarity). We explored the respective impact of these two factors (stimuli cross-modal similarity and stimuli bi-modal dissimilarity) on cross-modal performances for both the matching and transfer conditions.

2 Methods

2.1 Participants

Ninety French adults were observed. Their age ranked from 20 to 30 years. They were volunteers, all students at the University and naive with respect to the aims of the study. They were divided into two groups: the Matching group (N = 42) and the Transfer group (N = 48).

2.2 Material

Eight samples of automotive seat fabrics (size: 20*20 cm) were selected as stimuli. Four stimuli presented a high cross-modal similarity (HS) (mean Euclidean distance between the visual and the haptic position of individual stimuli: 0.28). The remaining four stimuli were characterized by a low cross-modal similarity (LS) (mean Euclidean distance: 2.60). For each set of stimuli, eight pairs (target and distracter) were created. Half of the pairs presented a high bi-modal dissimilarity (HD) (mean Euclidean distance between target and distracter in the visuo-haptic space: 2.88). The other half presented a low bi-modal dissimilarity (LD) (mean Euclidean distance between target and distracter in the visuo-haptic space: 0.30). There were thus 16 pairs of target-distracter. Each sample had a 2 mm foam support and was hooked on wood. The stimuli were presented in an apparatus made of wood that contained three haptic boxes (equipped with a curtain at their frontal side to avoid any visual influence) and three visual boxes (drawers).

2.3 Design and Procedure

The experiment was taken on individual participants and lasted one hour, on the average. Participants of the Matching and Transfer groups were assigned to three perceptual conditions: an inter-modal condition from vision-to-haptic, an inter-modal condition from haptic-to-vision, and an intra-modal condition from haptic-to-haptic (control condition). The order of presentation of the three perceptual conditions was counterbalanced across participants. For each condition, participants completed 18 trials (2 practice trials, 4 trials with HS and HD stimuli, 4 trials with HS and LD, 4 trials with LS and HD, and 4 trials with LS and LD). The order of presentation of the 18 trials per perceptual condition was randomized for each participant. At total, participants completed 54 trials.

In the matching procedure, participants were presented with a target stimulus (X) in one modality while they were presented successively with two test stimuli (A and B) in the same (intra-modal condition) or in the other modality (inter-modal conditions). They were asked to decide whether X was A or B as rapidly and accurately as possible. The percentage of correct responses was the performance measure. In the transfer procedure, a target stimulus (X) was first presented for 5 seconds in one modality, followed by a 5 seconds retention delay, and then two test stimuli (A and B) were successively presented in the same (intra-modal condition) or in the other modality (intermodal conditions). Participants were asked to decide whether X was A or B as rapidly and accurately as possible. The percentage of correct responses was the performance measure. Haptic exploration of the target stimuli was performed with the participant's dominant hand and by means of the lateral motion procedure (see [3]).

3 Results

Results from Table 1 showed that, when stimuli with a high degree of similarity were used, participants equally matched and transferred texture information in the three situations. By contrast, when stimuli with a low degree of similarity were used, asymmetries occurred: matching performances were higher than transfer performances, haptic-to-haptic matching performances were higher than inter-modal matching performances, and haptic-to-vision transfer performances were lower than vision-to-haptic and haptic-to-haptic performances.

Stimulus discriminability also had a strong impact on the performances: lower performances were obtained when stimuli presented a low degree of discriminability. Interestingly, stimuli with a high degree of similarity were much more affected by this factor than were stimuli with a low degree of similarity.

Table 1. Mean percentage of correct matching (A) and transfer (B) per condition, stimulus similarity and stimulus discriminability

Stimulus Similarity	**High**			**Low**		
Stimulus Discriminability	**High**	**Low**	***Mean***	**High**	**Low**	***Mean***
A. Matching Haptic-to-Haptic	**93.6**	**57.1**	***75.3***	**93.7**	**82.5**	***88.1***
Haptic-to-Vision	**86.8**	**56.1**	***71.4***	**83.1**	**75.5**	***79.3***
Vision-to-Haptic	**91.3**	**55.4**	***73.3***	**89.1**	**71.3**	***80.2***
B. Transfer Haptic-to-haptic	**90.6**	**56.3**	***73.4***	**88.0**	**75.5**	***81.7***
Haptic-to-Vision	**84.4**	**55.2**	***69.3***	**68.8**	**54.2**	***61.5***
Vision-to-Haptic	**90.6**	**51.0**	***70.8***	**84.4**	**73.8**	***79.1***

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