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SHORT REPORT

Space contraction experiences during acoustic metronomic stimulation: a synthetic discussion

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Abstract On the basis of the results of a previous research, we will present a new interpretation of some psychophysiological component of spatial experience. The research examined the role of the acoustic activity of a metronome (with different frequencies of 66, 144, 192/min) on a space estimation between two points. The stimulus distances between the points were 30, 60, 90 cm. Increasing the metronomic frequency determines an evident *contraction* of the estimation of the perceived distances for each of the three different stimulus distances. The results have been interpreted in light of a psychophysiological integrated model.

Keywords Spatial distance estimations · Rhythmic acoustic activity psychophysiology · Space contraction

Introduction

Our research investigates the *physiological mechanism* generating the subjective psychobiological experience of space. Our hypothesis is that space experience is related not only to the visual perceptual activity but also to an integrated, synthetic, transmodal phenomenon. The basal concept is that subjects, through their bodily receptors, *construct an internal integrated representation of the world*, considering both the external environment and the own body as concrete spatial structure. In order to produce an integrated experience, it is necessary that, in the central nervous system, different perceptual modalities must be synaptically interconnected. The result must be the construction of a unified experience of the *world*. In this research, we analyzed the role of the interaction of visual and rhythmic acoustic activities, on the visual estimation of spatial distance between two points hypothesizing that the forms of the transmodal interactions could modify the perceptual estimation of the distances.

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Subjects and procedure

The subjects were 60 undergraduate psychology students, males and females, aged from 18 to 25 years, invited to participate in an experiment on visual perception at the Laboratory of Clinical Psychophysiology, University of Rome "La Sapienza" (Ruggieri et al. 2011; Ruggieri 2010).

We asked subjects to evaluate different distances (30, 60, 90 cm) between two vertical bars placed in front of them and to reproduce the perceived distances acting directly on other two near-placed mobile bars. Subjects evaluated the three different stimulus distances in a basic condition and after, in random order, simultaneously perceiving a rhythmic, metronomic activity of 60 db from a metronome placed at 1 m of distance of different frequencies (66, 144, 192, respectively).

Results

Results showed important and statistically significant differences among the spatial distance estimations: a wide reduction in the spatial distances appeared during perceiving high frequency of metronomic activity.

Table 1

Actual length (cm)	Mean of squares	SD
30	35.63	16.83
60	60.76	20.30
90	89.88	26.75

$F = (2,177) = 1,950$, $P < 0.000$

Table 2

Metronomic frequencies	Mean of estimates
66	88.96 (SD 29.22)
144	58.16 (SD 18.41)
192	39.16 (SD 20.75)

$F = (2.354) = 5,128.28$, $P < 0.000$

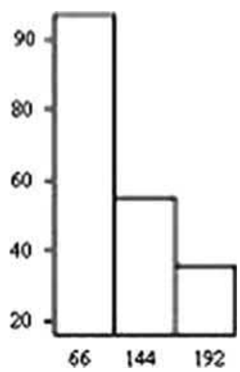

Fig. 1

In Table 1, the mean scores and standard deviations of all the estimates of each of the three stimulus distances, in basic conditions (in the absence of stimulation metronomic), are listed. As you can see, the differences between the estimates are statistically significant, reflecting the differences of stimulus distance.

Table 2 and Fig. 1 show the average distance estimates for all of the stimulus distances broken down for each of the metronomic frequencies. Each of frequencies appears to be associated with a different average score: the highest frequency (192) shows a contraction of the perception of spatial distance (39.16) that is greater than the estimate (58.16) of the intermediate frequency (144), which in turn is greater than the estimate (88.96) linked to the lowest frequency (66). The difference between the estimates is statistically significant. It is clearly a significantly inverse trend: the increasing frequency of metronomic reduces the estimate of spatial distance (the contraction of space perception in relation to the rhythmic acoustic frequency).

In Table 3 and Fig. 2, the estimates are reported separately for each of the stimulus distances. It is clear that for each of the stimulus distance reappears the phenomenon of contraction of the perception of space in reference to each

Table 3

Actual length (cm)	Metronomic frequencies	Mean of estimates
30	66	55.41 (SD = 3.01)
30	144	36.36 (SD = 3.84)
30	192	15.11 (SD = 3.05)
60	66	85.75 (SD = 4.43)
60	144	58.45 (SD = 5.64)
60	192	38.10 (SD = 6.08)
90	66	125.73 (SD = 5.65)
90	144	79.66 (SD = 5.34)
90	192	64.26 (SD = 5.47)

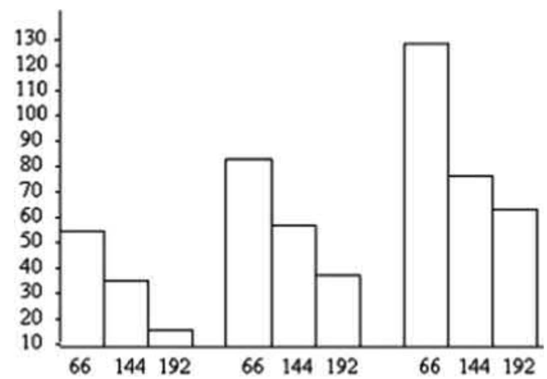

Fig. 2

Table 4 Anova: metronomic frequencies—actual length

	df	Sum of squares	Mean of squares	*F* value	*P* value
Actual length	2	265,407.21	132,703.60	4,950.05	<.0.001
Subjects (group)	177	4,745.11	26.80		
Metronomic frequencies	2	227,434.53	113,717.26	5,128.21	<.0001
Interaction	4	12,384.24	3,171.06	143.00	<.0001

of the differences metronomic frequencies. The phenomenon seems to occur in an identical manner for each of the stimulus distances (30, 60, 90 cm). It is observed that high frequencies determine the contraction of spatial perception significantly more than intermediate frequencies and lower frequencies. The interaction between stimulus distance sequence and real distances is statistically significant (see Table 4).

We interpreted these results considering that the interaction between visual and rhythmic acoustic perception is influenced not only by the acoustic sensory modality but also by the physiological mechanism that, in our point of view, is the basis of each rhythmic activity.

Each rhythmic activity is composed of two phases: (1) waiting for the reappearance of the stimulus and (2) the encounter with the stimulus itself.

We hypothesize that the waiting phase is characterized by increased muscle tension (increased activation) and that the encounter with the expected stimulus is characterized by a reduction in muscle tension of waiting.

In this way, the acoustic and the visual component bind to muscular activity rhythm.

Furthermore, we believe that the experience of the space involves, basically, the perception of muscular tone, which is characterized not only by the voltage level, but also by the duration of the voltages themselves. We consider, in fact, that the tonic muscle activity is a fundamental part of the preparatory program of each action. Every action has a temporal development, and the organization of time, in our opinion, is present at the time of preparation of the same programming.

In this way, the muscle tone is evaluated not only for the voltage levels, but also for the duration of the voltages thereof.

The muscular system therefore is an internal clock that is the basis for measuring distances, distances imaginatively as practicable. The imaginative operation binds the time component to the definition of the space component, in the same way with a clock which, through the displacement of the hands in space, defines the time.

So, conversely, the time durations of the internal clock, consisting of the muscles, define the space.

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