

SPACE AND TIME IN BENUSSI TAU EFFECT

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Abstract

Vittorio Benussi was the first researcher to demonstrate that, in perception, space and time are deeply intertwined. In particular, he showed the effect later known as a “tau effect”, where the length of temporal intervals influence the judgement on spatial distances. Although several years passed, the link between space and time has not yet been definitely clarified. The aim of this paper is to replicate Benussi’s original experiment in order to better analyse the conditions in which tau effect appears with visual stimuli. Our results confirmed the influence of the duration of temporal intervals on the perceived length of spatial distances. An interaction between space and time with both the position of the Standard Stimulus and the direction of stimuli presentation adds further meaning to Benussi results.

Traditionally, research has clearly proved that perception of time intervals and space distances can influence one each other. The influence of temporal duration on space distances is known as *tau effect* (Helson, 1930), while the influence of spatial distances on temporal duration is dubbed *kappa effect* (Choen, Hanel & Silvester, 1953). This relationship between space and time has been observed with tactile stimulations (Benussi, 1917; Helson, 1930; Helson, King, 1931), visual stimuli (Benussi, 1907;1913; Geldreich, 1934; Choen, Hansel & Sylvester, 1953) and auditory stimuli (Benussi, 1907; Scholz,1924; Choen et al., 1954).

In spite of the great number of studies about this issue, the way in which time and space are interlaced is not totally clear, and a definitive explanation of the phenomena is missing. For this reason, the interest in this topic is still alive and several studies try to determinate in which condition one of the two phenomena appears and why (e.g. Casasanto, Boroditsky 2007; Kawabe, Miura & Yamada, 2007).

In this field, the figure of Vittorio Benussi (1878-1927) appears extremely relevant. Studying the comparison between two spatial distances, Benussi demonstrates that, in perception, space and time are deeply intertwined (*Verschmelzung*). In particular, he was the first to show the effects later known as *tau effect* (Helson, 1930) and *kappa effect* (Choen, Hanel & Silvester, 1953). In the tau effect, if we have to compare two spatial distances between three lights, the length of the temporal intervals between their on and off influences the perception of their spatial distance (in the kappa effect the opposite phenomenon occurs). Vittorio Benussi’s research on the psychology of time is collected in his *Psychologie der Zeitauffassung* (Benussi, 1913), a monograph that presents the results of the experiments realized at the laboratory of psychology at the University of Graz. This work had been anticipated by a series of very remarkable articles. Among these, one of the most relevant is “*Zur experimentellen Analyse des Zeitvergleichs, I: Zeitgrösse und Betonungsgestalt*”(For the experimental analysis of the temporal comparison, I: temporal size and gestalt of cadence, Benussi, 1907).

The present study is aimed to explore tau effect with simple visual stimuli. As a first step, we decided to re-edit the first experiment proposed by Vittorio Benussi in his studies (Benussi, 1907; 1913) translating the texts from German to Italian. In these documents Benussi gave an accurate description of the experimental tools but, in spite of his carefulness, the description of the experimental design and the results appear incomplete and difficult to understand. For this reason, we tried to look for other papers in which this study is described. All Benussi’s

original manuscripts are preserved in “Fondo Benussi at ASPI (Historical Archive of Italian Psychology), an Interdepartmental Research Centre of the University of Milano-Bicocca; in particular, Benussi’s archive includes the draft of his classes and research. Although his deep interest in the issue of time, in his manuscripts there are no original notes about tau effect. Today, we are still studying his papers and we think to edit on the web the translation of the published article about tau effect, in order to make it available to the scientific community.

Experiment

To verify the conditions in which tau effect can be observed, the original Benussi’s experiment was replicated: seven different spatial distances were combined with nine different temporal intervals. However, if the original design employed 7938 trials, we run a simplified version of the same experiment following a suggestion given by Benussi in the same article.

Method

Participants

Twenty-five adults (twenty females and five males, aged 19-43 years) take part in the experiment. Thirteen participants had two repetitions for a total of thirty-eight observations. All subjects had normal or corrected-to-normal vision. Most of them were students at University of Milano-Bicocca and they received extra-credits for their participation.

Apparatus, stimuli and design

The stimuli were generated and presented using E-Prime software (Psychology Software Tools, Pittsburgh) on a Intel(R) Pentium 4CPU computer connected with a 19” LCD monitor with a refresh rate of 75.02 Hz.

On each trial, the participant observed a sequence of three dots (p1, p2, p3, see Fig.1) which were illuminated in succession. Each dot (diameter: 0.40 degrees of visual angle; presentation time: 100 ms) was white (luminance 90 cdm^2) and presented on a black background (luminance 3 cdm^2). The distance between the first and the second dot is called d1, whereas the distance between the second and the third dot was called d2. The temporal interval between the illumination of the first and the second dot was called t1, whereas the interval between the second and the third dot was called t2. To respect the original experiment, in the stimulus standard (Ss) the distance between two dots was fixed in space and time respectively to 80 mm (standard distance, sd) and 1000 ms (standard interval, st). For half stimuli, Ss was presented on the left of the central dot (that was fixed), whereas for the other half was presented on the right.

The Variable Stimulus (*Vs*) could assume seven different values for space distances (vd – from 65 mm to 95 mm with steps of 5 mm) and nine values for time intervals (vt – from 0 ms to 2000 ms with steps of 250 ms – (see. Fig. 1). Presentation direction was varied from left to right and from right to left.

In this way we have a 7 (spatial distance) x 9 (temporal intervals) x 2 (direction of presentation) x 2 (*Vs* position) design with a total of 252 trials to each subject.

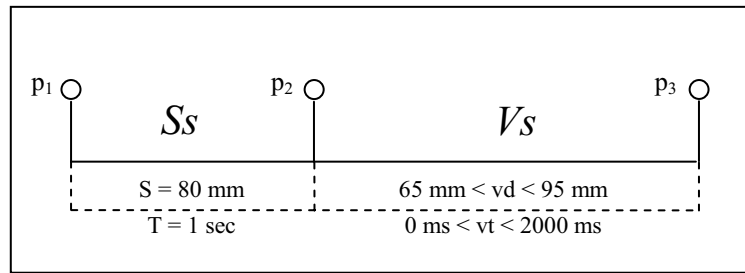


Figure 1. An example of the display used for the experiment. In S_s the distance between dots is 80 mm and the temporal interval is 1000 ms. In V_s the variable distance (v_d) is comprised between 65 to 95 mm while the variable time (v_t) is comprise between 0 and 2000 ms. The position of S_s can be on the left or on the right of the central point. Presentation direction was varied from left to right and from right to left.

Procedure

Participants sat in a dimly lit room facing the computer screen 60 cm in front of the monitor. At the beginning of the experiment, the participant read on the monitor the instructions in which it was asked to judge – by pressing one of two response buttons (p/q) – which of the two distances between the on and off of three lighting dots (eg. the one to the left or the one to the right of the central dot) appeared to be the longer one. The pressing of the response key started the next trial.

Before starting the experiment, the subject had to judge 10 trials in which the differences between spatial distances were more evident. This part of the experiment was presented to the participant as a familiarization task but they had to give the 50%+1 of correct answers to go on with the whole experiment.

Result and discussion

Benussi analysed the percentage of correct answers in relation to the duration of time intervals. He found that the percentage of correct answers was grater when “V (V_s) was not only spatially but also temporally longer than N (S_s)” (Benussi, 1907, p.411,) rather than when V was spatially longer but temporally shorter than N. This implies that the length of the temporal interval between the on and off of the two lights has an influence on the perceived length of their spatial distance: longer temporal intervals correspond to longer spatial distances (and shorter temporal intervals correspond to shorter spatial distances). In particular, in Benussi’s data, when space (d) and time (t) of V_s are *both* larger (smaller) than those of S_s , the percentage of correct answers was 55.62% (53.12%); when t of V_s was longer (shorter) but d was shorter (longer) the same percentage was 34.87% (36.24%).

Our experiment confirms in part Benussi’s results, even if our effect is not that strong: when V_s was not only spatially *but also* temporally longer (shorter) than S_s the percentage of correct answers are always grater than when v_d and v_t are not in agreement. Furthermore, we found another difference: when temporal intervals are longer (and spaces distances too), the percentage of correct answers is grater only in 2 percentage points, while when temporal intervals are shorter (and spaces distances too) the percentage of correct answer is grater in 10 percentage points (see fig. 2). These differences could be caused by several reasons: (i) Benussi’s subjects were “very expert” and they had to judge an enormous number of trials (precisely 7.938) which today would be considered a completely unacceptable experimental

situation; (ii) although Benussi was a very rigorous and careful researcher his papers lack in some important details, such as the distance of the subject from

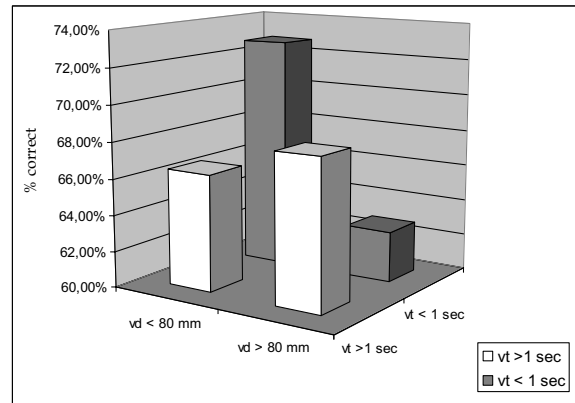


Figure 2. Percentage of correct answers when vt is longer than 1000 ms (white columns) compared with the percentage of correct answers when vt is shorter than 1000 ms (grey columns).

the screen and consequently the perceived dimension of the stimulus; (iii) Benussi’s apparatus was, for obvious reasons, very different from ours (he described it as “a light which appeared through a perforated screen placed on the dividing wall between two rooms”, Benussi, 1907, p.408). This could have some effects on the perceptual outcome (e.g. stimulus lightness, perceived dimension, perceived distance) and consequently on the “perceived” time.

A repeated measures Analysis of Variance (ANOVA) 7x9x2x2 (Space x Time x Direction x Ss Position) on the responses “longer than” revealed a main significant effect of Space [$F(1, 6) = 99,27, p = 0,000$] and Time [$F(2, 8) = 3,686, p = 0,001$]. Furthermore, the following interactions were significant: Space x Direction x Position [$F(1, 6) = 5,101, p = 0,000$] and Time x Direction x Position [$F(2, 8) = 4,071(8), p = 0,000$]. These results show that the direction of the presentation of the stimuli and the position of Ss influence the judgements and could, at least partially, explain the difference between our and Benussi’s results. To explain this effect is useful to observe Figure 3.

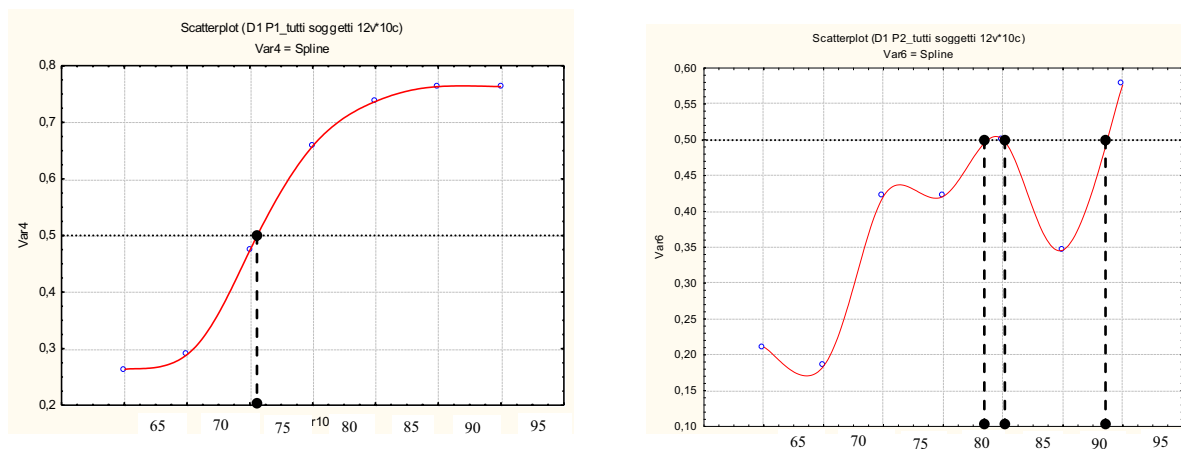


Figure 3. Example of PSE for experimental situation in which direction of movement (D) is congruent with the position of Ss (P) – curve on the left – and not – curve on the right.

Using the method of constant stimuli, PSE is obtained transforming the percentage of correct answers in z points. For each condition, we therefore calculate the proportion of the answers “longer than” to calculated PSE. However, in that conditions in which the direction of the presentation of the stimuli was opposite to the position of Ss, it was impossible to calculate the PSE (such as in Figure 3, left).

In figure 4 results are shown divided by the direction of movement (D) and the position of Ss (P). As it can be observed, in the upper section of the figure results are consistent with Benussi: When temporal intervals are shorter (< 1000 ms), the spatial distances are perceived as shorter while when temporal intervals are longer, the spatial distances are perceived as longer as well (see Fig. 2). When D and P are not in agreement one with each other (lower section of figure 4) data fluctuate around the average value regardless of the duration of the temporal interval. In other words, we can say that the disagreement between the direction of movement and the position of Ss covers the tau effect.

In conclusion, it is possible to say that this experiment confirms Benussi’s hypothesis (eg. Gelb, 1914; Sholz, 1924; Bill & Teft, 1969; 1972): the judgment about the perception of space distances and time intervals are not independent. Regarding the difference between the situation in which space and time were “in agreement” and the situation in which they are not in agreement, even if these data need further investigations, we might surmise a possible relation with peri-personal and extra-personal space. This hypothesis – which has to be tasted – is strictly related with the difference between our “modern” apparatus and Benussi’s one. Other studies found similar differences (Collyer, 1977).

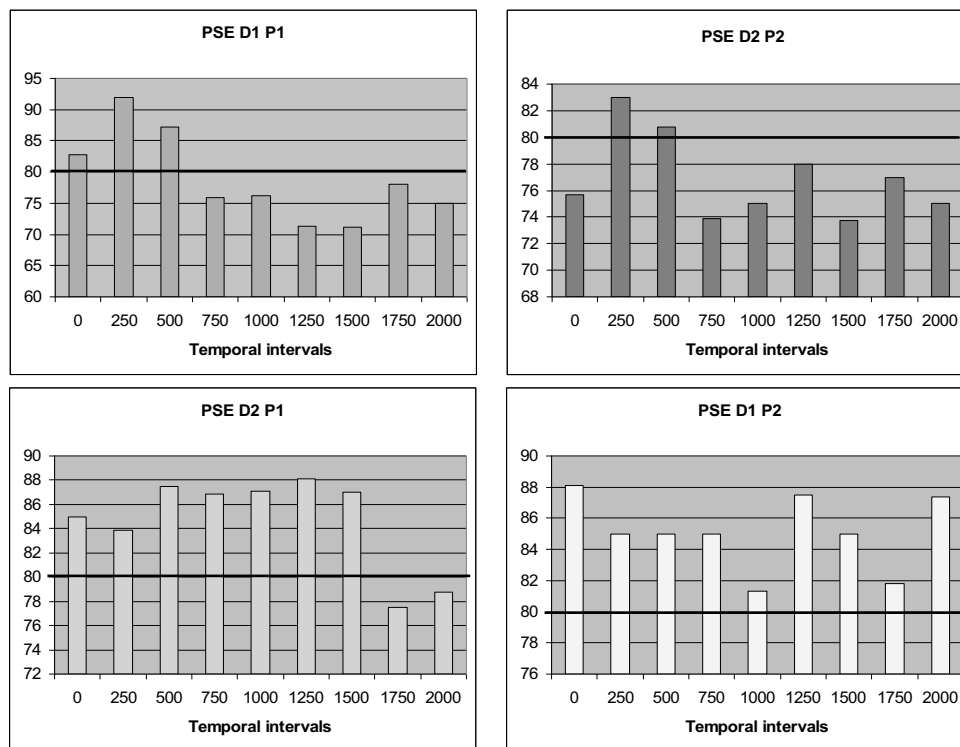


Figure 4. Values of PSE divided by direction of movement (D) and position of Ss (P). D1 correspond to the direction left to right, while D2 correspond to the direction right to left; P1 is used when Ss is on the left of the central lights while P2 is use when it is on the right.

Another possible explanation is related with the cognitive strategy participants use to give their judgment: it is possible that, for their comparison, they use the first stimulus as a sort of “anchor”. Only when the “anchor” coincides with *Ss* the judgment is facilitated. To test this hypothesis we are preparing a new experiment where temporal intervals between the three lights are longer than the one used here.

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