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Research Paper

Effect of Suggestion and Nature of Stimulus Rhythm on Temporal Estimation

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ABSTRACT

The effect of rhythm and suggestion has been studied extensively, but rarely has the concomitant effects of the two been under scientific scrutiny. Rhythm being composed of distinct temporal components such as pattern, meter, and tempo, is perceived differently by different people. Each feature requires different computational processes: meter involves representing repeating cycles of strong and weak beats; pattern involves representing intervals at each local time point which vary in length across segments and are linked hierarchically; and tempo requires representing frequency rates of underlying pulse structures. (Thaut et al., 2014) On the other hand, different human beings receive and process suggestions in different manners. The way they evaluate suggestions are contingent on their own unique history and mental frame at that particular instance. In this paper, the effects of rhythm and suggestibility have been studied on 30 male university students. A temporally varied set of 8 regular and irregular beats were customized, with one standard beat. With each set of data, a corresponding set of suggestion was provided to each subject. Results were analysed using Chi-square and it was concluded that the nature of stimulus rhythm, coupled with the inducement of a state of mind through suggestion, has an effect on the fine discrimination abilities of temporal duration of the subjects.

Keywords: *Rhythm, Suggestion, Temporal, Discrimination*

Psychophysics was defined by Fechner in 1860 as "an exact science of the functional relations or relations of dependency between body and mind, or more generally between the bodily and mental, the physical and the psychical world."

In this particular experiment the method of constant stimuli has been used, which derives its name from the fact that a number of fixed (constant) stimuli are presented to the subject. A

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large number of items usually appear in random order. Each time the stimulus is presented, the subject makes a judgement. Thus for each of the stimuli the percentage of different kinds of judgements may be computed and an estimate of the threshold is made on the basis of the distribution for all the stimuli. A chi square statistic is a measurement of how expectations compare to results. The data used in calculating a chi square statistic must be random, raw, mutually exclusive, drawn from independent variables, and drawn from a large enough sample. In this particular instance, chi square has been employed to calculate and compare variables and results.

Detection, discrimination, identification, and judging (scaling) have been the primary measures of Ω studied by psychoacousticians. (Yost, 1993) In musical scores, the notation of time intervals that constitute a rhythm is based on simple integer relations, and rhythm can indeed be represented as a sequence of integers. (Sadakata, Desain, and Honing, 2006) The concept of beat-based perception of time can be traced back to William James who wrote that “subdividing the time by beats of sensation aids our accurate knowledge of the amount of it that elapses” (James, 1890, Vol. 1, p. 619). Improved accuracy of time perception based on beat-based stimuli has been demonstrated in a number of studies (Essens and Povel, 1985; Palmer and Krumhansl, 1990; Parncutt, 1994; Grube and Griffiths, 2009). According to Essens and Povel (1985), temporal patterns can be classified into two types: those that are conceivable in terms of a metrical framework and those that are not. In this context, a metrical framework is seen as a mental time scale used in specifying the temporal structure of a pattern. Essens (1983) also concluded that an accurate internal representation will be arrived at only if the temporal structure of a pattern enables an organization in which hierarchical levels relate as integers with prime factors 2 or 3.(Essens, 1983).

The results of functional magnetic resonance imaging to test whether there are two neural representations of rhythm depending on the interval ratio showed two patterns of brain activations; the left premotor and parietal areas and right cerebellar anterior lobe were active for 1:2:4 and 1:2:3 rhythms, whereas the right prefrontal, premotor, and parietal areas together with the bilateral cerebellar posterior lobe were active for 1:2.5:3.5 rhythm. These activation patterns depended on the ratio of the rhythms that were produced by the subjects rather than the ratio of the presented rhythms, suggesting that the observed activations reflected the internal representation of rhythm. These results suggested that there are two neural representations for rhythm depending on the interval ratio, which correspond to metrical and nonmetrical representations. (Katsuyuki Sakai, Okihide Hikosaka, Satoru Miyauchi, Ryousuke Takino, Tomoe Tamada, Nobue Kobayashi Iwata and Mathew Nielsen ,Journal of Neuroscience 15 November 1999, 19 (22) 10074-10081). Several studies have further demonstrated improved timing for regular compared to irregular sequences (e.g., Sakai et al., 1999; Patel et al., 2005; Grahn and Brett, 2007; Teki et al., 2011).

Psychological studies have proposed two types of rhythm representation depending on the interval ratio of the rhythm: metrical and non-metrical representation for rhythms formed with small integer ratios and non-integer ratios, respectively. (Sakai et al., 1999) Sakai et al.

(1999) used functional magnetic resonance imaging to test whether there are two neural representations of rhythm depending on the interval ratio the results of which correlated highly with the hypothesis.

Patel et al. (2005) found out that that for auditory patterns, a strongly metrical structure did not improve overall accuracy of synchronization compared with isochronous patterns of the same beat period, though it did influence the higher-level patterning of taps. Synchronization was impaired in weakly metrical patterns in which some beats were silent. In an experiment conducted on metricality by Grube and Griffiths (2009), it was seen that subjective ratings of rhythmicality of sequences yielded main effects of strength of meter and ending. The data supported an increase in the precision of temporal pattern encoding for sequences with a higher-order metrical time framework.

A timing system is implicated in core regions of the motor network such as the cerebellum, inferior olive, basal ganglia, pre-supplementary, and supplementary motor area, pre-motor cortex as well as higher-level areas such as the prefrontal cortex. Teki et al. (2011), proposed a unified model of time perception based on coordinated activity in the core striatal and olivocerebellar networks that are interconnected with each other and the cerebral cortex through multiple synaptic pathways. Timing in this unified model is proposed to involve serial beat-based striatal activation followed by absolute olivocerebellar timing mechanisms. (Teki, Grube and, Griffiths, 2011).

Grahn and McAuley's (2009) experiments revealed that activation in auditory and motor areas was correlated with individual differences in beat perception, even when participants performed a timing task in which no behavioral differences occurred. The results support two conclusions. First, a bias toward beat perception is mediated by the activation of cortical circuits involved in rhythm production. Second, some individuals more readily engage these cortical beat-based circuits when making timing judgments than do others. (Grahn and McAuley, 2009) On the basis of recent neural and cross-species data on musical beat processing, Patel and Iversen (2014) argue that beat perception is a complex brain function involving temporally-precise communication between auditory regions and motor planning regions of the cortex (even in the absence of overt movement).

METHODOLOGY

Hypotheses

$N0_0$ - There is no association between rhythm (regular and irregular) and suggestion.
$N0_1$- There is no effect of suggestion on temporal estimation.
$N0_2$- There is no effect of rhythm of stimulus (regular and irregular) on temporal estimation.

Plan of experiment

Within subject design:

In this design, two beats (regular and irregular) have been selected and the suggestion to perform better by paying more attention has been introduced after the first set of data has been collected without any suggestion as such. The independent variable has been selected to be rhythm (both regular and irregular) and suggestion. Temporal estimation of duration has been selected as dependent variable. The constant error value is to be calculated using the formula- Constant Error (CE) = Point of Subjective Equality (PSE)- Standard Stimulus. Also, for each set of data from each subject, a point of subjective equality (PSE) is to be reached, which will be either ‘overestimation’, or ‘underestimation’, or ‘accurate’ judgement, based on their frequency of correct and incorrect responses.

Sample

A large sample of 30 (Hogg and Tanis, 1977) was employed to test the hypothesis. All subjects of the experiment were male. All of them were holders of a Bachelor’s degree and are currently pursuing their Masters from West Bengal State University. Judgmental sampling, which is a non-probability sampling technique wherein the researcher selects subjects to be sampled based on their knowledge and professional judgement has been employed in the present study.

Procedure

The data was collected individually from 30 post graduate students of West Bengal State University. A comfortable location was chosen to eliminate the effects of noise as far as practicable. Instructions were provided repeatedly and comprehensively. Earphones were provided to the subject and they were asked to pay attention as closely as possible. The order of the beats were randomized beforehand to prevent the occurrence of practice effect. For the first set of data, the subjects were presented with regular beat followed with a minute pause by irregular beat and were asked to effectively judge which one played for a longer duration. For the second set, the similar routine was followed, with the exception that this time a suggestion to pay more attention and to do better was provided to the subjects. For the other condition, the subjects were similarly asked to discriminate between the lengths of two sets of regular beats and respond which one played for a longer duration. In the final set, the same routine was followed but for the exception that a suggestion to listen closer and to do better was provided which the subject was actively involved in giving data. After data collection, the point of subjective equality of each set was estimated, based on the frequency of correct and incorrect responses. After data collection, the constant error (CE) was consecutively found out. The sets of data were then statistically treated by using Chi square statistic. The rationale behind using Chi square is that we were on the lookout if the two variables of rhythm and suggestion are mutually dependent or independent.

A 4X3 chi-square statistic was also used to calculate the relationship between rhythm (regular and irregular), suggestion (with and without suggestion), and the frequency of underestimated, overestimated, and accurate responses.

INSTRUCTION

Without suggestion and Regular-Irregular beat-

"Please be seated comfortably and have the headphones on. You are to be presented with two kinds of beats for a very short duration of time. There will be a minute pause between the two beats. After each presentation, you are to judge and respond saying which of the two beats according to you played for a longer duration. Please report in case of any difficulty."

With suggestion and Regular-Irregular beat-
"You have to perform the same way as you have been doing for the previous set. Pay attention more closely. We will inform you in case you are doing poorly and in that case you have to focus more clearly. Please report in case of any difficulty."

Without suggestion and Regular-Regular beat-
"Now you are going to be presented with two similar beats followed by a brief pause. You are to simply discriminate and respond saying which one played for a longer duration. Please report in case of any difficulty."

With suggestion and Regular-Regular beat-
"You are to perform in the same way as you had been doing for the previous set. Pay attention more closely. We will inform you in case you are doing poorly and in that case you have to focus more clearly. Please report in case of any difficulty."

DISCUSSION

Table 1. 2X2 chi-square of the constant error (CE) values

Df	Critical value at 0.05 level	Critical value at 0.01 level	Obtained value	Result
1	3.84	6.64	6.90	Significant at 0.01 level

Table 2. 4X3 chi-square result table as computed using the frequencies of overestimation, underestimation, and equal judgement of duration under varying conditions of rhythm (regular and irregular) and suggestion (with and without).

Df	Critical value at 0.05 level	Critical value at 0.01 level	Obtained Value	Result
6	12.59	16.81	19.10	Highly significant at 0.01 level.

The analysis revealed that the 2 beats (Regular, Irregular) did significantly affect the suggestion in temporal estimation. Chi square results showed that the two variables that is, rhythm and suggestion are mutually dependent, hence leading to a rejection of all the null hypotheses. An examination of the effect of suggestion in the time estimation (overestimation and underestimation) showed that **over-estimation** was **decreased** and **under-estimation** and **equal estimation** were **increased** in case of **regular** beat with the help of **suggestion**. In

case of **irregular** beat, **under-estimation** was **decreased** but **over-estimation** and **equal estimation** were **increased** with the help of **suggestion.**
The second Chi-square analysis revealed that there is a significant difference between regular beat and irregular beat, both with and without suggestion.

INTERPRETATION

Putting it in plain terms, the change in rhythm did significantly affect the perceiver's ability of fine discrimination in both instances of suggestion and no suggestion. This essentially means that temporal estimation of regular beat is more accurate than its irregular counterpart, due to finer judgement that is made possible by the metricality of regular rhythmic beat. The results also support the hypothesis that suggestions do indeed induce a mental state wherein the judgements tend to come closer to accuracy. This finding thus, is in tandem with the findings of Essens and Povel (1985), according to whom a metrical framework is seen as a mental time scale used in specifying the temporal structure of a pattern, and that there is a significant increase in the precision of temporal pattern encoding for sequences with a higher-order metrical time framework. Metricality, in simple terms, refers to the periodic structure at multiple time scales in a single beat. In this regard, metricality hugely correlates with isochrony in a beat, as supported by Patel, Iversen, Chenn, and Repp (2005). Their finding was that beat perception and synchronization have a special affinity with the auditory system, meaning, the synchronicity of beats is pertinent to a much higher degree to our audition, than any other sensory systems. This finding too, is parallel to that of ours wherein the isochrony in regular rhythm led to far accurate judgements of duration than non-isochronous rhythm, in an auditory modality. Again, a finding by Essens (1983) that says accurate internal representation will be arrived at only if the temporal structure of a pattern enables an organization in which hierarchical levels relate as integers with prime factors 2 or 3 can be found relevant in this regard because regular rhythms serve as a catalyst in creating mental ratios by means of which judgement turns swifter as opposed to irregular rhythms of the same duration. In this instance, the study by Katsuyuki Sakai, Okihide Hikosaka, Satoru Miyauchi, Ryousuke Takino, Tomoe Tamada, Nobue Kobayashi Iwata and Mathew Nielsen (1999) holds special importance since it was a pioneering study that supported the hypothesis that the internal representations of 1:2:4 and 1:2:3 rhythms is synchronized with the activation of left premotor and parietal areas and right cerebellar anterior lobe respectively, and the parietal areas together with the bilateral cerebellar posterior lobe are active for 1:2.5:3.5 rhythm. This is also in tandem with the experimental findings of Sakai et al., (1999) who used functional magnetic resonance imaging to prove there are two neural representations of rhythm depending on the interval ratio. A timing system is implicated in core regions of the motor network such as the cerebellum, inferior olive, basal ganglia, pre-supplementary, and supplementary motor area, pre-motor cortex as well as higher-level areas such as the prefrontal cortex. Teki et al. (2011), proposed a unified model of time perception based on coordinated activity in the core striatal and olivocerebellar networks that are interconnected with each other and the cerebral cortex through multiple synaptic pathways. Timing in this unified model is proposed to involve serial beat-based striatal activation followed by absolute olivocerebellar timing mechanisms. (Teki, Grube and, Griffiths, 2011) All such findings point to the factors that aid in the distinguishing of the fine differences in duration for regular and irregular rhythms. Studies on informative and confirmatory suggestion styles, where in the former the experimenter presents task relevant information, and in the latter they inform the subjects of their failure, also affect performance. These two types of suggestion or feedback activate two different pathways in the brain. While informative suggestion trials elicit greater activity in the dorsolateral prefrontal ional reactions to failure thereby activating the amygdala, dorsal anterior cingulate cortex, and the thalamus (including the habenular). (Woo et al., 2015) In the present experiment, an informative style of suggestion was presented to the subjects, and thus, performance was actually improved in the trials with suggestion.

CONCLUSION

It can thus be concluded that, the nature of stimulus rhythm, coupled with the inducement of a state of mind through suggestion, has an effect on the fine discrimination abilities of temporal duration of the subjects of an all-male sample.

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