A stronger hallucination tendency enables human to perform better on spontaneous synchronization task

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Abstract

Synchronizing with the external stimuli is a common behavioral phenomenon of human. Here we use a simple behavioral task to show that human differs in their ability to vocally synchronize with the outer auditory stimuli based on their hallucination tendency. Without instructing them to synchronize, human of high hallucination tendency can better spontaneously synchronize with the external auditory stimuli. However, in another deliberate synchronization task, they only show average performance. These findings imply that hallucination can affect speech production through an unconscious approach while human's subjective control can inhibit its effect.

Introduction

When people hear music, they sometimes shake their leg or head following the rhythm of that music, even though they might not notice their dancing behavior. Such a kind of motion, unconsciously influenced by the rhythm of sound, is further studied by Assaneo et al. in their research about the "spontaneous synchronization to speech (SSS)" [1]. They asked the subjects to listen to sounds of syllables, pay attention to the syllables themselves, but at the same time whisper a syllable "tah" continuously.

According to how subjects' whisper follow the rhythm of the sound of syllables they hear, the subjects can be split into two groups: the "high synchronizer" and the "low synchronizer". The extent of synchrony (how rigorously they follow the rhythm) is calculated by the Phase Locking Value (PLV). For more details about how PLV measures synchronization, please refer to the original paper.

Surprisingly, the subjects' PLV are mostly rather high or rather low, and only few subjects perform medially. The PLV result thus shows a bimodal distribution. Assaneo et al. also found out that high synchronizers tend to have more musical training and stronger frontal-temporal functional connectivity, but from these data, there doesn't seem to be a bimodal distribution. Therefore, the tendency to unconsciously follow a rhythm or PLV, might have some non-linear relationship with musical training or brain connectivity features (Fig.1).

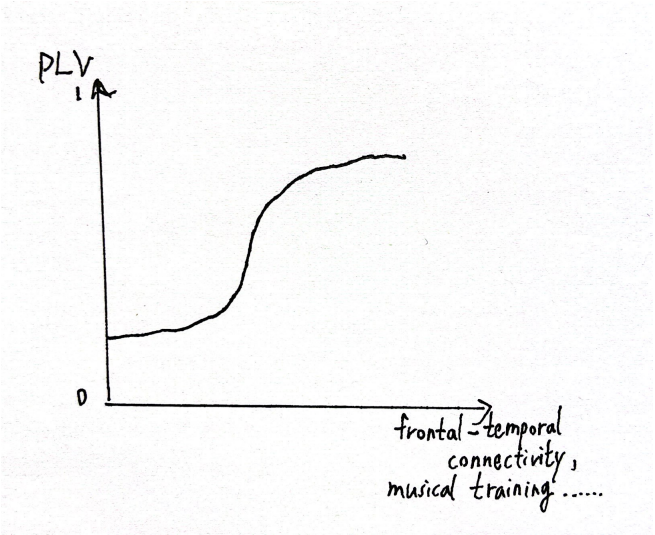

Fig.1 | A possible relationship between spontaneous synchronization (PLV) and frontal-temporal connectivity & musical training.

Trying to find more features of this phenomenon, this research will apply the SSS procedure to auditory verbal hallucination (AVH) patients.

AVH patients sometimes hear sound of speech when no such sound is actually presented to him/her. Some evidences showed that AVH might come from previous experience, [2] namely, the hallucination sound they hear might actually be the sound they heard before. Also, when hallucinating, there's usually tiny movements in the patients' sound production system, for example throat. In such cases, AVH is a kind of action, which is too weak to produce real sound, but the auditory effect can be clearly perceived by the patients.

The mechanism of such an aberrant auditory-motor relationship in AVH might overlap with the auditory-motor related mechanism in SSS. This research will try to test this possibility.

Methods

Participates (N=10) were instructed to complete two behavioral tasks. In the first task (distracted task) participants listened to a rhythmic train of syllables at 4.5 syllables/s while concurrently whispering the syllable 'tah' for 30 seconds. Their voices were covered by the sound of syllables from the headphone and they were required to remember the syllable they have heard so that attention was distracted from whispering [1]. In the second task (focused task) participants listened to the same rhythmic train of syllables, however, this time they were instructed to try their best to synchronize their whisper with the sound of syllables. PLVs were then

computed between participants' sounds and sound of syllables in both tasks to evaluate how coherence they were. In addition, participants were required to complete a questionnaire to rate their rating [3]. Ratings were linearly fitted with PLVs to investigate their relationship.

Results

Since the tasks need to be conducted in a extremely silent environment, three of the ten participants' data were excluded due to high environmental noises. Among all seven successful trails, higher rating participants shows higher PLVs in distracted task (Fig.2), meaning they synchronize with rhythm of syllables better when their attention is distracted.

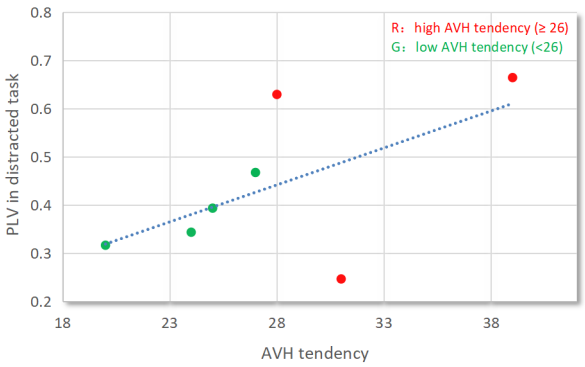

Fig.2 | AVH tendency versus PLV in distracted task. Higher rating participants have higher PLVs in the distracted task. participants are devided into two groups based on their rating shown in red dots and green dots.

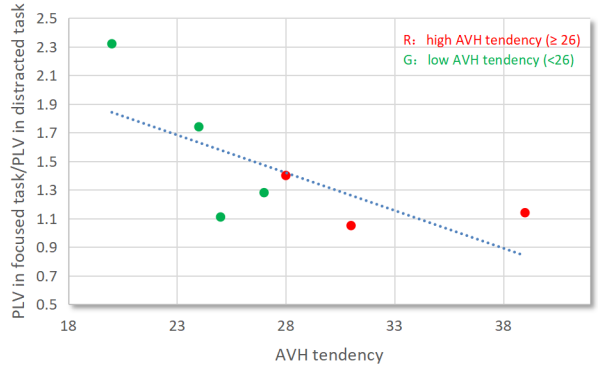

Fig.3 | AVH tendency versus PLV in focused task divided by PLV in distracted task Higher rating participants (shown in red dots) shows lower increase rate in PLV when they focus their attention on the task compared with low rating participants (shown in green dots)

However, in the focused task, higher rating participants' PLVs aren't significantly higher than lower rating participants (Fig.3). This means when focusing their attention on the task, higher rating participants show lower increase rate in PLV compared with low rating participants.

Discussion

Above all, due to the lack of subjects, no rigorous conclusion can be made. However, in both Fig.2 and Fig.3, patterns are obvious that high AVH tendency subjects are more likely to become high synchronizers, and when unconsciously synchronizing, they tend to synchronize more accurately, closer to their best performance in the second test. It seems that AVH tendency perhaps have positive correlation with spontaneous synchronization tendency. In future studies with real AVH patients and more subjects, we'll look closer into this pattern.

The bimodal distribution of PLV can not be observed clearly in this research, also due to a lack of samples. Generally, from our data, high AVH tendency patients tend to be closer to the edge (too high or too low). This might be further explored in the future experiments, too.

If those patterns still exists when more subjects are tested, this might imply that AVH mechanism interfere with SSS mechanism. For example, it might do so by making synchronization more easily become spontaneous with less musical training.

In addition to behavioral results, AVH patients shows low frontal-temporal functional connectivity, [4] while this is more correlated with low synchronizers. After all, the synchronization task needs to let the action (more frontal located motor areas) follow the sound (more temporal located auditory areas). What if, in future experiments, AVH patients really have more tendency to spontaneously synchronize?

One possibility is that, SSS is a choice, rather than ability. To make an ability stronger, connectivity might need to be stronger; to make an unconscious choice more likely to be chosen, connectivity doesn't necessarily need to be stronger or weaker. Weaker connectivity in AVH's case might also lead to less precise inhibition control system: without a conscious intention to do so, synchronization might be inhibited, and the original rhythm of speech can be maintained.

References

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