Disconnected speech and altered peripersonal space: bridging language and motricity in schizophrenia

Francesca Magnani[1;2], Linda Dori[1], Veronica Sordi[1], Alberto Dell'Eva[1], Francesca Ferroni[1], Matteo Tonna[1;3]

1.Department of Medicine & Surgery, Unit of Neuroscience, Univeristy of Parma, Parma, Italy; 2. Department of Local Mental Health, AUSL Piacenza, Piacenza, Italy; 3. Department of Local Mental Health,AUSL Parma, Parma, Italy

Introduction

Self-embodiment processing rests on an integrated sensorimotor network, whose disruption can be detected along the entire schizophrenia spectrum and long before the onset of psychosis. **Sensorimotor integration processing is particularly relevant for defining the peripersonal space (PPS)**, which has well-defined boundaries, and the plastic property to be shaped by different motor and social stimuli. **Patients with schizophrenia show a reduced PPS size and blurred PPS boundaries, due to an underlying impairment of multisensory networks.**

An early disruption of sensorimotor networks, which are crucial for embodiment, may also play a role in the language disturbances often seen in schizophrenia patients. In fact, **anatomically and functionally, sensorimotor and language processes form a unique integrated system, as a result of the reuse/exploitation of pre-existing sensorimotor circuits for the development of language during evolution.** Indeed, a maladaptive over-expression of evolutionary-developmental trajectories towards language may have exposed the human species to a disruption of embodiment processes, at the core of schizophrenia vulnerability.

Despite the fact that language and sensorimotor circuits share intertwined evolutionary and developmental pathways, and that both are specifically impaired in schizophrenia, no study to date has investigated a possible link between the two domains. We believe that **the search for putative linguistic-sensorimotor biomarkers could refine the early detection of psychotic vulnerability.**

Objective

Our study aims to explore the relationship between sensorimotor and language impairments in patients with schizophrenia (SCZ), by assessing possible correlations between PPS parameters (taken as a proxy for impaired multisensory integration) and language connectedness as assessed by Speech Graph Analysis (see Mota et al., 2014).

Methods

16 SCZ (mean age: 34.4,SD 9.51; 25% female, N=4) had been rectuited at the University of Parma (Italy). Participants underwent two different tasks:
- **PPS task**, to estimate PPS size and boundaries definition before and after a social stimulation, as measures of the integrity of multisensory integration processing.
- **Speech task**, to obtain speech recordings from which to derive parameters concerning speech connectivity, following the SpeechGraph Analysis method.

SCZ were also administered the TLC (Thought and Language Communication scale).

Figure 1. Visuo-tactile integration task based on virtual reality

Using a **validated multisensory integration task based on virtual reality** (see Ferroni et al. 2022, Figure 1), we obtained two parameters: the **PSE** (Point of Subjective Equality) and the **DL** (Difference Limen), expressing respectively the PPS **size** and the **definition of PPS boundaries**. PSE and DL were calculated before and after performing a social task (i.e., reproducing a construction with bricks in collaboration with an experimenter). A **smaller PPS size with less defined boundaries suggests some impairment in the effectiveness of multisensory integration mechanisms.**

Participants were recorded while describing eight selected TAT pictures. The audio-files were transcribed and entered into the SpeechGraph Java software, to obtain the **Speech Graph Attributes -SGA (i.e., measures expressing speech production, connectivity and recurrence**; see Mota et al. 2014). Specifically, the **LSC (Largest Strongly Connected Component)** and the **LCC (Largest Connected Component)** are considered to be the most meaningful measures expressing the level of speech connectivity and sorting the patients with schizophrenia from the controls.

Analyses

Given the small sample size, we performed only explorative and preliminary analyses. First, we examined qualitatively the PPS behavior in SCZ after the social stimulation task, comparing it with data observed in the healthy control sample. Second, we explored correlations between the PPS features and measures of language impairment (SGA and TLC scores), using the Pearson and Spearman correlations where appropriate.

Results

SCZ tended to show a smaller PPS size compared to controls. From a qualitative observation, the social stimulation task induced a restriction of PPS size in SCZ, while contributing to a better definition of PPS boundaries. This behavior was qualitatively different from that observed in a contextually recruited sample of 48 healthy controls (Ferroni et al., in preparation), who did not show any changes in PPS size after the task.

In terms of correlations between PPS measures and speech connectivity, our data showed that a **smaller PPS size at baseline (i.e., higher PSE values) is associated with lower speech connectivity(higher LSC and LCC values, see Figure 2), and lower number of nodes.** In addition, higher density correlated with less defined PPS boundaries at baseline (higher DL values).

Higher levels of language impairment as assessed by the clinical scale (TLC total score) also correlated with less defined PPS boundaries as induced by the social task (higher DeltaDL values, see Figure 4).
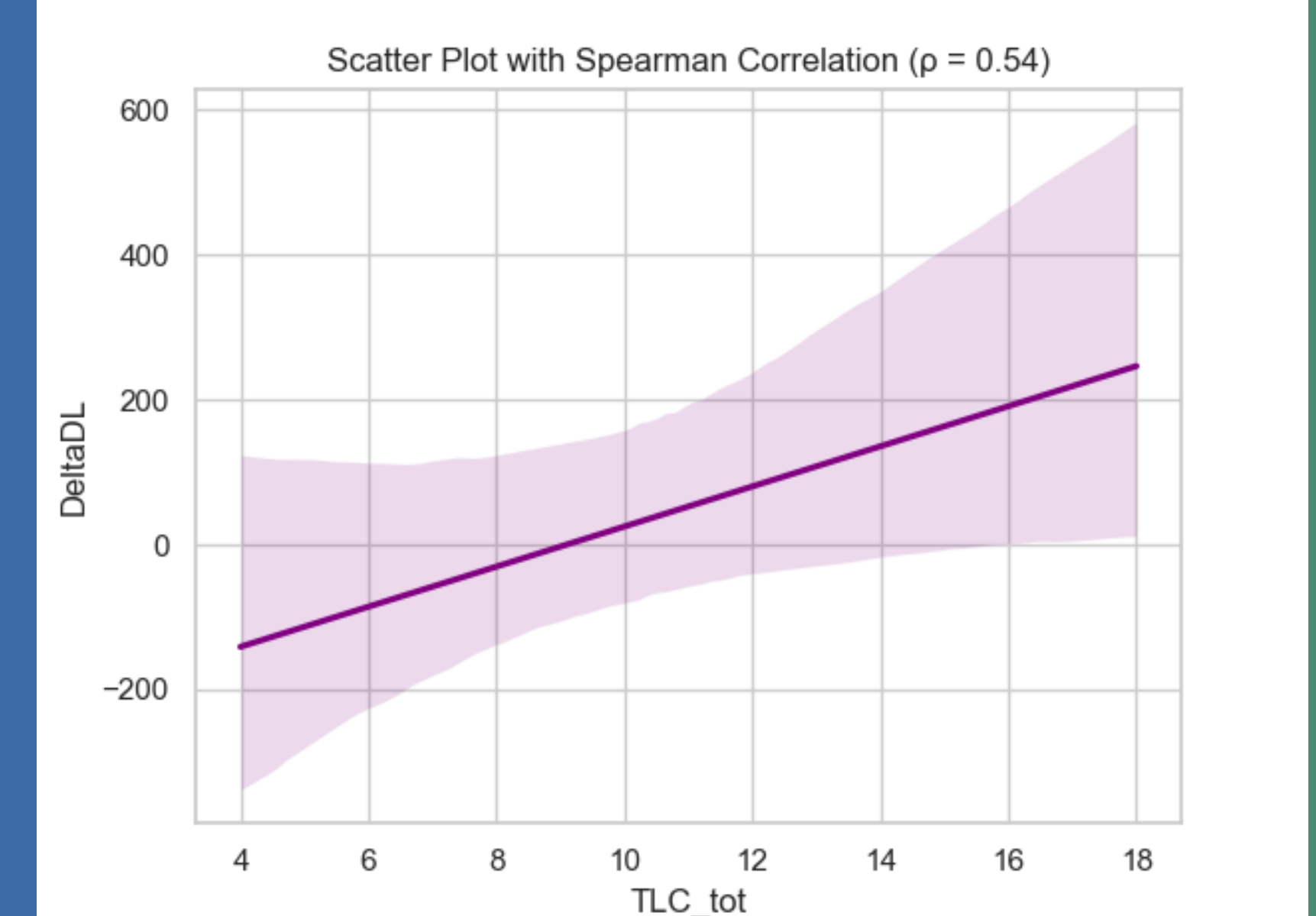

Figure 3. Graphic representation of the correlation between TLC scores and DeltaDL, expressing the change in PPS boundaries definiton after the social stimulation
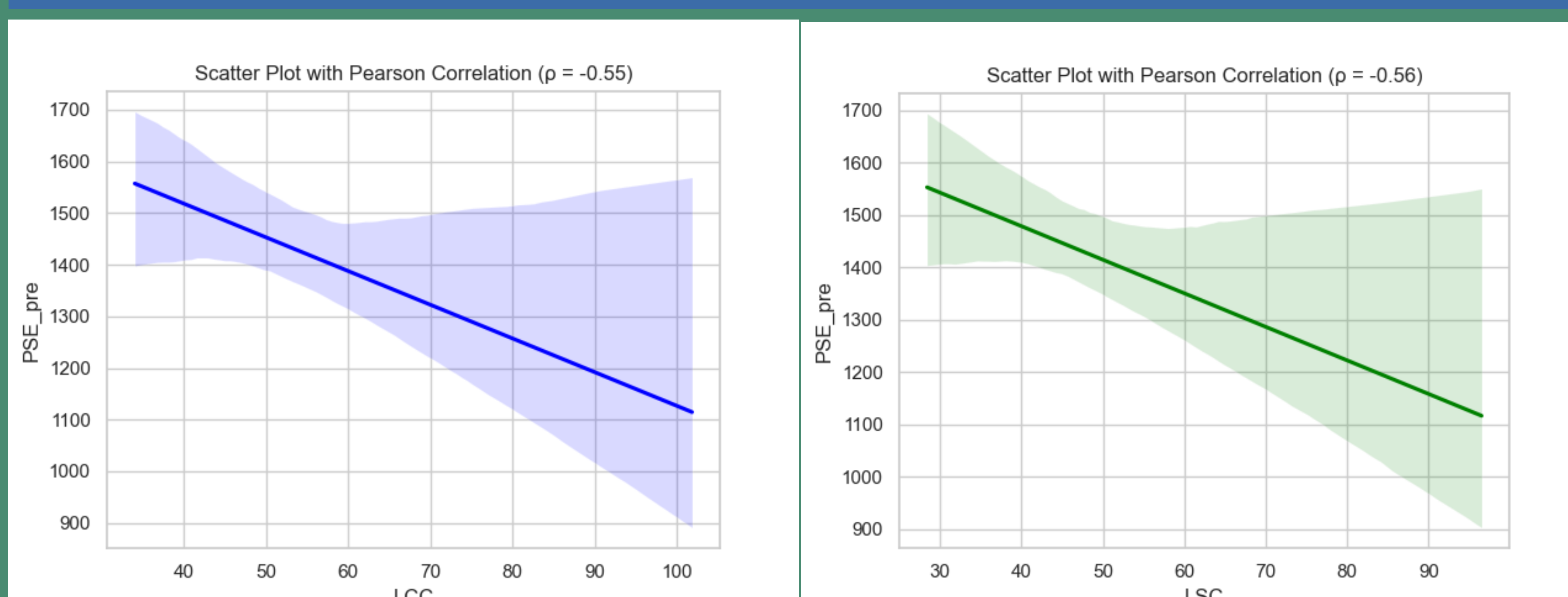
Conclusion

Our results, although preliminary given the small sample size, seem to corroborate the potential link between motor and language dimensions in schizophrenia. Specifically, patients with greater impairment in sensorimotor integration mechanisms also showed less connected speech, suggesting a **common pattern bridging language and motor disorganization, hypothetically based on the neurodevelopmental origin of the disorder.**

Figure 2. Graphic representations of correlations between LCC, LSC and PPS size at baseline

References

1. Ferroni F, Ardizzi M, Magnani F, Ferri F, Langiulli N, Rastelli F, et al. Tool-use Extends Peripersonal Space Boundaries in Schizophrenic Patients. Schizophr Bull. 2022;48:1085–93.
2. Ferroni F, Gallese V, Soccini AM, Langiulli N, Rastelli F, Ferri D, et al. The Remapping of Peripersonal Space in a Real but Not in a Virtual Environment. Brain Sci. 2022;12:1125.
3. Mota NB, Vasconcelos NAP, Lemos N, Pieretti AC, Kinouchi O, Cecchi GA, et al. Speech graphs provide a quantitative measure of thought disorder in psychosis. PloS One. 2012;7:e34928.
4. Mota NB, Furtado R, Maia PPC, Copelli M, Ribeiro S. Graph analysis of dream reports is especially informative about psychosis. Sci Rep. 2014;4:3691.
5. Tonna M, Lucarini V, Borrelli DF, Parmigiani S, Marchesi C. Disembodiment and Language in Schizophrenia: An Integrated Psychopathological and Evolutionary Perspective. Schizophr Bull. 2023;49:161–71.