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INTERNATIONAL DEVELOPMENT

Scientific validation

The effects of the Muscarà Rehabilitation Method for Stuttering (MRM-S) on phonolog

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INTRODUCTION

- A discrete body of research has been pursued to study the link between phonology and stuttering research in the stuttering literature (Sasisekaran, 2014).
- A number of studies have used rhyme judgment to study phonological processing in People Who Stutter (PWS) (Weber-Fox et al., 2008, 2010).
- Rhyme judgment of a word pair involves segmentation of the initial word in the pair into its constituent onset and rhyme, followed by holding this information in short-term memory and then comparing this information with that of the target word (e.g. CANE–PANE).
- Weber-Fox and colleagues (2008) tested behavioral (percent errors) and event-related brain potential (ERP) elicited during rhyme judgment in Children Who Stutter (CWS) and age-matched Children who do Not Stutter (CNS). They found that CWS made more errors in the task. The groups were comparable in the Rhyming effect (RE) waveform associated with the rhyme decision, but differences were observed in the peak amplitude of the contingent negative variation (CNV), associated with the processes involved in holding and comparing two words for rhyme.
- According to the diffusion model (Ratcliff & McKoon, 2008), observed response times (RTs) following choice behavior, such as deciding if a word pair rhymes or not are made up of two parts. One corresponding to the time required to make a the decision (i.e. drift rate – v), the other corresponding to time related to other non-decision processes, including monitoring the perceptual features of a target stimulus and the motor execution of task response (i.e. non-decision time – ter).
- The Muscarà Rehabilitation Method for Stuttering (MRM-S) is a speech-motor intervention focused on the mechanisms of speech production (breathing, vocal fold vibration, articulation of sounds) in order to increase 1) the awareness of new language-related sounds are produced and 2) the ability to monitor feedback as a person speaks with reduction in the severity or frequency of stuttering.

MATERIALS AND METHODS

Participants

- 21 PWS subjects (18 males) undergoing a 1-week MRM-S course
- Mean age: 21.429 (± 3.918)
- Mean education: 14.667 (± 2.415)

Experimental Design

- **Follow-up design**: participants were tested just before beginning (**Time 0**) and after completing (**Time 1**) a one-week, daily intervention using the Muscarà Rehabilitation Method for Stuttering (**MRM-S**).

RHYME JUDGMENT TASK

- **Target words** drawn from
- **Target words selection**
- **Prime words** chosen from
- **Pseudo-words** generated
- **64 Targets** (32 words)

ANALYSES AND RESULTS

- **Step 1 Aim:** To evaluate the effects related to **Session, Word** and **Rhyme** experimental factors between **Time 0** and **Time 1**.
- **Step 2 Aim:** To test the generalizability of any effect across **subjects** and across **items (random-effects)** and any source of variability ascribable to word-onset difficulty.
- **Step 3 Aim:** To test the effects related to **Session, Word** and **Rhyme** experimental factors between **Time 0** and **Time 1** measured in terms of drift rate (v) and non-decision time (ter) parameters related to the **diffusion model**.

Analysis Level	Statistical Model	Scaling Design	# Cases Excluded	DF	Planned Contrasts	Result	F	p	dfn	dfd
STEP 1	...	...	...	...	...	...	...	...	...	...
STEP 1	...	...	...	...	...	...	...	...	...	...
STEP 1	...	...	...	...	...	...	...	...	...	...
STEP 1	...	...	...	...	...	...	...	...	...	...
STEP 1	...	...	...	...	...	...	...	...	...	...
STEP 1	...	...	...	...	...	...	...	...	...	...

(Note: Significant Time (T1, T2), Session (Start, Finish), Rhyme (Rhyme, non-Rhyme), Word effects, Pseudo-Words)

STEP 1 – STEP 2

- The **three-way interaction among time, session and word** was significant in both the analyses by subjects (F1) and by items (F2) and is reliably **generalizable** across **PWS subjects** and **across words**. Decomposing the interaction we observed that PWS were overall faster at T1 with respect to T0 for both conditions across both sessions, however RTs decreased more for words in Session 2 at T1 with respect to T0.

This result suggests that the MRM-S program exerts a significant influence on phonological processing in PWS. In addition, the short-term RT decrease observed only for words in Session 2 after MRM-S intervention (1-week) is in line with the hypothesis that stuttering may be related more to monitoring of the phonetic aspects of speech, which reflect the real-time characteristics of the spoken words and are actualized in time, rather than of time-invariant phonological representations. (Vasić and Wijnen, 2005).

STEP 3

- The observed "Time" x "Rhyme" x "Word" interaction with a greater decrease in ter values at T1 only for **phonologically rhyming word pairs** only supports observations of an overall language processing system that is sensitive to more **general cognitive control** demands in PWS.

MRM-S seems to exert a beneficial effect on more general and different cognitive processes involved in rhyme monitoring, such as self-monitoring for subtle phonetic irregularities (Vasić and Wijnen, 2005), pre-articulatory monitoring of speech motor commands (Max et al., 2004) or monitoring of auditory (external) feedback, occurring more downstream with respect to phonological monitoring and encoding.

- **Step 1 Results**
  1) A significant **Time*Session*Word** interaction effect
  when looking response **speed** (both by subject (p< .05) and
  (p< .05).
  Post-hoc analyses reveal that the effect is driven by an
  speed in answering to **Words** in **Session 2** (Figure 1).
  2) No significant main effect of **Time** or interaction effects
  response accuracy.
- **Step 2 Results**
  1) The **Time*Session*Word interaction effect** is general
  (both **subjects** and **items** (random-effects) and is not influ
  word onset difficulty (ANCOVA).
- **Step 3 Results**
  1) A significant **Time*Rhyme*Word** interaction effect (p
  evident for **non-decision time** (ter).
  2) *Post-hoc* analyses reveal that the effect is driven by a
  decrease in ter parameter estimate when responding only
  and only in the **rhyming condition** at T1 (Figure 2).
  3) No significant main effect of **Time** or interaction effects
  rate (v).

CONCLUSIO

We suggest that MRM-S
judgment performance
individuals who stutter by
capacity of a central
system, namely acting up
processes involving ph
and auditory aspects

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Augmented multisensory feedback stimulation for improving stuttering

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INTRODUCTION

Stuttering is a speech disorder involving fluency disruptions like repetitions, prolongations, and blockages, often leading to emotional distress and social withdrawal. Here, we present Augmented Multisensory Feedback Stimulation (AMFS), a novel personalized intervention to improve speech fluency in people who stutter (PWS). AMFS includes a five-day intensive phase aiming at acquiring new skills, plus a reinforcement phase (6-9 months with a weekly session) designed to facilitate the transfer of these skills across different contexts and their automatization into effortless behaviors. The concept of our intervention derives from the prediction of the neurocomputational model D rections into Velocities of Articulators (DIVA) (Tourville & Guenther, 2011). The treatment applies dynamic multisensory stimulation to disrupt PWS' maladaptive over-reliance on sensory feedback mechanisms, promoting the emergence of participants' natural voices.

Figure 1. The figure illustrates some of the equipment used for AMFS. The left image shows a participant with biofeedback sensors during a fluency assessment session. The right image shows a participant during a rehabilitation session in the post-intensive phase, which includes auditory (microphone + headphones), visual (monitor), and vibrotactile (vest) stimulation.
The figure shows some pieces of the equipment in this study and is protected by a patent (patent number: 102020000021810, Italian Patent and Trademark Office, De Vita & Muscarà, 2020)

AMFS

aims are to (i) disengage the automaticity of the overlearned response of stuttering; (ii) achieve the desired motor target, namely PWS' natural fluent voice; (iii) consolidate the motor plans necessary for the production of the natural voice, promoting and reinforcing re-engagement with the new target to create an automatic alternative strategy over the stuttering response; and (iv) foster system flexibility to perturbation, thus generalizing the alternative fluent response across different conditions.
The AMFS training comprises three main activities: (i) auditory stimulation, (ii) visual stimulation, and (iii) visual plus somatosensory stimulation.

MATERIALS & METHODS

Participants: The PWS group comprised forty-six Italian native speakers (40 males, mean age = 25.9 ± 7.5), whereas the control group included 24 non-stuttering

OUTCOME MEASURES

1) Primary: The Stuttering Severity Instrument (Fourth Edition (SSI-4)

2) Secondary: Physiological Parameters

The physiological measures included heart rate as measured through blood volume pulse (BVP), electromyographic (EMG) mean amplitude, skin conductance response (SCR), peripheral temperature, and respiratory rate (number of breaths per minute). The physiological parameters were collected using the BioGraph Infiniti (version 6, Thought Technology Ltd., Montreal, QC, Canada), which recorded the parameters and provided the previously mentioned measures as outcomes. The physiological parameters were collected through a plethysmograph on the left hand's third finger, two cutaneous conductance detectors on the second and fourth left fingers, and two stripes positioned around the thorax and the abdomen to control lung ventilation.

Experimental Procedure
In the PWS group, primary and secondary outcome measures were collected at three different time points: before starting the training (T0), immediately after the intensive phase (T1), and at follow-on, namely during the reinforcement phase (T2), two to four months after the end of the intensive phase. The outcome measures were collected only once for the control group.

Statistical Analyses
PWS' baseline characteristics were reported as median and interquartile range and frequency and percentage for continuous and categorical variables, respectively. Considering the primary endpoint, namely stuttering severity measured through the SSI-4, the effect of time (T0, T1, and T2) was analyzed in the PWS group to measure the changes induced by the treatment. The stuttering severity score was computed by summing all non-zero variables that constitute SSI-4, indicating the presence of a stuttering condition. The effect of treatment was performed using non-parametric statistics, namely the Friedman test. Pairwise comparisons were performed using Conover's all-pairs test, with Bonferroni correction applied for multiple comparisons. PWS' SSI-4 scores at different time points were contrasted with the control group's scores using the Mann–Whitney test for independent data. All statistical analyses were performed using R statistical software version 4.0.4

RESULTS

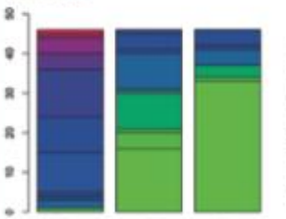

Figure 2. The figure depicts the different performance levels in SSI-4 total scores. The y-axis represents the number of participants at each time point (x-axis) and their levels of performance (depicted through different colors). Specifically, the color of the bar plot identifies a gradient of disease. The green color represents a disease score equal to 0, the shades of blue represent a disease score between 1 and 15 (lighter blue indicates a lower score, while darker blue indicates a higher score within the 1-15 range), and the red represents a disease score equal to 16.

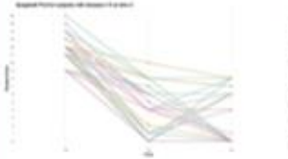

Figure 3. Individual trends in SSI-4 total scores. The Spaghetti plot shows subjects with a disease score ≥ 9 at T0. A cutoff value of 9 was chosen, representing the third quartile of the disease variable, thus identifying the subgroup of patients with a worse disease condition. As can be seen, all subjects experienced an improvement at T1, whereas more heterogeneous patterns emerged at T2, with some participants showing enhanced improvements, others showing stable performance, and others worsening compared to T1.

The table summarizes the descriptive values (median and interquartile range) of physiological indexes during the spontaneous speech conditions at the three different time points for the patients' group and the only spontaneous speech measurement in the control group. Significant comparisons within and between groups are highlighted in bold.

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