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

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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., 2005, 2008).
- 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 – *t0*).
- The Muscara' 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 how 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.

AIM OF STUDY

We used a rhyme judgment task in order to investigate the effects of the MRM-S on phonological processing in PWS before and after MRM-S intervention (1-week).

We used a diffusion model to analyze response times for rhyme judgments in order to see if MRM-S specifically affects decisional processes influenced by the phonological representations of the stimuli (*v*) or more general non-decisional processes related to rhyme monitoring of the stimulus and to the motor execution of task response (*t0*).

MATERIALS AND METHODS

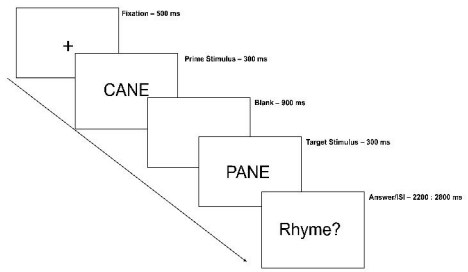
Participants

- 21 PWS subjects (18 males) undergoing a 1-week MRM-S course
- Mean age: 21.429 (±3.919)
- 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 JUDGEMENT TASK



Stimuli

- **Target words** drawn from Italian word databases (Corpus e Lessico di Frequenza dell'Italiano Scritto (CoLFIS). http://linguistica.sns.it/CoLFIS/Home.htm; Della Rosa *et al.*, 2010); within-lemma frequency >90 percentile.
- **Target words selection parameters** Lenght (long/short : 40/24), Onset Letter (Consonant/Vowel : 44/20), Concreteness (Concrete/Abstract : 32/32).
- **Prime words** drawn from the same databases as words, matched to targets for i) frequency, ii) length, iii) concreteness, iv) familiarity.
- **Pseudo-words** generated matching selected target words (#letters, minimum mismatch)

Task Design

- **64 Targets** (32 words/32 psuedo-words) x **2 Rhyme conditions** (Rhyme/non-rhyme), counterbalanced between sessions.
- 128 pairs repeated across **two sessions** (256 total).

Experimental Procedure

- Task administered using a 7" display **Android tablet** (Lenovo Tab 2 A7-30H) through an APP specifically developed with Android **libraries optimized** for recording response times (**ms**) and accuracy data on all conditions of the Rhyme Judgement Task.

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* (***t0***) parameters related to the **diffusion model**.

Analysis Level	Statistical Model	Statistical Design	# Factors Included	DEP	Parameter Estimated	Result	F	p	df1	df2
STEP 1	Rep Meas (RM) 2x2x2x2 ANOVA within subjects (F1)	2(Time) x 2(Session) x 2(Rhyme)x 2(Word)	4	RT	Mean (256 Items) by subject (21)	**Int Time*Session*Word**	4.282	**.05**	1	20
	Rep Meas (RM) 2x2x2x2 ANOVA within subjects (F1)	2(Time) x 2(Session) x 2(Rhyme)x 2(Word)	4	Accuracy	Mean (256 Items) by subject (21)	Int Time*Session*Word	.029	.87	1	20
	Rep Meas (RM) 2 (within) x 2x2x2 (between) ANOVA (F2)	2(Time) x (2(Session) x 2(Rhyme)x 2(Word))	4	RT	Mean (21 subjects) by item (256)	**Int Time*Session*Word**	4.582	**.03**	1	248
STEP 2	UNIANOVA 3 (between subjects), random effects (F1)	2 (Time) x 2(Session) x 2(Word), Subjects (random-effects)	3	RT	Mean (256 Items) by subject (21)	Int Time*Session*Word*Subject	1.173	.27	20	10516
	UNIANOVA 2 (between items), random effects (F2)	2 (Time) x 2(Session), Items (random-effects)	2	RT	Mean (21 subjects) by item (256)	Int Time*Session*Item Num	.765	.78	23	5083
	UNIANCOVA (F2)	2 (Time) x 2(Session) x Rating Word Difficulty	2	RT	Mean (21 subjects) by item (256)	Int Time*Session*Rating Diff	1.273	.28	2	123
STEP 3	Rep Meas (RM) 2x2x2x2 ANOVA within subjects (F1)	2(Time) x 2(Session) x 2(Rhyme) x 2(Word)	3	v	Mean (256 Items) by subject (21)	Int Time*Rhyme*Word	2.901	.10	1	20
	Rep Meas (RM) 2x2x2x2 ANOVA within subjects (F1)	2(Time) x 2(Session) x 2(Rhyme) x 2(Word)	3	t0	Mean (256 Items) by subject (21)	**Int Time*Rhyme*Word**	4.125	**.05**	1	19
Factors Specifications: Time (T0, T1); Session (Sess1, Sess2); Rhyme (Rhyme, non Rhyme); Word (Word, Pseudo-Word)										

- **Step 1 Results**
  1) A significant **Time*Session*Word interaction effect** emerges when testing response **speed** both by subject (p= .05) and by item (p= .03).
  Post-hoc analyses reveal that the effect is driven by an increase of speed in answering to **Words** in **Session 2** (Figure 1).
  2) No significant main effect of **Time** or interaction effects on response accuracy.
- **Step 2 Results**
  1) The **Time*Session*Word interaction effect** is generalizable to both **subjects** and **items** (random-effects) and is not influenced by **word onset difficulty** (ANCOVA).
- **Step 3 Results**
  1) A significant **Time*Rhyme*Word interaction** effect (p= .05) is evident for **non-decision time** (t0).
  2) *Post-hoc* analyses reveal that the effect is driven by a significant decrease in t0 parameter estimate when responding only to **words** and only in the **rhyming condition** at T1 (Figure 2).
  3) No significant main effect of **Time** or interaction effects for drift rate (v).

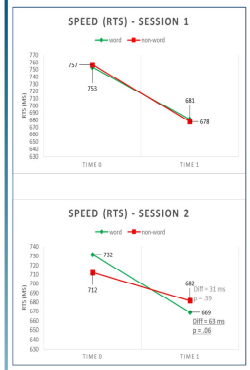


Figure 1

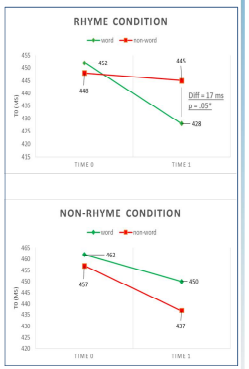


Figure 2

FINDINGS AND CONCLUSIONS

STEP 1 – STEP 2

- The **three-way interaction among time, session and word** was significant in both the analysis 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 *t0* 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.

CONCLUSION

We suggest that MRM-S affects rhyme judgment performance in a group of individuals who stutter by targeting the capacity of a central processing system, namely acting upon monitoring processes involving phonetic, motor and auditory aspects of speech.

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