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Indications for the facilitating effect of MIT repetition in aphasic patients

A study on regular aphasia tests, articulatory and phonological deficits
as predictors for facilitation of MIT repetition

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Background: Melodic Intonation Therapy is a speech production therapy for aphasic patients, in which melodic aspect of speech are used to improve speech production. The therapy has shown to be effective for a specific group of patients. Furthermore, MIT is a very intensive therapy. Therefore, there is relevance to know for which patients MIT is facilitating.

Aim: The main goal of this study is to determine indications for the facilitation of MIT repetition.

Materials and methods: In 11 aphasic patients, who are possible MIT candidates, normal repetition is compared to MIT repetition. This study analyzes the differences between patients that do or do not show facilitation for MIT repetition. There will be looked at scores on regular aphasia tests and articulatory or phonological problems shown in these tasks.

Results: Most patients do not show facilitation of MIT repetition. This is remarkable, because patients and therapists often report facilitation for MIT repetition. Only two patients showed facilitation and two patients showed decline for MIT repetition. The patients in whom facilitation was found suffered from articulatory difficulties.

Conclusions: In most patients examined in this study, MIT repetition does not facilitate speech production. Therefore, no predictors could be differentiated for the purpose of indicating MIT candidates.

Keywords: Aphasia, Melodic Intonation Therapy, facilitation, articulation.

INTRODUCTION

The aim of this study is to identify indications for the facilitating effect of MIT repetition. We analyze the scores on regular aphasia tests of possible MIT candidates and the articulatory and phonological deficits they show in these tasks. Thereby, we hope to determine predictors for the patients that show facilitation for MIT repetition.

Melodic Intonation Therapy, MIT, is a therapy developed by Albert et al. (1973). In this therapy, speaking is initiated through singing. MIT is based on the observation that aphasic patients with severely limited speech

production are capable of singing familiar lyrics (Smith, 1966; Sparks et al., 1974; Straube et al., 2008). Several studies showed an increase in speech production after MIT for patients who did not respond to other therapies (e.g. Albert et al., 1973; Baker, 2000; Belin et al., 1996; Bonakdarpour et al., 2003; Goldfarb & Bader, 1979; Marshall & Holtzapple, 1976; Naeser & Helm-Estabrooks, 1985; Schlaug et al., 2008; Wilson et al., 2006). However, this therapy is only effective for a very specific group of patients. Furthermore, the therapy needs to be given intensively (Sparks et al., 1974). It would be a waste of time to do the therapy with patients for whom it will not be effective. Therefore, there is a clinical relevance to determine which type of patients will benefit from MIT. Often, a short task is taken before starting therapy to determine if MIT facilitates speech production for this patient. In this task, a few sentences are sung with a patient. If a patient shows facilitation, this is an indication for starting therapy. Facilitation is proven to be an indication for therapy outcome in the study of Hickin et al. (2002) on phonological therapy for word-finding difficulties.

This study aims to determine criteria on regular aphasia tests, which therapists can use to identify possible MIT candidates. Furthermore, it analyzes the articulatory and phonological deficits shown in the speech production tasks. If successful, therapists no longer have to do a separate task to identify MIT candidates.

The present study is part of a larger study by Van der Meulen & Van de Sandt, currently running at Rijndam rehabilitation centre (Rotterdam). This is a clinical trial, examining the efficacy of MIT in chronic and sub-acute aphasic patients. At the end of that study, conclusions can be made with respect to the interaction of the MIT facilitation task and the effect of therapy. The findings of these two studies combined will give a more complete view on the indications for the facilitating effect of MIT.

BACKGROUND

Melodic Intonation Therapy

In Melodic Intonation Therapy, sentences are presented in a melodic pattern based on three notes (Sparks & Holland, 1976). The intonation pattern of the sentence is used with attention to the normal prosodic and stress patterns of the target phrases (see example).

Example of intonation patterns

‘Hoe	gaat	het?’	‘Goe-de	mor-gen’
(How	*are*	*you?)*	*(Good*	*mor-ning)*

In addition, sentences are intoned very slowly and tapped out in a syllable-by-syllable hand movement (Helm-Estabrooks, 1983). Simplified, the therapy design is as follows; the patient sings a sentence in unison with the therapist and they both make the syllable-by-syllable hand movement. If successful, the therapist slowly fades out. Thereafter, the patient has to repeat the sentence in the MIT way (sung + hand movement). The aim of

this therapy is that in the end, a patient is able to pronounce the sentence independently and without use of melody.

Besides the reported improvement in speech production after MIT (e.g. Albert et al., 1973; Baker, 2000; Belin et al., 1996; Bonakdarpour et al., 2003; Goldfarb & Bader, 1979; Marshall & Holtzapple, 1976; Naeser & Helm-Estabrooks, 1985; Schlaug et al., 2008; Wilson et al., 2006), MIT is also reported to improve auditory comprehension (Albert et al., 1973; Marshall & Holtzapple, 1976) and articulation (Marshall & Holtzapple, 1976; Sparks & Holland, 1976; Wilson et al., 2006;). Furthermore, after MIT, reduced frequency of paraphasic errors is observed (Sparks et al., 1976) and patients are reported to be less perseverative and to show a decrease in stereotype behaviour (Marshall & Holtzapple, 1976).

Candidacy for MIT

MIT is only effective for a very specific group of patients (Sparks & Deck, 1994). Several studies have shown indications for the effect of MIT (see table 1). Table 1 presents the indications for a good MIT candidate.

Table 1 Indications for the facilitating effect of MIT.

	Indications	
Speech production	Non-fluent	(van der Lugt-van Wiechen, 1995; Naeser & Helm-Estabrooks, 1985)
	Severely impaired repetition	(Sparks & Deck, 1994; Sparks et al., 1974)
Comprehension	Good auditory perception	(Albert et al., 1973; Helm-Estabrooks, 1983; van der Lugt-van Wiechen, 1995; Naeser & Helm-Estabrooks, 1985; Sparks & Deck, 1994; Sparks & Holland, 1976)
Articulation & Phonology	Articulation problems	(Naeser & Helm-Estabrooks, 1985; van der Lugt-van Wiechen, 1995)

Patients who are good candidates for MIT are also reported to show (some of) the characteristics presented in table 2. Furthermore, MIT is reported to be effective for patients with Broca aphasia (Belin et al., 1996; van der Lugt-van Wiechen, 1995), global aphasia (van der Lugt-van Wiechen, 1995) and for patients with apraxia of speech (van der Lugt-van Wiechen, 1995; Marshall & Holtzapple, 1976; Sparks & Deck., 1994).

Table 2 Characteristics of good MIT candidates

	Characteristic	
Speech production	Severely limited speech production	(Albert et al., 1973; Helm-Estabrooks, 1983;van der Lugt-van Wiechen, 1995; Naeser & Helm-Estabrooks, 1985; Sparks & Deck, 1994)
	Limited spontaneous utterances	(van der Lugt-van Wiechen, 1995)
	Neologistic, perseverative utterances	(Sparks & Deck, 1994)
	Naming pictures is severely impaired	(Sparks & Deck, 1994)
	Show self correction	(Sparks & Deck, 1994; Sparks et al., 1974)
Articulation & Phonology	Stereotype like articulation	(Sparks & Deck, 1994)
	Phonologic paraphasias	(van der Lugt-van Wiechen, 1995)
Other	Emotional stable	(Sparks et al., 1974)
	Good attention span	(Sparks et al., 1974)
	Buccofacial apraxia	(Sparks & Deck, 1994)
	Hemiplegia, more sever e in arm than in leg	(Sparks & Deck, 1994)

The absence of the indications from table 1 can be seen as contraindication for MIT. Table 3 shows (additional) contraindications for MIT.

Table 3 Contraindications for MIT.

	Contraindications	
Speech production	Fluent	(van der Lugt-van Wiechen, 1995)
	Unimpaired repetition	(van der Lugt-van Wiechen, 1995; Naeser & Helm-Estabrooks, 1985; Sparks et al., 1974)
Comprehension	Speech perception problems	(Albert et al., 1973; Sparks & Deck, 1994)
Articulation & Phonology	Good articulation	(Naeser & Helm-Estabrooks, 1985)
Type of Aphasia	Wernicke	(van der Lugt-van Wiechen, 1995; Sparks & Deck, 1994)
	Transcortical	(Sparks & Deck, 1994)
Brain damage	Lesion in Wernicke's area	(Naeser & Helm-Estabrooks, 1985)
	Right hemisphere lesion (bilateral)	(Naeser & Helm-Estabrooks, 1985)

Why is MIT facilitating?

There are many aspects of MIT which could contribute to the facilitating effect; e.g. use of melody, singing in unison with someone and reduction of speech rate. There are different views on the cause of the positive effect of MIT.

Melody: The original hypothesis on MIT is that it uses melody (e.g. Albert et al., 1973; Goldfarb & Bader, 1979; Sparks et al., 1974). The use of melody would activate the right hemisphere, because melody is lateralized right (e.g. Özdemir et al., 2006). This hypothesis is supported by the study of Cohen (1992). She reports improved intelligibility after singing therapy. Different studies however, question this hypothesis. In these studies, no facilitation for singing is observed (e.g. Boucher et al., 2001; Racette et al., 2006). Furthermore, it remains disputable whether MIT really activates the right hemisphere. Belin et al. (1996) found reactivation of Broca's area (left hemisphere) related to MIT repetition. They also found abnormal right hemispheric activation in aphasic patients during normal (spoken) repetition tasks. According to them, MIT helps to correct the abnormally right-shifted activation and reactivates the impaired motor language zones in the left hemisphere. Activation in the right hemisphere would represent the use of a less-effective strategy for language tasks. This is supported by the observation that a decrease in activation of the right hemisphere is connected to the success of language therapy, for both speech production and speech comprehension (e.g. Richter et al., 2008).

Singing in unison: Although Racette et al. (2006) argue that singing does not facilitate speech, they did find facilitation for singing in unison. For speaking in unison however, they found no facilitating effect. In their hypothesis, the advantage arises from the opportunity to synchronize one's performance with a stable model.

Syllable lengthening: Another hypothesis claims that the effect of MIT is caused by the use of lengthened syllables, because sung words are articulated at a slower rate than spoken words (Hébert et al., 2003). Evidence in favour of this hypothesis was found by Laughlin & Naeser (1979). In their study, all patients performed better in a MIT session when syllables were prolonged. The sustained vowel sounds would give patients time to 'think ahead' about the next speech sound (Norton et al., 2009). It is reported that intelligibility improves when speech production is slowed (Racette et al., 2006). Norton et al. (2009) claim that the right hemisphere is better suited for processing slowly modulated signals. The left hemisphere would be

more sensitive to rapidly modulated signals. MIT therefore, would decrease the dependency on the left hemisphere (Norton et al., 2009; Schlaug et al., 2008).

Hand movement: An important aspect of MIT seems to be the hand movement. Helm-Estabrooks (1983) observed that the hand movement often preceded naming behaviour. This was most notably in patients which were treated successfully with MIT. They argue that, the face and hand, particularly the thumb, have adjacent cortical representation in the precentral motor gyrus. Therefore, they conclude that the hand movement might be a priming mechanism for the initiation of speech. The study of Meister et al. (2003) indeed showed a relation between speech production and activation of the hand motor area. In their study, they found that during reading aloud, the excitability of the primary motor hand area is increased in the language-dominant hemisphere (left hemisphere). Aphasic patients often show a right sided paresis, therefore in MIT, the left hand is used. Schlaug et al. (2008 & 2009) discuss that the movement of this hand would engage a right hemispheric, sensorimotor network. This hemisphere could be language dominant in aphasic patients. However, it is unclear whether there is a difference between using the left or right hand in MIT.

Rhythm: The use of rhythm is related to the described hand movement. The hand movement indicates a rhythm, which could be facilitating as well. This hypothesis is supported by the study of Boucher et al. (2001). They found no facilitating effect for the use of melody. However, they did find a facilitating effect for the use of rhythm. They argue that rhythm facilitates articulation, because the intensity and duration give information on the forcefulness of articulation

Inner speech: A last aspect of MIT is the inner speech. The patient starts a session by listening to the therapist while she sings a sentence. Norton et al. (2009) point out that this is an important aspect of MIT. They hypothesize that a patient makes an inner representation of the sentence he is going to sing. This inner speech would initiate a higher level of prosodic or phonologic representation. This would give a patient the possibility to correctly sequence his motor commands (Norton et al., 2009).

MATERIALS AND METHODS

Patients

This study examines patients, which were included in the MIT project of Van der Meulen & Van de Sandt from October 2009 to May 2010. Table 4 shows the characteristics of the 11 included patients.

Table 4 Patient characteristics.

	Patient	Gender	Age	Sub-acute / Chronic
1	DL	f	44	s
2	AP	f	43	c
3	HD	f	62	c
4	PW	f	76	c
5	SE	f	46	c
6	AS	m	82	c
7	PJ	m	65	c
8	TL	m	60	c
9	VD	f	25	s
10	DR	f	21	c
11	WJ	f	51	s

The dataset consists of three males and eight females. Their age ranges from 21 to 82 with a mean age of 52 (st.d. 19). Three of the patients are sub-acute and eight of them are chronic aphasic.[1]

A patient is included in the group study when he shows poor speech production, problems with the repetition of words and sentences, articulatory problems and relatively good language comprehension. The inclusion criteria are based on the MIT literature and applied as follows:

- **Non fluent**: < 50 words per minute
- **Severe restriction of repetition**: AAT subtests "repetition" ≤ 74, and "repetition of sentences" ≤ 10
- **Articulation problems**: AAT "spontaneous speech", subtest score "Articulation"≤ 3
- **Good to moderate auditory comprehension**: Functional comprehension ≥ 6, AAT subtest "auditory comprehension" ≥ 33.

Design

In the study of Van der Meulen & Van de Sandt, patients perform several tasks before therapy starts. The current study analyzes three of these, namely the 'Akense Afasie Test', AAT (Graetz et al., 1991), 'Amsterdam Nijmegen Everyday Language Test', ANELT (Blomert et al., 1994)[2] and a facilitation task, which is designed for the study of Van der Meulen & Van de Sandt.

AAT: Of this test, we analyze two subtasks. 'Speech repetition', in which patients have to repeat sounds, words and sentences. And 'language comprehension', in which patients have to choose a picture corresponding to a spoken or written word or sentence. These tests are scored according to the manual of the AAT. Besides the scores for the complete tasks*, Language comprehension* is subdivided into a score for *auditory comprehension* and *comprehension of words* versus *comprehension of sentences* (both auditory and written). *Repetition* is subdivided into scores for *repetition of sounds*, *words* and *sentences*.

Apart from the scores on the AAT, we also analyze the level of articulatory and phonological deficits. For this, the number of distortions and phonologic paraphasias were counted. Following Shuster & Wambaugh (2000), a distortion is defined as a sound that is distorted in either manner (+/- voice) or place of articulation, (see table 5).

Table 5 The International phonetic alphabet for Dutch consonants.
Source: Rietveld & van Heuven (2001) & the International Phonetic Association (2005)

	place							
	Bilabial	**Labiodental**	**Alveolar**	**Postalveolar**	**Palatal**	**Velar**	**Uvular**	**Glottal**
Plosive	p b		t d		c ɟ	k g		
Fricative		f v	s z	ʃ ʒ		x ɣ		ɦ
Trill			r				ʀ	
Lateral approximant			l					
Approximant	w	ʋ			j			
Nasal	m	ɱ	n		ɲ	ŋ		

Where symbols appear in pairs, the one on the right represents a voiced consonant.
Shaded areas indicate articulations judged to be impossible

[1] Sub-acute = 2-3 months after CVA; Chronic = 1, or more years after CVA
[2] For this study, the original Dutch version of the ANELT is used.

For this study, a change in place of articulation is only counted as distortion when it differs only one step (palatal → velar = distortion, palatal → uvular = paraphasia). Other inaccurate phonemes are counted as phonologic paraphasia (see example). We count the number of items, in which phonologic paraphasias occur.

Example of articulation analysis

Item:	'**ch**ocola**d**e' *(chocolate)*	/**ʃ**okola**d**ə/
Utterance:	"**g**okola**t**e"	/**ɣ**okola**t**ə/

Distortion: [**d**] -> [**t**] (alveolar plosive **voiced** → alveolar plosive **voiceless**)

Paraphasia: [**ʃ**] -> [**ɣ**] (post-alveolar fricative voiceless → velar fricative voiced)

Vocals are transcribed as distortions, when they show abnormal articulation or lengthening/shortening ([ɑ] → [a]) (Haley et al., 2001). These are all vocals, which cannot be classified as correct, substitution or accepted variation. If an utterance or a part of an utterance is unrecognisable or does not show any resemblance to the item, the articulation is not analyzed (for instance "ie-a-u-o" or "bor-choo-ik-den-pek" instead of *'*voorlichtingsgesprek'*, advisory consultation*).

ANELT I: This test analyzes verbal speech production in everyday communicative situations. A patient has to show verbally how he would respond to a specific situation (see example).

Example from ANELT

You see your neighbour walking by. You want to ask him/her to come to visit you some time. What do you say?

Speech production is analyzed on two scales, comprehensibility (scale A) and intelligibility (scale B). The test is scored according to the manual.

Facilitation Test: To see whether there is a facilitating effect of repetition in the MIT way, this study compares *normal spoken repetition* of sentences to *repetition in a MIT way*. The facilitation test consists of 22 sentences which increase in difficulty (see example).

Example from Facilitation Test

'Goedemorgen'	*(Good morning)*
'Mag ik koffie?'	*(Can I have some coffee?)*
'Ik zoek een warme jas'	(*I am looking for a warm coat)*

First the patient has to repeat all 22 sentences in a normal spoken condition. Thereafter, all sentences are sung by the tester and the patient has to repeat them sung. The test is scored per good syllable, with a maximum of

108 correct syllables. We have chosen this measurement, because an improvement of (only) an adequate word can increase the comprehensibility of a patient. For instance, if someone asks you what you want to drink, the utterance 'coffee' is sufficient. The complete sentence 'I would love to have some coffee' is not necessary.

The facilitation of MIT repetition is determined by the difference between the spoken condition and MIT repetition. If a patient shows a δ of at least 10 syllables, they are differentiated as either decline (δ ≤ -10) or facilitation (δ ≥ 10). All other patients show no facilitation. These groups will be analyzed for differences on all variables in an Analysis of Variance, ANOVA. Furthermore, we analyze possible correlations of all variables to δ.

The facilitation test is not validated. Therefore, no criteria for defining improvement are known. To divide the patients over three groups, we have chosen a subjective criterion. Similar to this study, different studies have divided patients into categories before (e.g. Naeser & Helm-Estabrooks, 1985; Sparks et al., 1974). However, these studies did not report which criteria they used. A criterion could be a difference of one standard deviation, as used by for instance Paolucci et al. (1998), in a study on functional outcome in stroke inpatient rehabilitation. They differentiated a standard response group, excellent and poor prognosis. The disadvantage, of using standard deviations as a criterion, is that it is a circular measure. This is not useful for this study, because we do not want to know how the patients differ from each other, but how each individual differs from the spoken condition.

RESULTS

Analysis 1: Comparison of MIT repetition to normal repetition

Table 6 shows the number of syllables correct for *normal repetition* and *MIT repetition*. The difference, δ, between these two conditions shows the facilitation of MIT repetition. Furthermore, the improvement is given in a percentage of possible improvement.

Table 6 Comparison of normal repetition and MIT repetition, δ ascending.[3]

Patient	*Normal Repetition*	*MIT repetition*	δ	Improvement*
PJ	53	31	**-22**	**-40 %**
DR	67	56	**-11**	**-27 %**
SE	51	43	-8	-14 %
PW	17	15	-2	-5 %
AS	28	27	-1	-1 %
TL	0	0	0	-
AP	7	9	2	4 %
DL	2	5	3	6 %
WJ	0	4	4	4%
HD	20	31	**11**	**32 %**
VD	21	39	**18**	**21 %**

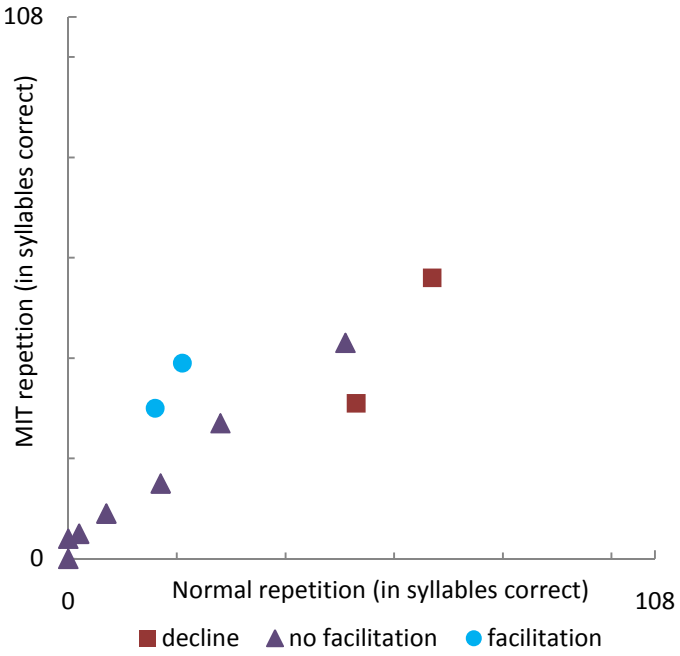
of possible improvement (= 100(δ /(108-normal repetition))

Most patients show no facilitation for MIT repetition. Two patients show facilitation and two patients show decline for MIT repetition. In a paired-samples T-test, no significant difference for *normal repetition* (μ = 24; st.d. = 23) and *MIT repetition* (μ = 23; st.d. = 18) is found. The two variables even show a significant correlation:

[3] P01, P02, P03 & P04 were presented with only 11 sentences instead of 22 (= 54 syllables). Their improvement is calculated for a maximum score of 54.

r = 0,888; p = 0,000. As shown in figure 1, people with high scores for *normal repetition* also show high scores for *MIT repetition*.

Figure 1 Scatter-plot of *normal repetition* and *MIT repetition*



Analysis 2: Relation of δ to other variables

In a second step, the patients are split up into groups: decline (δ ≤ -10), no facilitation (-10 < δ < 10) and facilitation (δ ≥ 10). These groups are analyzed for differences on all variables in an ANOVA[4], see table 7 and 8. Table 7 shows the mean scores for the analyzed aphasia tests; the facilitation task: *normal* and *MIT repetition*, AAT: *repetition* and *comprehension,* and the ANELT*: comprehensibility* and *intelligibility.* Table 8 shows the articulatory and phonological deficits in the speech repetition task of the AAT; mean number of *distortions*, items in which *paraphasias* occur and *not analyzable answers.*

Table 7 Analysis of regular aphasia tests, mean scores for AAT, ANELT and Facilitation Test.

		Decline PJ, DR	**No facilitation** DL, AP, PW, SE, AS, TL, WJ	**Facilitation** HD, VD	**Group Difference**
Facilitation test	*Normal repetition*	60 (st.d. 10)	51 (st.d. 19)	21 (st.d. 4)	**p = 0,029**
	MIT repetition	44 (st.d. 18)	43 (st.d. 15)	39 (st.d. 6)	p = 0,077
AAT	*Repetition*	74 (st.d. 7)	38 (st.d. 22)	57 (st.d. 16)	p > 0,05
	Comprehension	95 (st.d. 4)	78 (st.d. 18)	78 (st.d. 5)	p > 0,05
ANELT	Scale A *Comprehensibility*	26 (st.d. 4)	3 (st.d. 7)	21 (st.d. 6)	**p = 0,002**
	Scale B *Intelligibility*	44 (st.d. 5)	8 (st.d. 19)	37 (st.d. 18)	**p = 0,037**

[4] Note that we compare very small populations. Therefore possibly, the results are not representative.

Table 8 Analysis of speech production deficits, mean number of distortions, paraphasias and not analyzable answers.

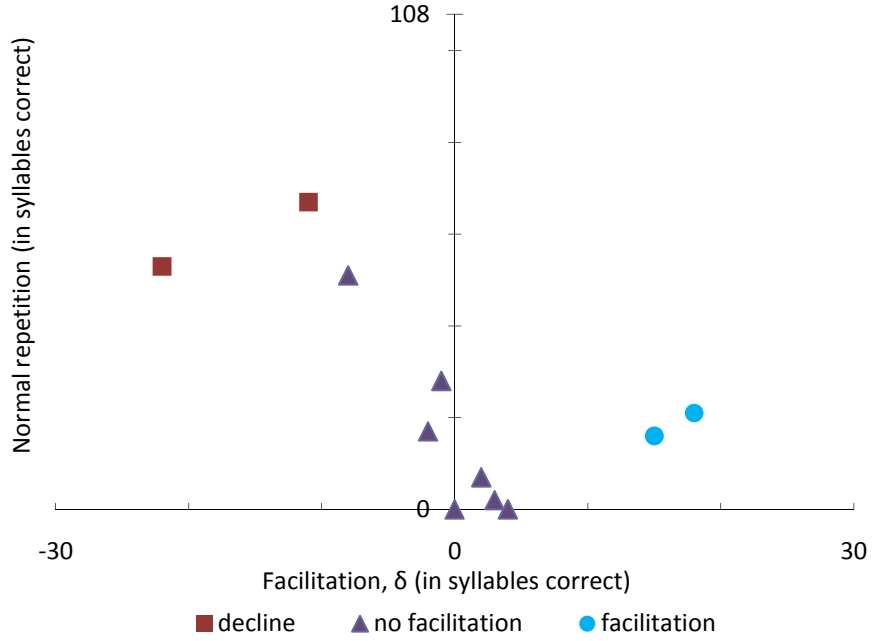
	Decline PJ, DR	**No facilitation** DL, AP, PW, SE, AS, TL,[5]	**Facilitation** HD, VD	**Group Difference**
Distortions	7 (st.d. 6)	9 (st.d. 11)	11 (st.d. 10)	p > 0,05
Paraphasias	14 (st.d. 8)	11 (st.d. 12)	22 (st.d. 13)	p > 0,05
Not analyzable answers	16 (st.d. 6)	27 (st.d. 14)	19 (st.d. 12)	p > 0,05

The groups differ significantly for *normal repetition* in the Facilitation task: F(2) = 5,691; p = 0,029 and on the ANELT for *comprehensibility* (scale A): F(2) = 14,810; p = 0,002 as well as for *intelligibility* (scale B): F(2) = 5,151 ; p = 0,037. All other tasks or subtasks (for instance: *comprehension of sentences*), did not reach significance. Furthermore, no group differences were found for the use of *paraphasias*, *distortions* or *not analyzable answers*.

In a second analysis, all variables were analyzed for correlations to δ. Only normal repetition correlates significantly to δ: *r* = -0,644; p = 0,032. The reported significant results are analyzed more detailed per task.

Facilitation test: Figure 2 shows a scatter-plot of facilitation (δ) and the scores for normal repetition per patient.

Figure 2 Scatter-plot of *facilitation (δ)* and *normal repetition*.

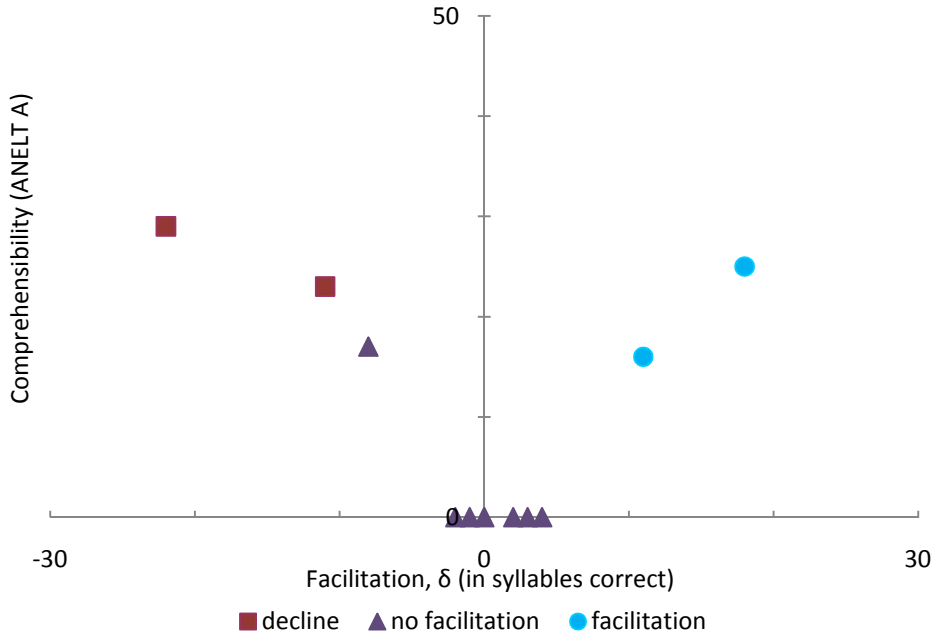


The two patients that show decline have better repetition scores than the patients that show either facilitation or no facilitation. The significant correlation and the group differences show that, the more problems patients have with *normal repetition*, the more they are facilitated by *MIT repetition*. The patients with relatively good repetition skills even show a decline for MIT repetition.

[5] The sound file of the AAT repetition task of patient WJ was not yet available. Therefore, her speech production was not analyzed.

ANELT: Patients differed significantly on both *comprehensibility* and *intelligibility*. The *comprehensibility* is given in a scale, which represents the ability of a patient to transfer adequate information. For instance, if a patient only produces the word 'coffee' when he wants to invite his neighbour to visit him, the comprehensibility of this patient is very low. Although some information is given, it is not enough to fully understand his intention. *Intelligibility* represents the percentage of an utterance that was directly transcribable. Figure 3 shows a scatter-plot of *facilitation* and *comprehensibility* (a graph on *intelligibility* is comparable to this one).

Figure 3 Scatter-plot of *facilitation (δ)* and *comprehensibility*



As illustrated in figure 3, patients that not show any difference between *normal repetition* and *MIT repetition*, have no speech production on the ANELT, except for patient SE, who shows no facilitation but has some speech production on the ANELT. Patients who show either decline or facilitation are able to produce at least some verbal information.

Analysis 3: Speech production analysis

In the ANELT, only five patients show some degree of speech production. The verbal production of these patients is described in a qualitative view. First, a (representative) example of their speech production is given. Secondly, important aspects of their speech production are described.

> 'Situation: You see your neighbour walking by. You want to ask him/her to come to visit you some time. What do you say?'

Decline	PJ	"Buurvrouw, deze asjebiet lekke koffie eh …. Taart ofzo. Leuk."	*(Neighbour, this one please, good, coffee ehm …. Cake maybe. Fun)*
	DR	"Mag ik ... een koffie? Nemen, brengen"	*(May I …. a coffee? Take, Bring)*
No facilitation	SE	"Koffie, thee, melək"	*(Coffee, tea, milk)*
Facilitation	VD	"Eh kom zeg lekker eh lekker eh met mij eh lekker w….die (laughs) ha …we ha ….we me mij bezoek zie."	*(Ehm, come yeah, good, ehm good, ehm with me, ehm good, w that (laughs), ha, we ha, we me, me visit see.)*
	HD	"Kohə toffie dɣinken	*(Do you come drink coffee?)*[6]

Decline:

PJ: This patient shows moderate speech production and his answer is quite adequate. His articulation is good, however he shows reduction for clusters. Furthermore, the articulation of the /r/ is unclear. This however, could also be a feature of an accepted language variation.

DR: This patient has limited speech production. Her utterance lacks some adequate information. She is reported to have apraxia of speech, however, this was not noticeable. She speaks calmly and her intelligibility is very good.

No facilitation

SE: This patient has very limited speech production. Although she says some words, she does not give enough relevant information. She seems to have some articulatory or phonological problems. However, she produces too little speech to analyze this properly.

Facilitation

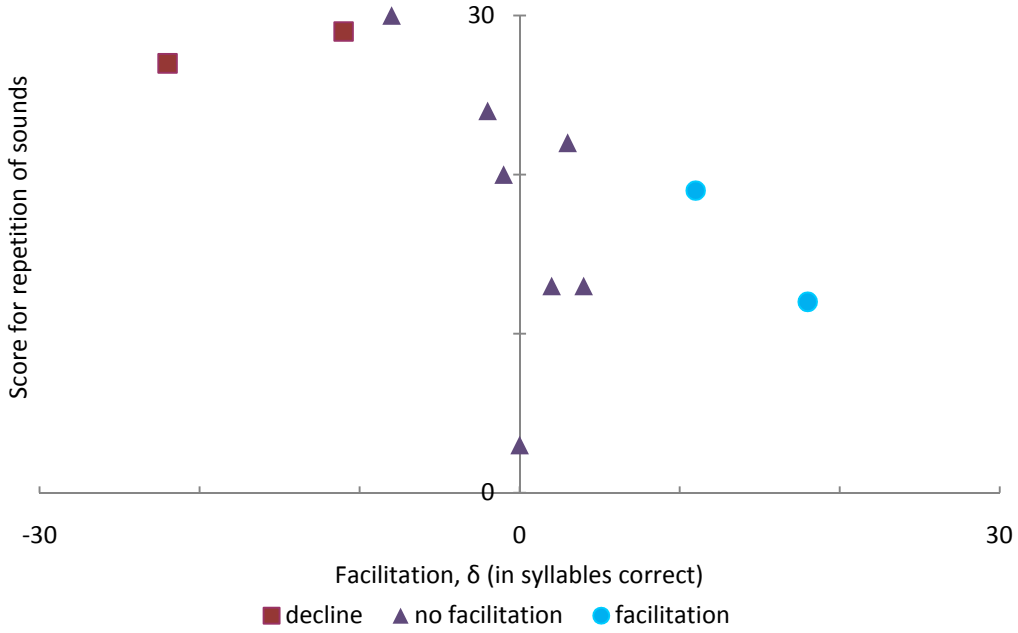
HD: The articulation of this patient is very unclear. Therefore, it is difficult to understand her. Her utterance however, contains adequate information.

VD: This patient shows moderate speech production. Her answer however, misses some relevant information. She shows word retrieval problems, but also articulation problems. Her intelligibility is better than that of patient HD, probably because she speaks louder and is less insecure.

Patient HD and VD, who show facilitation of MIT, also show articulation problems. Although these are only two patients here, articulation problems in general are reported to be an indication for the facilitating effect of MIT. The speech production problems of the patients who show a decline seem to be more phonological. This is supported by the observation that δ correlates with the repetition of sounds, see figure 4.

[6] This translation is only illustrative. It does not represent mispronunciations and is not representative for linguistic deviations in Dutch.

Figure 4 Scatter-plot of *facilitation (δ)* and *repetition of sounds.*



Without patient TL, the correlation between *facilitation (δ)* and *repetition of sounds* is significant r = -0,750; p = 0,012. If a patient shows difficulty for *repetition of sounds*, this indicates articulatory problems.[7] The more articulatory problems patients show, the more they are facilitated by MIT repetition.

Patient TL, who is incapable of repeating any speech, except for some sounds, is an outlier. A further analysis shows that he is not capable of producing any speech or repeating anything. He only produces some random vocals ("ie-a"). Therefore, he seems different from all other patients, who are all capable of producing a little speech and show some speech repetition abilities.

DISCUSSION

Results

The purpose of this study was to identify indications for the facilitating effect of MIT repetition. Therefore, *repetition in a MIT* way and *spoken repetition* were compared. However, in this study most patients showed no facilitation. Only two patients showed facilitation and two patients even showed a decline for MIT repetition. This was surprising, because in clinical practice it is often reported, by both the patient and the therapist, that MIT repetition facilitates speech production. This study shows, that if more sentences are analyzed than is usually done in clinical practice, this reported facilitation cannot be observed. Therefore, the aim of this study could not be attained. This study was designed to determine regular aphasia tests which could be used as indications for a possible MIT repetition facilitation. This study was not capable of determining regular aphasia tests for this aim. However, it did show that the facilitation test is not capable of differentiating aphasic patients.

[7] Patient PW, who has severe apraxia of speech scores relatively high on this task (score = 24) Therefore, this task is not necessarily representative for articulatory problems. Possibly, PW compensates her articulatory problems, because she only has to produce one sound at a time.

The observation that the majority of the patients showed no facilitation is in consensus with several earlier studies in which there was not found a facilitating effect for simple repetition in a MIT way (Racette et al., 2006; Tonkovich & Marquardt, 1977). Tonkovich & Marquardt (1977) argued that this task requires immediate repetition. Therefore, more effort on the part of the patients is required. Racette et al. (2006) did not find a facilitating effect for singing alone, as was done in our study. However, singing in unison did prove to be facilitating. This observation is strengthened by the findings of Sentker (in progress). She did a study similar to our current study, also as part of the project of Van der Meulen & Van de Sandt. Different from our study, patients repeated the sentences sung together with the therapist. She found greater facilitation and for more patients than we have found in the current study. This supports the hypothesis that singing in unison is an essential part of MIT.

Four patients showed either facilitation or decline. Although these were only a few patients, a short interpretation is appropriate. These patients had more speech production than the not facilitated patients. Therefore, a minimum of speech production seems necessary for MIT repetition to have an effect. The patients that showed facilitation had articulatory problems. This was not observed for the patients who showed a decline, their speech production problems seem to be more phonologically. More than the decline patients, the facilitated patients showed articulatory struggle and problems with *repetition of sounds*. Therefore, the cause of their speech errors seem physically; the controlling and directing of speech muscles, more than a phonological problem. This observation indicates that MIT facilitates articulation for (at least) these two patients. This is in concordance to the findings of Naeser & Helm-Estabrooks (1985), who report that MIT helps patients with slow, poorly articulated speech. They add, that MIT is of questionable benefit to patients who have little or no articulation problems

A decline for *MIT repetition* was not expected. However, two patients did perform significantly worse for *MIT repetition* than for *normal repetition*. The patients, who showed decline, showed relatively good *spoken repetition*. Furthermore, they showed no problems for *repetition of sounds*. Therefore, they do not seem to have articulatory problems. However, both of these patients showed a length effect. Patient PJ explicitly pointed out that some sentences were too long for him to repeat. This indicates a memory or capacity problem. The different aspects of MIT could possibly ask even more of their attention, because it is a new and different manner of speaking. It might be that the different aspects of MIT interfere more with their linguistic processes, than they facilitate.

Finally it should be pointed out that, the results of this study do not have any implications for the effect of therapy. If a patient shows no facilitation for *MIT repetition*, this does not implicate that he will not profit from therapy.

MIT and articulation

In the literature on MIT there are two hypotheses on the effect of MIT. The original hypothesis was that MIT reactivates linguistic systems necessary for speech production. Another hypothesis is that MIT only stimulates articulation. Although the results of the current study were limited, they do support the hypothesis that MIT facilitates articulation. This hypothesis is strengthened by studies that report improved articulation after MIT

(Marshall & Holtzapple, 1976; Sparks & Holland, 1976; Wilson et al., 2006). Naeser & Helm-Estabrooks (1985) even point out that MIT is of questionable benefit to patients who have little or no articulation problems. Furthermore, many of the different aspects of MIT are reported to facilitate articulation. This paragraph discusses the relation of MIT and articulation. First, it describes the different aspects of MIT and their influence on articulation. Secondly, it discusses some of the observations from this study and relates them to theories and models on articulation.

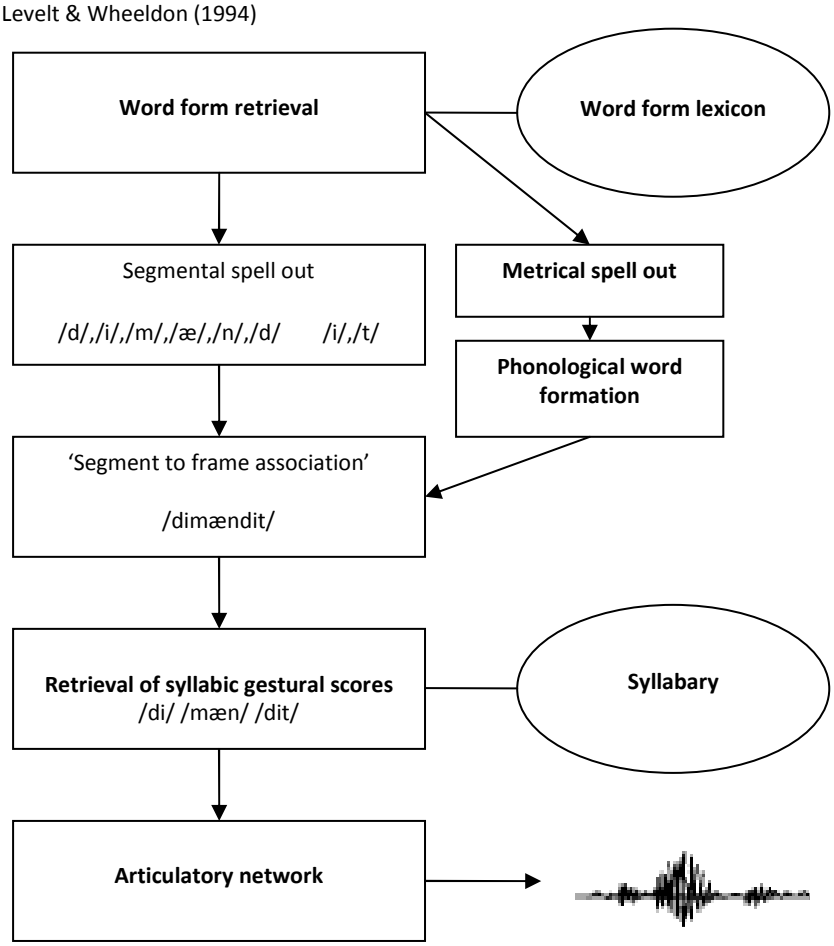
Aspects of MIT: Most of the aspects of MIT seem to have a facilitating effect on articulation. First, the singing in unison gives a patient the opportunity to adjust his speech to both the oral movements of the therapist (Racette et al., 2006) as to the auditory feedback he gets from the utterance of the therapist (Norton et al., 2009; Racette et al., 2006). Furthermore, the use of rhythm would give information on the forcefulness of articulation (Boucher et al., 2001). Rhythm is also reported to be facilitating for patients with apraxia of speech (Brendel & Ziegler, 2008). The hand movement, that indicates this rhythm, could possibly trigger speech production (Helm-Estabrooks, 1983). The lengthening of syllables is known to facilitate articulation (Laughlin & Naeser, 1999). Because patients have more time, the processing of auditory feedback would improve (Norton et al., 2009). Finally, inner speech would facilitate a feed-forward control (Norton et al., 2009).

No observed facilitation of MIT repetition: Although great improvements after MIT have been observed, this study did not show any improvement in most patients for simple MIT repetition. MIT repetition differs from therapy in several aspects.

First, besides the fact that the singing in unison aspect was left out in this study, MIT repetition was only done once and not rehearsed, as in therapy. Wilson et al. (2006) report that rehearsal was very important for the benefit of the patient they analyzed. This can be explained by the hypothesis that MIT trains the production of articulatory speech sequences.

Levelt & Wheeldon (1994) hypothesize that articulation is produced in syllables. They give an example to illustrate this. If we utter the sentence ‘the police demand it’, the unstressed function word ‘it’ is glued to the head word ‘demand’. This results in the phonological word ‘demandit’. Next, the articulatory gesture sequences for the ‘new syllables’ (‘de-man-dit’) are retrieved from the ‘syllabary’ (see figure 5). This implicates that articulation does not consist of phoneme sequences, but articulatory speech movement sequences. Important is, that these movements are learned through repetition (e.g. Tach, 1998). After a movement is learned, the neural network can perform these movements much faster (Kawato, 1987). As a consequence, it is reasonable to believe that, the speech sequences presented in MIT have to be trained before an improvement can be observed.

Figure 5 A (simplified) framework for phonological encoding and articulatory output.
Source: Levelt & Wheeldon (1994)



Secondly, inner speech, that would be an important aspect of MIT, is not stimulated or not enough in the simple repetition condition. This inner speech is important for speech motor control, which has an important role in articulation. In this hypothesis, MIT trains or strengthens the speech motor control.

Perkell et al. (1997) propose that speech is controlled by an internal model (feed-forward). This model consists of functional properties of the speech production mechanisms. They propose this internal model, because they claim that for auditory feedback the delay would be too large. Norton et al. (2009) hypothesize that the inner speech, used in MIT, initiates a feed-forward control. Another possibility is that slowed speech in MIT provides patients time to adjust their speech with auditory feedback. The study of Schlaug et al. (2009) supports this hypothesis. They observed structural changes in the arcuate fasciculus. This fiber bundle connects Wernicke's area, Broca's area and the adjacent premotor cortex. Schlaug et al. (2009) explain that reorganization is necessary in order to provide fast feedback mechanisms for vocal articulation and for auditory-motor coupling. They point out that, mapping sounds to vocal motor actions is a left-hemisphere function that is typically destroyed in Broca's aphasia. These hypotheses, on either feed-forward or feed-back control, do not have to exclude each other. Speech production is probably controlled by both feed-back and feed-forward mechanisms (Max et al., 2004).

Why train articulation through singing? If MIT only facilitates articulation, why is it necessary that patients sing? If you would keep all the aspects of MIT (e.g. slowed speech, rhythm), but only change the sung repetition to spoken repetition, it is probably not (as) effective (Racette et al., 2006). Apparently, sung repetition, or at least singing in unison, differs from spoken repetition in one or more essential aspect.

In the model of Levelt et al. (1999) articulation is the last step in speech production. It is preceded by conceptual preparation, lexical selection, morphological and phonological encoding, and phonetic encoding. In the aphasic patients in this study, it might be that these other stages interfere with the training of articulation. Singing would share neural correlates with the production of speech, which represents same mechanisms for sung and spoken verbal production (Hébert et al., 2003; Özdemir et al., 2006; Racette et al., 2006). Özdemir et al. (2006) hypothesize that there is a neural network for the motor preparation, execution and sensory feedback for both intoned and spoken vocal production. As singing is not impaired in these aphasic patients, this gives an entrance to practice articulation. For instance, the auditory-vocal interface, which is lateralized right, would be preserved in singing (Racette et al., 2006). Wilson et al. (2006) argue that the act of combining melody and speech, promotes different storage or access to the sung phrases. This supports the original hypothesis on MIT; that it facilitates speech because of the use of melody. This would also explain why patients report a difference or improvement when they sing a sentence, although no quantitative improvement is observed. Possibly, the patients approach the speech production differently, when they sing and they notice this difference. An improvement however, as discussed previously, can only be observed after a period of therapy.

Remarks

Finally, some notes should be made with respect to this study. First of all, it should be stressed that this study has analyzed a very small dataset. Therefore, conclusions are possibly not representative. However, as with all aphasia studies it is very difficult to analyze large patient samples. This is also caused by the heterogeneity of the analyzed patients. Although this study was set up to analyze this heterogeneity, it remains difficult to really differentiate between variables and confounding factors.

Furthermore, the tests were not completely comparable for all patients. The facilitation task of patient PJ (who shows decline for MIT repetition) was done by moving his right hand. For all other patients the left hand was used. Another point is that not all patients were tested with the complete facilitation task. Patient DL, AP, HD and PW were tested with only 11 items, whereas the other patients were tested on 22 sentences. A possible difference would be less distinct in these patients. Patient HD nevertheless, showed significant facilitation. A last confounding variable could be patient DR (decline), her repetition scores were too high for inclusion. However, because of a mistake she was included nevertheless.

Secondly, the analysis of the articulation is very subjective. Although, guidelines from other studies are used, the classification of the sounds was done by only one person and therefore remains subjective. Furthermore, the interpretation of phonologic paraphasias and distortions is possibly perceptual. Observed phonologic paraphasias could actually be distortions (Haley et al., 2001).

A difficult aspect of this study was the criterion for differentiating patients as decline, no facilitation or facilitation. Because no objective norm was available, we used a subjective criterion. Ideally, we would have repeated the normal repetition several times for each patient. A difference of one standard deviation from the average variance could be seen as a significant improvement or decline.

A last remark has to be made on the conclusion of this study. Although it was expected to find facilitation for MIT repetition, only for two patients facilitation was actually observed. This discussion has tried to explain this observation. However, it is possible that the observed results are not caused by any of the discussed variables, but by heterogeneity of the studied patients. Possibly, the patients from our study would not show facilitation for (for instance) singing in unison either.

CONCLUSIONS

The aim of this study was to identify indications for the facilitating effect of MIT repetition. Therefore, we analyzed articulation and different aphasia tests for their relation to the facilitation of MIT. Surprisingly, results showed that most patients do not show facilitation for MIT repetition. Although the end of this study was not attained, it did show that the facilitation test is not capable of differentiating aphasic patients. This was remarkable, because both therapists and patients often reported facilitation for MIT repetition.

Although most patients showed no difference between normal repetition and MIT repetition, a few patients showed facilitation or surprisingly decline for MIT repetition. These patients had more speech production than the not facilitated patients. Furthermore, the facilitated patients showed articulatory problems. These findings, although limited, support the hypothesis that MIT facilitates articulation. Finally, it should be stressed that this study has no implications for the effect of therapy. The relation between the MIT repetition task and effects of therapy are still unknown.

This should be analyzed in further research, in which the results of this study are related to the effect of therapy. This study has indicated that singing in unison is an important aspect of MIT. Therefore, it would be interesting to repeat this study, but to use singing in unison. If the repetition task would be analyzed further, it would be important to set up objective criteria. As proposed in this study, the normal variance per patient should be determined. This could be used to objectively identify significant differences in patients.

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REFERENCES

Albert, M.L., Sparks, R.W. & Helm, N.A. (1973). Melodic intonation therapy for aphasia. *Archives of Neurology, 29*, pp. 130-131.

Baker, F.A. (2000). Modifying the Melodic Intonation Therapy Program for adults with severe non-fluent aphasia. *Music Therapy perspectives*, *18*, pp. 110-114.

Belin, P., van Eeckhout, P., Zilbovicius, M., Remy, P., François, C., Guillaume, S., Chain, F., Rancurel, G. & Samson, Y. (1996). Recovery from nonfluent aphasia after melodic intonation therapy: A PET study. *Neurology*, *47*, pp. 1504-1511.

Blomert, L., Kean, M.L., Koster, C. & Schokker, J. (1994). Amsterdam-Nijmegen Everyday Language Test: Construction, reliability and validity. *Aphasiology, 8,* pp. 381-407.

Bonakdarpour, B., Eftekharzadeh, A. & Ashayeri, H. (2003). Melodic intonation therapy in Persian aphasic patients. *Aphasiology, 1,* pp. 75-95.

Boucher, V., Garcia, L.J., Fleurant, J. & Paradis, J. (2001). Variable efficacy of rhythm and tone in melody-based interventions: Implications for the assumption of a right-hemisphere facilitation in non-fluent aphasia. *Aphasiology, 15,* pp. 131-149.

Brendel, B. & Ziegler, W. (2008). Effectiveness of metrical pacing in the treatment of apraxia of speech. *Aphasiology, 22*, pp. 77-102.

Cohen, N. (1992). The effect of singing instruction on the speech production of neurologically impaired persons. *Journal of Music therapy, 29,* pp. 87-102.

Goldfarb, R. & Bader, E. (1979). Espousing melodic intonation therapy in aphasia rehabilitation: A case study. *International journal of rehabilitation research, 2* (3), pp. 333-342.

Graetz, P., de Bleser, R. & Wilmes, K. (1991). *Akense Afasie Test. Nederlandstalige versie (AAT).* Lisse: SWETS & Zeitlinger.

Haley, K.L., Bays, G.L., Ohde, R.N. (2001). Phonetic properties of aphasic-apraxic speech: A modified narrow transcription analysis. *Aphasiology, 15*, pp. 1125-1142.

Hébert, S., Racette, A., Gagnon, L. & Peretz, I. (2003). Revisiting the dissociation between singing and speaking in expressive aphasia. *Brain, 126*, pp. 1838-1850.

Helm-Estabrooks, N. (1983). Exploiting the Right Hemisphere for language rehabilitation: melodic intonation therapy. In E. Perecman (ed.). *Cognitive Processing in the right hemisphere*. New York: academic press.

Hickin, J., Best, W., Herber, R., Howard, D. & Osborne, F. (2002). Phonological therapy for word-finding difficulties: A re-evaluation. *Aphasiology, 16*, pp. 981–999.

the International Phonetic Association (2005). IPA: Pulmonic & IPA: Vowels. URL: http://www.langsci.ucl.ac.uk/ipa/pulmonic.html, 19-04-2010.

Kawato, M., Furukawa, K. & Suzuki, R. (1987). Hierarchical neural-network model for control and learning of voluntary movement. *Biological Cybernetics, 57,* pp. 169-185.

Laughlin, S. & Naeser, M.A. (1979). Effects of three syllable durations using the melodic intonation therapy technique. *Journal of speech and hearing research, 22,* pp 311-320.

Levelt, W.J.M., Roelofs, A. & Meyer, A.S. (1999). A theory of lexical access in speech production. *Behavioral and brain sciences*, *22*, pp. 1-75.

Levelt, W.J.M. & Wheeldon, L. (1994). Do speakers have access to a mental syllabary? *Cognition, 50,* pp. 239-269.

van der Lugt-van Wiechen, K.G.M. (1995) Geprogrammeerde therapie. In E.G. Visch-Brink, F. van Harkamp & D. de Boer (ed.) *Neurologische taal- en spraakstoornissen 1: afasietherapie*. Amsterdam/Lisse: Swetz & Zeitlinger.

Marshall, N. & Holtzapple, P. (1976). Melodic Intonation Therapy: Variations on a theme. In R.H. Brookshire (ed.) *Clinical Aphasiology, 6, Preceedings of the conference*. Minneapolis: BRK Publishes, pp. 115-141.

Max, L., Guenther, F.H., Gracco, V.L., Ghosh, S.S. & Wallace, M.E. (2004) Unstable or insufficiently activated internal models and feedback-biased motor control as sources of dysfluency. *Contemporary Issues in Communication Science & Disorders, 31,* pp. 105-122.

Meister, I.G., Boroojerdi, B., Foltys, H., Sparing, R., Hubert, W. & Töpper, R. (2002). Motor cortex hand area and speech: implications for the development of language. *Neuropsychologia, 41,* pp. 401-406.

Naeser, M.A. & Helm-Estabrooks, N. (1985). CT scan lesion localization and response to melodic intonation therapy with nonfluent aphasia cases. *Cortex, 21,* pp. 203-223.

Norton, A., Zipse, L., Marchina, S. & Schlaug, G. (2009). Melodic intonation therapy: Shared insights on how it is done and why it might help. *Annals of the New York academy of sciences*. The neurosciences and music III-Disorders and plasticity, *1169*, pp. 431-436.

Özdemir, E., Norton, A. & Schlaug, G. (2006). Shared and distinct neural correlates of singing and speaking. *Neuroimage, 33*, pp. 628-635.

Paolucci, S., Anotnucci, G., Prates, L., Traballesi, M., Lubich, S., Grasso, M.G. (1998). Functional outcome in stroke inpatient rehabilitation: Predictin no, low and high response patients. *Cerebrocascular diseases, 8*, pp. 228-234.

Perkell, J.S., Matthies, M.L, Lane, H., Guenther, F., Wilhelms-Tricarico, R., Wozniak, J. & Guiod, P. (1997). Speech motor control: Acoustic goals, saturation effects, auditory feedback and internal models. Speech communication, 22, pp. 227-250.

Racette, A., Bard, C. & Peretz, I. (2006). Making non-fluent aphasics speak: sing along! *Brain, 129,* pp. 2571-2584.

Richter, M., Miltner, W.H.R. & Straube, T. (2008). Association between therapy outcome and right-hemispheric activation in chronic aphasia. *Brain 131,* pp. 1391-1401.

Rietveld, A.C.M. & van Heuven, V.J. (2001). *Algemene Fonetiek*. Bussum: Uitgeverij Coutinho.

Schlaug, G.K., Marchina, S. & Norton, A. (2008). From singing to speaking: Why singing may lead to recovery of expressive language function in patients with Broca's aphasia. *Music perception, 25*, pp. 315-323.

Schlaug, G.K., Marchina, S. & Norton, A. (2009). Evidence for plasticity in white-matter tracts of patients with chronic Broca's aphasia undergoing intense intonation-based speech therapy. *Annals of the New York academy of sciences*. *The neurosciences and music III-Disorders and plasticity, 1169*, pp. 385-394.

Sentker, K. (in progress). Master thesis

Shuster, L..I. & Wambaugh, J.L.. (2000). Perceptual and acoustical analyses of speech sound errors in apraxia of speech accompanied by aphasia. *Aphasiology, 14,* pp. 635-651.

Smith, A. (1966). Speech and other functions after left (dominant) hemispherectomy. *Journal of Neurology, Neurosurgery and Psychiatry, 29*, pp. 467-471.

Sparks, R.W. & Deck, J.W. (1994). Melodic Intonation Therapy. In R. Chapey (ed.) *Language intervention strategies in adult aphasia* (pp.368-379). Baltimore: Williams & Wilkins.

Sparks, R.W., Helm, N. & Albert, M. (1974). Aphasia rehabilitation resulting from melodic intonation therapy. *Cortex, 10,* pp.303-316.

Sparks, R.W. & Holland, A.L. (1976). Method: Melodic Intonation Therapy for aphasia. *Journal of speech and hearing disorders, 41*, 287-297.

Straube, T., Schulz, A., Geipel, K.., Mentzel, H-J. & Miltner, W.H.R. (2008). Dissociation between singing and speaking in expressive aphasia: The role of song familiarity. *Neuropshygologia, 46,* pp. 1505-1512.

Tach, W.T. (1998). A role for the cerebellum in learning movement coordination. *Neurobiology of learning and memory, 70,* pp. 177-188.

Tonkovich, J.D. & Marquardt, T.P. (1977). The effects of stress and melodic intonation on apraxia of speech. In *Clinical aphasiology Conference.* Minneapolis: BRK Publishes*. Pp. 97-102.*

Wilson, S.J., Parsons, K. & Reutens, D.C. (2006). Preserved singing in aphasia. A case study of the efficacy of the melodic intonation therapy. *Music Perception, 24,* pp. 23-36.