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Coordination and timing of speech gestures in Parkinson's disease

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/ekstɹəz/

A

Target words

Table A.1 The Dutch target words as included in the study of Chapter 2. Words were embedded in the target phrase ‘*Hij heeft weer [TARGET] gezegd*’: “He has said [TARGET] again.”

Vowel	Post-vocalic consonant	Target words
/a/	/p/	apen, schapen
	/b/	kabel, sabel
	/t/	water, vaten
	/d/	zadel, vader
	/k/	draken, haken
/i/	/p/	iepen, keeper
	/b/	giebel, wiebel
	/t/	gieter, bieten
	/d/	bieden, wieden
	/k/	ziekenhuis, wieken
/u/	/p/	hoepel, koepel
	/b/	troebel, roebel
	/t/	voeten, toeter
	/d/	hoeden, poedel
	/k/	boeken, koeken

Table A.2 The Slovenian target words as included in the study of Chapter 2. Words were embedded in the target phrase '*Beseda* [TARGET] *ima več kot en zlog*': "The word [TARGET] has more than one syllable."

Vowel	Post-vocalic consonant	Target words
/a/	/p/	kapa, papež
	/b/	žaba, kabel
	/t/	solata, vrata
	/d/	brada, čelada
	/k/	omaka, mlaka
	/g/	žaga, glagol
/i/	/p/	pipa, ekipa
	/b/	riba, siba
	/t/	kita, pita
	/d/	robida, piramida
	/k/	pika, slika
	/g/	figa, knjiga
/u/	/p/	lupa, pupa
	/b/	rubelj, tuba
	/t/	ruta, valuta
	/d/	pudelj, Buda
	/k/	bukev, kljuka
	/g/	vijuga, uganka

B

Speaker metadata

Table B.1 The individuals with PD included in the studies of Chapters 3, 4, and 5. The table shows the gender, the age, the province in which the subject spent most of his or her life, and the self-reported speech difficulties (if any) of the subjects.

Subject	Gender	Age	Province	Self-reported speech difficulties
PD01	male	74	Noord-Holland	Atypical speech rate, speech freezing, unintelligible speech
PD02	male	70	Gelderland	Reduced volume, impaired articulation
PD03	female	66	Noord-Holland	Reduced volume, harsh voice
PD04	male	68	Groningen	Reduced volume, unintelligible speech
PD05	male	55	Zuid-Holland	Impaired articulation, reduced volume
PD06	male	76	Fryslân	Impaired articulation
PD07	male	73	Noord-Holland	Unintelligible speech
PD08	male	76	Overijssel	Reduced volume
PD09	female	71	Utrecht	Reduced volume, impaired articulation
PD10	male	75	Noord-Holland	Reduced volume, impaired articulation
PD11	female	72	Fryslân	None
PD12	male	71	Noord-Brabant	Unintelligible speech
PD13	male	52	Noord-Brabant	Reduced volume, atypical speech rate, impaired articulation, speech freezing
PD14	male	72	Drenthe	Unintelligible speech
PD15	male	80	Groningen	Reduced volume
PD16	male	72	Noord-Brabant	Reduced volume, atypical speech rate, unintelligible speech
PD17	female	60	Noord-Brabant	Unintelligible speech
PD18	male	62	Groningen	None
PD19	male	70	Gelderland	Unintelligible speech
PD20	female	65	Overijssel	Reduced volume, impaired articulation
PD21	male	75	Noord-Holland	Impaired articulation
PD22	male	73	Gelderland	Reduced volume, unintelligible speech
PD23	male	64	Overijssel	Impaired articulation, reduced volume
PD24	female	68	Noord-Holland	Impaired articulation, speech freezing

Table B.2 The disease progression of the individuals with PD included in the studies of Chapters 3, 4, and 5. The table shows the years since the diagnosis was made, the scores on the MDS-UPDRS scales, the answer to MDS-UPDRS tremor question 2.10, the scores on the SCOPA-COG test, and whether or not the subjects were treated with levodopa.

Subject	Years since diagnosis	MDS-UPDRS non-motor: PART I	MDS-UDPRS motor: PART II	MDS-UPDRS 2.10: tremor	SCOPA-COG	On levodopa medication
PD01	7	6	16	0	26	Yes
PD02	3	15	14	1	25	Yes
PD03	1	0	0	0	23	Yes
PD04	8	10	25	1	20	Yes
PD05	3	7	9	0	23	Yes
PD06	8	20	35	4	22	Yes
PD07	12	4	10	1	24	Yes
PD08	18	11	32	1	23	Yes
PD09	4	18	34	2	23	Yes
PD10	10	13	17	1	22	Yes
PD11	11	11	3	0	28	Yes
PD12	8	19	20	1	32	Yes
PD13	6	23	23	2	33	Yes
PD14	7	3	25	0	29	Yes
PD15	19	11	23	2	28	Yes
PD16	3	10	11	0	32	Yes
PD17	12	15	23	3	23	Yes
PD18	3	10	7	1	30	Yes
PD19	10	13	38	1	21	Yes
PD20	10	7	12	1	34	Yes
PD21	3	10	8	1	25	Yes
PD22	3	13	13	0	25	Yes
PD23	4	2	15	1	34	Yes
PD24	4	27	25	1	31	Yes

Table B.3 The typical speakers included in the studies of Chapters 3, 4, and 5. The table shows the gender, the age, and the province in which the subject spent most of his or her life.

Subject	Gender	Age	Province
TP01	female	73	Noord-Holland
TP02	female	69	Gelderland
TP03	male	56	Zuid-Holland
TP04	male	69	Utrecht
TP05	female	62	Noord-Holland
TP06	female	55	Noord-Brabant
TP07	male	71	Drenthe
TP08	male	63	Drenthe
TP09	female	79	Gelderland
TP10	male	62	Noord-Brabant
TP11	male	72	Utrecht
TP12	male	67	Utrecht
TP13	male	64	Utrecht
TP14	female	73	Noord-Holland
TP15	female	74	Fryslân
TP16	male	78	Fryslân
TP17	male	72	Groningen
TP18	male	60	Groningen
TP19	male	71	Groningen
TP20	male	67	Overijssel
TP21	male	66	Drenthe
TP22	male	72	Zuid-Holland
TP23	male	71	Noord-Holland
TP24	male	71	Noord-Holland
TP25	male	67	Noord-Holland

C

De noordenwind en de zon

De noordenwind en de zon

De noordenwind en de zon waren erover aan het redetwisten wie de sterkste was van hun beiden. Juist op dat moment kwam er een reiziger aan, die gehuld was in een warme mantel. Ze kwamen overeen dat degene die het eerst erin zou slagen de reiziger zijn mantel te doen uittrekken de sterkste zou worden geacht. De noordenwind begon toen uit alle macht te blazen, maar hoe harder ie blies, desto dichter trok de reiziger zijn mantel om zich heen; en ten lange leste gaf de noordenwind het op. Daarna begon de zon krachtig te stralen, en hierop trok de reiziger onmiddellijk zijn mantel uit. De noordenwind moest dus wel bekennen dat de zon van hun beiden de sterkste was.

/inɛm/

English summary

Many individuals with Parkinson's disease (PD) experience articulatory difficulties, which often have a considerable impact on their quality of life. It is currently poorly understood which mechanisms underlie these articulatory difficulties. By means of this thesis, I aimed to broaden our knowledge on this topic, through examination of the coordination and timing of speech gestures in PD. Both these aspects are intrinsic to articulation, but at current it is unknown how they contribute to the articulatory difficulties observed in PD speech. The studies in this thesis address this issue using state-of-the-art methods. In Chapter 2, I describe the first study of this thesis in which the effect of levodopa on vowel articulation in PD was examined. The results from this study suggest that articulation of vowels is not influenced by levodopa. In Chapter 3, I describe our first kinematic study in which we examined spatial and temporal aspects of speech gestures during fast syllable repetition. The results from this study suggest that the relationship between the timing and spatial execution of speech gestures is atypical in PD and that especially the timing of speech gestures is impaired. In Chapter 4, I describe our second kinematic study in which we examined

syllable organization in onset clusters in PD speech. The results from this study indicate that the coupling (and thus timing) between speech gestures is impaired in PD. In Chapter 5, I describe our third kinematic study in which the prevalence and nature of tongue tremor in individuals with PD were investigated. Using a computer algorithm, we found different types of tongue tremor in our data, which we believe may affect the timing of speech gestures. Together, these studies show that coordination and timing are indeed impaired in the speech of (at least some) individuals with PD. We believe that this impairment may be caused by the presence of malfunctioning regulatory mechanisms in PD speech.

Nederlandse samenvatting

Veel mensen met de ziekte van Parkinson (ZvP) ondervinden articulatieproblemen, welke de kwaliteit van leven vaak aanzienlijk doen verminderen. Het is vandaag de dag onduidelijk welke mechanismes ten grondslag liggen aan deze problematiek. Mijn doel met dit proefschrift was om meer te weten te komen over dit onderwerp, door middel van het bestuderen van de coördinatie en timing van spraakbewegingen bij mensen met de ZvP. De experimenten in dit proefschrift maakten gebruik van de modernste onderzoekstechnieken, zodat een gedegen studie kon worden uitgevoerd. In Hoofdstuk 2 beschrijf ik onze eerste studie, waarin het effect van levodopa op de articulatie van klinkers is onderzocht. De resultaten van deze studie doen vermoeden dat levodopa geen effect heeft op de articulatie van klinkers. In Hoofdstuk 3 beschrijf ik onze eerste kinematische studie waarin ruimtelijke en temporele aspecten van spraakbewegingen zijn onderzocht. De resultaten van deze studie laten zien dat deze relatie afwijkend is in de spraak van mensen met de ZvP en dat mensen met de ZvP met name moeite hebben met de timing van hun spraakbewegingen. In Hoofdstuk 4 beschrijf ik onze tweede kinematische studie waarin wij de organisatie van syllabes in

onset-clusters hebben onderzocht in de spraak van mensen met de ZvP. De resultaten van deze studie doen vermoeden dat de koppeling (en dus de timing) tussen opeenvolgende spraakbewegingen is verstoord in de spraak van mensen met de ZvP. In Hoofdstuk 5 beschrijf ik onze derde kinematische studie waarin zowel de prevalentie alsook de kenmerken van tong-tremoren bij mensen met de ZvP is onderzocht. Door gebruik te maken van een computer-algoritme vonden wij verschillende soorten tremor in onze data. Het is goed mogelijk dat deze tremoren (deels) ten grondslag liggen aan spraakproblemen bij mensen met de ZvP. Samenvattend laten de experimenten in dit proefschrift zien dat de coördinatie en timing van spraakbewegingen verstoord kunnen raken bij mensen met de ZvP. Wij vermoeden dat deze verstoringen mogelijk het gevolg zijn van suboptimaal werkende regel-mechanismes in het brein van mensen met de ZvP.

/θæŋks/

Acknowledgments

Although it is just my own name on the cover of this book, this dissertation is the product of the interactions between myself and many others. Some of these interactions were short, others were longer. Some were in groups, others with individuals. Some were in Dutch, others in English. What they all have in common is that they gave me the motivation and inspiration that I needed to write this dissertation. I would therefore like to finish this book with the most popular section of all: my acknowledgments.

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Jidde

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