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Validating molecular analysis of stuttering

’stuttering is not a unitary concept’ (Brutten, 1967)

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Topics addressed

- Some facts about stuttering
- Refinement of categories of stuttering behavior
- Comparison of stutterers and nonstutterers
- Clustering of disfluencies
- Validity of types of disfluencies: negative emotion, language disability, genetic factors

Stuttering disfluencies and related orofacial behaviors

Stuttering: some data

- Stuttering is a disorder of childhood, it occurs most likely between ages of 2 and 5
- Life time risk is about 5% and prevalence 1%; indicative of spontaneous recovery
- A balanced sex-ratio at age of two, in older children and adults about 4:1
- Stuttering runs in families (16% of first degree relatives of stutterers are affected)

Four leading themes in stuttering theory

Stuttering as an outgrowth of normal disfluency

Anxiety contributes to a disintegration of speech

Deficits in syntactic and lexical skills

A geneticallly predisposed neuromotor deficit contributes to the disorganization of the sensomotoric pattern of speech movements

Unit of analysis: from molar to molecular

- Stuttering moment/event: any disruption of fluent speech
- The 8 a priori categories of W. Johnson

Hypothesis: Stuttering as an outgrowth of normal disfluency

Table 20. Mean Number of Disfluencies Per 100 Words of 68 Male Stuttering and 68 Male Nonstuttering Children

From: Wendell Johnson and Associates, **The Onset of Stuttering,** University of Minnesota Press, Minneapolis. ©1959 University of Minnesota. By permission.

	Stutterers	Nonstutterers	P*
Interjections	3.62	3.13	NS
Sound and syllable repetitions	5.44	.61	.01
Word repetitions	4.28	1.07	.01
Phrase repetitions	1.14	.61	.01
Revisions	1.30	1.43	NS
Incomplete phrases	.34	.23	NS
Broken words	.12	.04	.05
Prolonged sounds	1.67	.16	.01
All categories	17.91	7.28	.01

*Level of significance of the difference between stutterers and nonstutterers.

Unit of analysis: from molar to molecular

- Stuttering moment/event: any disruption of fluent speech
- The 8 a priori categories of W. Johnson

- Further differentiating disfluencies:

a) Sound, syllable, word and syntactic unit
b) Fast and slow repetitions
c) Interjections and blocks
d) With/without orofacial behavior

- Differences between stutterers and nonstutterers
- Clusters of disfluencies

Differentiating stuttering and nonstuttering boys (13-16 yrs)

	Stutterers		Nonstutterers	
	Mean	*SD*	Mean	*SD*
Fast Sound Repetitions	9.31	17.61	.13	.33
Fast Word Repetitions	.67	1.58	0	–
Sound Prolongations	9.10	12.81	.06	0.32
Tense Blocks	9.96	21.57	0	–
Non-Tense Blocks	6.71	10.76	.90	1.61
Vocalized Blocks	.98	4.21	0	–
Fast Sound Interjections	2.86	9.72	0	–
Slow Sound Interjections	5.10	9.76	1.13	1.08
Slow Word Interjections	1.27	4.23	4.85	5.49
Slow Sound Repetitions	2.83	3.54	1.33	2.64
Slow Syllable Repetitions	2.27	2.99	1.90	2.24
Slow Word Repetitions	4.58	5.14	3.38	2.33
Phrase Repetitions	3.23	3.75	1.63	1.66
Reading Errors	5.63	4.20	10.50	8.25

Table 1. Mean frequencies and standard deviations of specific disfluency types for stuttering and nonstuttering boys.

Disfluency: oral reading of 54 stuttering and 33 nonstuttering children (6-9 yrs.)

Table 1. Specific disfluency types for stuttering (n = 54) and nonstuttering (n = 33) children, aged from 6 to 9 years.*

	Stutterers		Nonstutterers		
	Mean	% of total disfluency	Mean	% of total disfluency	P
1. Fast sound repetitions	3.11	8	-	-	-
2. Fast word repetitions	.11	0	-	-	-
3. Prolongations	2.71	7	.04	1	-
4. Sound prolongations	1.02	3	-	-	-
5. Non-tense block	3.23	8	.09	1	.001
6. Tense block	8.64	22	-	-	-
7. Vocalized block	.37	1	-	-	-
8. Slow sound interjections	1.79	5	.61	10	ns
10. Slow word interjections	2.19	6	1.63	25	ns
12. Slow sound repetitions	4.74	12	.42	7	.001
13. Slow syllable repetitions	1.94	5	.40	6	.001
14. Slow word repetitions	7.61	20	1.48	23	.001
15. Phrase repetitions	2.40	6	1.77	28	ns

* per 230 words

Arriving at clusters of disfluencies.

- Fast sounds repetitions, prolongations, blocks and associated nonverbal behavior vary largely among stutterers.
- A central question is, if these disfluencies are interrelated and influenced by similar factors.
- Some data reduction might solve problems of distribution and the rather low frequency of occurrence of some behaviors.
- Factor and cluster analyses were performed at the data of several age groups of stutterers and nonstutterers to arrive at consistent behavioral clusters.
- Calculations were performed with absolute frequencies as well as percentages, various association coefficients and split-procedures.

EFA disfluencies and nonverbal orofacial behaviors (48 stuttering boys, 13-16 yrs)

Variables: / Factors:	1	2	3	4	5	6	h^2
Fast Sound Repetitions	.25	.33	-.04	.71	.10	.10	.74
Fast Word Repetitions	.19	.04	.01	.60	-.09	.13	.42
Sound Prolongations	-.08	.63	.27	.40	.19	-.19	.70
Tense Blocks	.18	.21	.18	.12	.61	-.04	.50
Vocalized Blocks	.31	.69	.22	-.02	.17	.16	.68
Non-Tense Blocks	.07	-.02	.03	-.05	.56	.10	.33
Fast Sound Interjections	.44	.43	.03	.27	.24	.07	.51
Slow Sound Interjections	.57	.31	.15	.17	.45	.19	.71
Slow Word Interjections	.14	.33	.16	.01	.06	.10	.17
Slow Sound Repetitions	.42	.39	.27	.15	.19	.19	.49
Slow Syllable Repetitions	.69	.25	.21	.12	-.38	-.38	.88
Slow Word Repetitions	.79	.09	.34	.11	-.07	-.07	.77
Phrase Repetitions	.59	.01	.10	.13	.18	.06	.41
Reading Errors	-.01	-.27	-.48	-.04	-.27	-.12	.39
Eye Blinks	.33	.65	.18	-.12	-.01	.08	.59
Movements Forehead	-.27	.23	.14	.10	.37	-.17	.32
Movements Eyelids	-.09	.41	-.03	.09	.01	.07	.19
Movements Head	.28	.54	-.01	-.14	.06	-.19	.43
Movements Mouth	.43	.28	.04	-.07	.09	.31	.37
Breathing Irregularities	.33	.06	-.01	.10	.34	-.01	.26
Looking Away	-.02	.22	.07	.36	.06	.55	.90

Hierarchical cluster analysis: 15 disfluencies and 2 nonverbal behaviors, 48 stutterers (13-16 yrs)

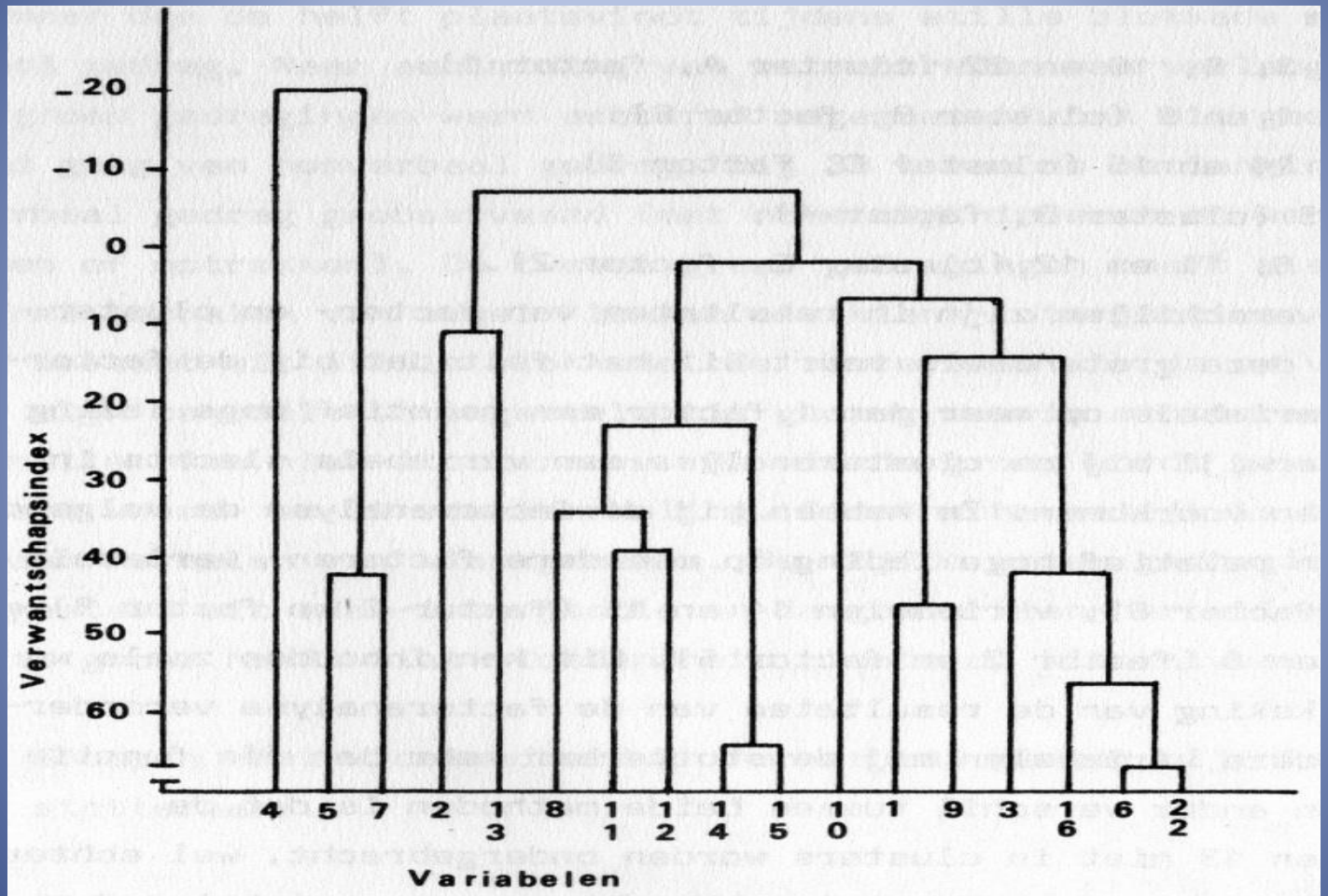
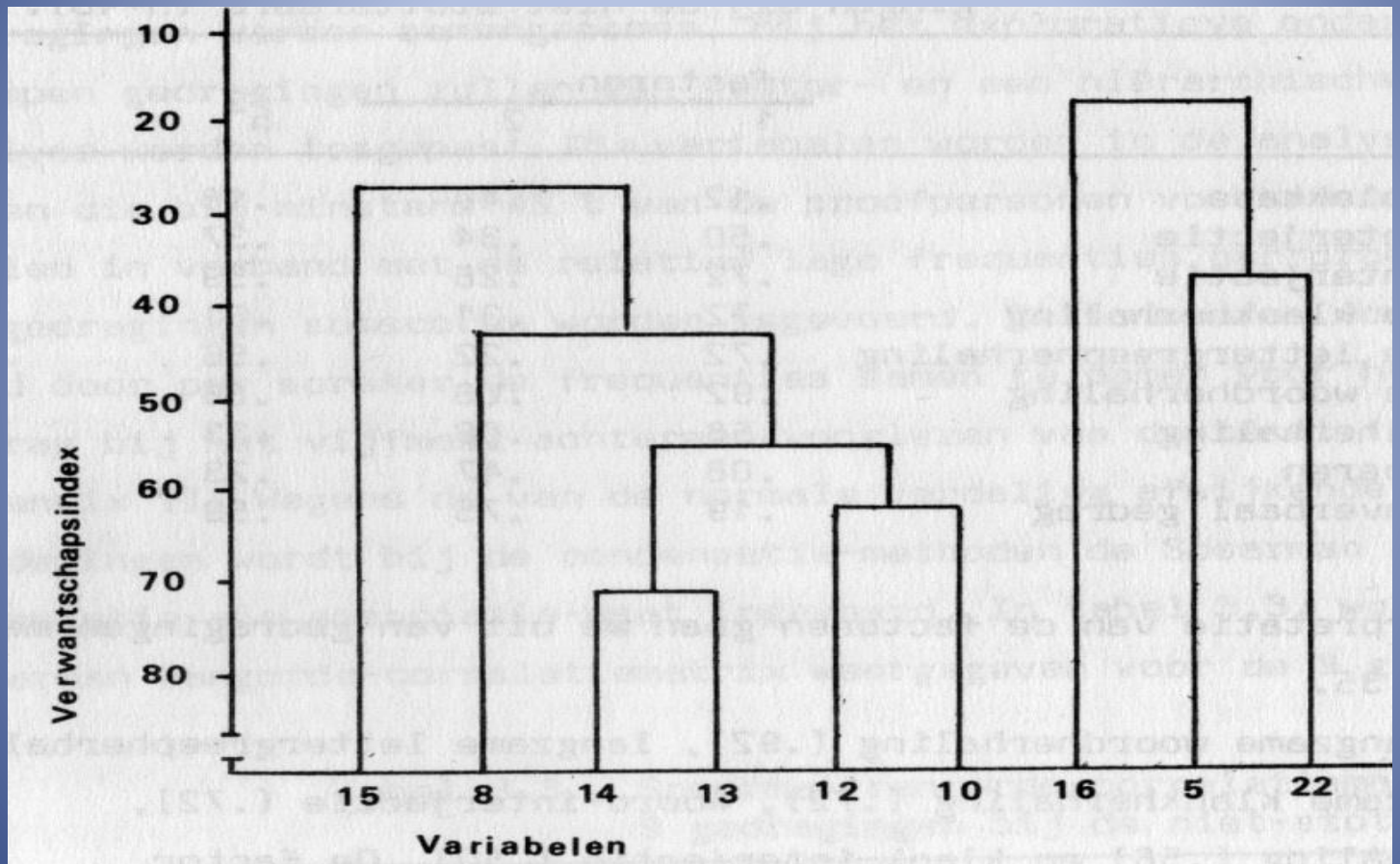


Fig.3.1 Clusteranalyse bij de stotteraars

Efa disfluencies and orofacial nonverbal behaviors (nonstuttering boys, 13-16 yrs)

Variables: / Factors:	1	2	3	4	5	6	h^2
Slow Sound Repetitions	.74	.23	-.02	-.05	-.03	.19	.65
Slow Syllable Repetitions	.78	-.08	-.09	-.22	.07	.27	.74
Slow Word Repetitions	.84	.13	-.04	.01	.12	.05	.72
Phrase Repetitions	.54	.04	-.08	-.01	.09	-.11	.33
Slow Sound Interjections	.62	.01	.16	-.01	-.07	-.11	.43
Slow Word Interjections	.83	-.06	.08	.16	.10	.01	.74
Non-Tense Blocks	.18	.05	.22	-.16	.65	-.12	.54
Reading Errors	.83	-.01	.09	-.06	.03	.08	.71
Eye Blinks	-.15	.08	.14	.03	.22	.41	.27
Movements Forehead	-.08	.10	.13	.10	.09	-.49	.29
Movements Eyelids	.29	-.13	.45	-.17	-.25	.06	.40
Movements Head	-.09	.09	.56	-.30	.12	-.18	.47
Movements Mouth	.04	.03	-.07	-.05	.51	.13	.29
Looking Away	.34	.06	.04	-.04	.07	.39	.28

Hierarchical cluster analysis: 7 disfluencies and 2 nonverbal behaviors; 48 nonstutterers (13-16 yrs)



Flg. 3.2 Clusteranalyse bij de niet – stotteraars

Emperically clusters

Table 1. Summary of factor analysis and cluster analyses for the dysfluencies and nonverbal behaviors of stuttering and nonstuttering boys.

Stuttering boys (n = 48)	**Nonstuttering boys (n = 48)**
Cluster A: Head and facial movements, tense blocks, eye blinks, prolongations.	Cluster a: Slow word syllable, sound and phrase repetitions, sound and word interjections.
Cluster B: Fast sound repetitions and interjections, fast word repetitions.	Cluster b: Head and facial movements, Non-tense blocks.
Cluster C: Non-tense blocks, vocalized blocks.	
Cluster D: Slow word, phrase and syllable repetitions.	
Cluster E: Breathing irregularities, Slow sound repetitions, sound interjections.	

Observed orofacial nonverbal behaviors in stutterers

1. Jaw movements including tightening of the muscles and sideways movements of the mandible.
2. Mouth movements including pressing lips together, pursing lips, and sideways lip movements.
3. Eyelid movements including complete or partial closure of the eyes and enlarged eye openings.
4. Forehead movements defined as wrinkling the forehead or tightening the muscles of the forehead.
5. Eyebrow movements defined as excessively raising the eyebrows.
6. Head movements including movements back, down, or to either side.
7. Eyeblinks defined as any fast closure of an eye or eyes.

Nonverbal orofacial behavior: oral reading, 48 stuttering and 48 nonstuttering boys

	Stutterers		Nonstutterers	
	Mean	*SD*	Mean	*SD*
Eye Blinks	7.76	5.80	2.93	2.42
Movements Forehead	4.10	6.90	2.00	2.66
Movements Eyelids	1.56	4.13	.03	.14
Movements Head	2.30	3.90	.91	1.21
Movements Mouth	1.07	3.32	.72	1.24
Breathing Irregularities	1.94	4.88	.10	.59
Looking Away	.22	.58	.22	.57

Table 2. Mean frequencies and standard deviations of specific nonverbal behaviours for stuttering and nonstuttering boys.

What is the nature of nonverbal behavior in stuttering?

- Learned avoidance and escape behaviors to cope with an anticipated or actual speech block
- Visible part of an increase in physical tension of the speech-related or neigbouring muscles that may have resulted from deficits in fine motor control of speech muscle systems
- Communicative and/or supportive function

Relatedness of nonverbal orofacial behavior in stuttering (2 min. spontaneous speech)

MEAN PROPORTION OF NONVERBAL BEHAVIOURS AND STANDARD DEVIATIONS FROM SYLLABLES STUTTERED, SPOKEN DISFLUENTLY AND FLUENTLY

Behavior	Stuttered			Disfluent			Fluent		
	M	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*
Movements									
Jaw	.334	.845	11	.012	.051	2			0
Mouth	.350	.726	15	.014	.054	2	.000	.001	2
Eyelid	.181	.345	9	.020	.036	5	.003	.009	4
Forehead	.050	.068	11	.001	.008	1	.002	.007	2
Eyebrow	.546	1.312	17	.056	.070	13	.019	.017	19
Head	.588	1.369	22	.032	.052	9	.037	.045	21
Eye blinks	.659	1.770	18	.146	.146	19	.541	1.981	22
Total nonverbal	2.707	6.066	24	.238	.221	21	.602	1.972	23

Hypothesis: Anxiety disruption hypothesis of stuttering

(Brutten & Shoemaker, 1967).

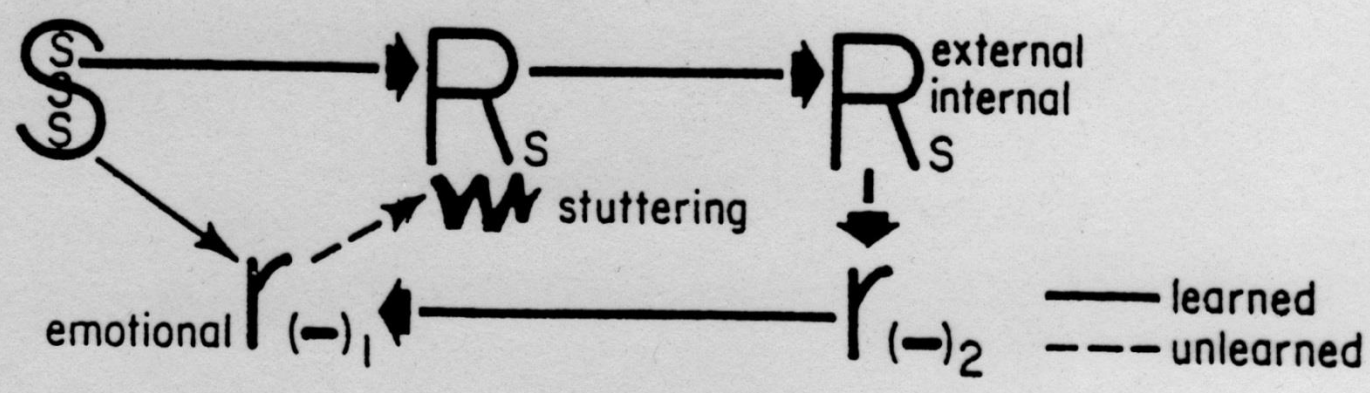


FIGURE II-4, Stage 3: Stuttering (R_{ws}) leads to noxious responses from the external and internal listeners ($R_{s\ \substack{ext \\ int}}$). The resulting negative emotion $(r_-)_2$ summates with the negative emotion $(r_-)_1$ elicited by the initial stimulus situation (S), and stuttering is increased.

Reading a 230 word text: clusters of disfluency

Stutterers	Exp. anxiety	Skin cond.	Spont. fluct.	Heart rate
Cluster a	.36**	.21	-.10.	.16
Cluster b	.22	.30*	.31*	.46**
Cluster c	.17	.08	.05	.01
Cluster d	.26	.04	-.01	.11
Cluster e	.31*	.17	.06	.22
Nonstutterers				
Cluster a	.11	.04	.14	-.37**
Cluster b	.29*	-.09	.12	-.11

*P < .05, **p< .01

Stuttering boys

Cluster a: head and facial movements, tense blocks, eye blinks, prolongations

Cluster b: fast sound repetitions and interjections, fast word repetitions

Cluster c: non-tense blocks, vocalized blocks

Cluster d: slow word, phrase and syllable repetitions

Cluster e: breathing irregularities, slow sound repetitions, sound interjections

Nonstuttering boys

Cluster a: slow word, syllable, sound and phrase repetitions, sound and word interjections

Cluster b: Head and facial movements, non-tense blocks

Relationship of indices of anxiety and disfluency in stuttering: therapy outcome

Table 2. Correlations Between Pretreatment Measures of Cognitive and Autonomic Anxiety and Posttreatment Gain Scores for Measured Fluency Failures

	Residual gain scores		
	Fast repetitions	Silent/oral prolongations	Slow repetitions/ interjections
Cognitive Anxiety			
Speech Situation Checklist	−.14	−.13	−.36[a]
Experienced anxiety	−.08	−.02	−.03
Autonomic Anxiety			
Skin conductance	−.61[b]	−.37[a]	−.20
Spontaneous fluctuations	−.23	−.26	.03
Heart rate	−.08	−.13	.11

[a] $p < 0.05$, two-tailed.
[b] $p < 0.01$, two-tailed.

Reading ability in stuttering and nonstuttering children

Group Mean Proportions and Standard Deviations for Each Type of Reading Error for Stuttering and Nonstuttering Children

	Stutterers		Nonstutterers		
Type of reading error	Mean	SD	Mean	SD	*t*-value
Wrong emphasis	0.018	0.035	0.015	0.034	0.46
Word spelling[a]	0.001	0.006	—	—	—
Breaking up a word	0.023	0.049	0.031	0.049	−0.72
Redoubling of sounds[a]	0.002	0.010	—	—	—
Plural form[a]	—	—	0.013	0.037	—
Omission of a word	0.052	0.064	0.063	0.061	−0.84
Addition of a word	0.049	0.063	0.051	0.063	−0.14
Replacement by a new (synonymous) word[a]	—	—	0.002	0.010	—
Replacement by a new (not synonymous) word	0.079	0.085	0.065	0.079	0.55
Replacement of an article	0.153	0.104	0.150	0.118	0.19
Inversion of words	0.005	0.026	0.001	0.006	0.95
Inversion of a sound	0.015	0.033	0.027	0.045	−1.34
Replacement of a sound	0.197	0.126	0.159	0.106	1.53
Omission of a sound	0.274	0.161	0.213	0.133	1.96
Addition of a sound	0.114	0.104	0.182	0.162	−2.36*
Anticipation of a sound	0.020	0.047	0.020	0.036	0.00
Miscellaneous errors	0.001	0.009	0.007	0.025	−1.43

[a]No *t*-value calculated due to the nonoccurrence of this error type in one of the two groups.

*$p < 0.05$.

Reading ability and disfluency in stuttering and nonstuttering children

Correlations Between Reading Ability and Grade, and Partial Correlations Between Reading Ability and Disfluency

	Stutterers			Nonstutterers		
	Grade	Disfluency		Grade	Disfluency	
Reading ability		WT	DST		WT	DST
Reading Errors WT	−0.15	−0.14	−0.18	−0.29	0.62**	0.48**
Number of words WT	0.54**	−0.33*	−0.54**	0.54**	−0.26	−0.62**
Reading errors DST (%)	−0.53**	−0.10	−0.02	−0.46**	0.34*	0.63**
Errors revised DST (%)	0.16	−0.02	−0.17	0.02	−0.20	−0.13
Correct responses RCT	0.31*	0.07	−0.07	−0.31*	−0.37*	−0.62**
Working time RCT	−0.51**	0.06	0.27	−0.03	0.36*	0.48**

* $p < 0.05$.
** $p < 0.01$.

Genetic history and clusters of disfluencies (78 stutterers, 8-12 and 13-16 yrs)

Table 1. Fluency Failures, Normal Disfluencies, and Nonverbal Adjustive Behaviors of Elementary- and High-school Stutterers Having a Positive or Negative Family History of Stuttering

	Positive family history		Negative family history		Univariate
	Mean	SD	Mean	SD	*F* value
Elementary-school children					
Fast repetitions of sounds or syllables	0.52	0.56	1.22	2.74	0.84
Oral and silent prolongations	12.02	16.66	1.77	3.04	9.10[b]
Normal disfluencies	4.47	2.56	4.84	3.68	0.10
Nonverbal adjustive behaviors	14.67	12.27	6.77	8.00	5.49[a]
High-school children					
Fast repetition of sounds or syllables	2.78	2.64	4.85	9.25	0.84
Oral and silent prolongations	9.75	10.18	4.53	5.90	4.10[a]
Normal disfluencies	4.73	5.04	4.47	4.12	0.03
Nonverbal adjustive behaviors	8.66	10.39	8.61	14.22	0.00

[a] $p < 0.05$.
[b] $p < 0.01$.

Speech motor and language skills prior to onset

Young stutterers prior to onset

Table 3. Two-factor analyses of (co)variance for groups, gender and group by gender interactions.

	Two-way ANCOVA F-values			
	Covariate Age	Group	Gender	Group x Gender
SPEECH-MOTOR				
Articulation rate	50.71**	8.28**	3.06	.22
Variability art.rate	16.26**	.02	.01	3.56
LANGUAGE RECEPTIVE				
Reynell	-	.30	.87	.87
PPTV	-	.24	1.02	.30
LANGUAGE EXPRESSIVE				
Reynell	-	1.69	.33	1.94
MLU	61.16**	3.56	1.74	.09

* p<.05; ** p<.01

Persistent and remitted stutterers

Table 2. Two-factor analysis of (co)variance with repeated measures for time, group and time by group interaction.

	Covariate Age F-value	Time F-value	Group F-value	Group x Time F-value
Child variables				
ARTICULATORY SKILLS				
Articulation rate	7.62**	25.16**	.52	4.27*
Variability art.rate	.08	.08	7.17**	.40
LANGUAGE RECEPTIVE				
Reynell	16.93**	72.43**	.50	.14
PPTV	8.92**	73.11**	.28	.08
LANGUAGE EXPRESSIVE				
Reynell	15.19**	74.11**	.90	4.08
MLU	7.26**	56.00**	.29	.54
Mother variables				
COMMUNICATIVE STYLE				
Non-intervening	-	.67	.11	4.24*
Explaining	-	2.13	2.32	.03
Directing	.25	.02	.11	.01
SPEAKING BEHAVIOR				
Speaking rate	-	1.07	2.87	.08
Language complexity	.33	2.10	6.31*	.05

* p<.05; ** P<.01

DISCUSSION

Molecular analysis of stuttering behavior and leading themes in stuttering theory

Prolongations, blocks and fast repetitions are very unlikely an outgrowth of normal disfluency.

Autonomic and cognitive anxiety is differentially associated with the type of disfluent speech of the stutterer.

Deficits in syntactic and lexical skills do not contribute to the characteristic disfluencies of the stutterer.

A geneticallly predisposed neuromotor deficit contributes to the disorganization of the sensomotoric pattern of speech movements in stuttering.