Kraaimaat, F.W. (1980). Molecular analysis of disfluency and nonverbal behavior of stutterers and nonstutterers. In F.W. Kraaimaat, *Stuttering: a molecular analysis of stuttering* behavior (pp. 15-33). Swets & Zeitlinger, Lisse. (Translated from the Dutch)

Introduction

Disfluencies are mostly studied using the classification in 8 types of disfluency suggested by Johnson (1955, 1961). With this classification, a relatively high overlap is displayed between the frequency of occurrence of disfluency between persons who stutter (PWS) and persons who do not stutter (PWNS) in interjections, word repetitions, phrase repetitions, revisions and incomplete phrases (Johnson et al., 1967, Johnson, 1961). A comparison of the proportions of these eight types of disfluency showed that the disfluency of PWS is mainly localized at sounds and syllables, while those of PWNS is localized at words and phrases. The relatively high overlap in disfluency between PWS and PWNS might be due to taken together of the same disfluency that occurs at the level of a sound, word, syllable, and phrase in one subtype (i.e., interjections of sounds, syllables, words, and phrases). Next, one might argue that Johnson's classification combines disfluencies while the interrelation of those disfluencies is unknown. Moreover, disfluencies that were combined in these categories might differ in function. Furthermore, if that is the case, a too global classification obscures research into its function.

Thus the study of stuttering might gain from a specific and molecular analysis of disfluency (Brutten, 1973). The results of such an analysis might pave the way to clarify several critical issues in stuttering. First, concerning the assumed overlap and differences between PWS and PWNS in disfluency, it is essential to differentiate disfluencies that occur at the level of sound, syllable, word, and phrase. Also, the determinants and functions of the separate disfluencies that characterize the PWS might be quite different from those of the PWNS. Next, there is a lack of studies into nonverbal behaviors during speech that has no articulatory or communicative function. For instance, it is assumed that nonverbal behavior, such as eye blinks and head movements accompany the PWS's efforts to speak fluently. However, clinical observation is that these behaviors occur in PWS as well as PWNS. Thus it is not clear to what extent these behaviors are typical for the PWS or what is the function of these behaviors. The purpose of the present study is to address these issues.

Method

Subjects. The subjects were 48 young male PWS and PWNS between the ages of 13 and 16 years. None of the PWS was in therapy at the moment of data collection. No subjects included in the PWNS group had a history of previous speech disorders.

Procedure. The subject's task consisted of the oral reading of a 230-word passage in the presence of an experimenter. Each subject was tested individually. All oral readings were recorded on a video recorder for later analysis.

Analysis of disfluency.

The speech sample was analyzed according to the following 15 types of disfluency: fast sound repetitions, fast word repetitions, prolongations, sound prolongations (within a word), tense blocks (blocks with concomitant inappropriate movements or fixations of the face or head), *non-tense blocks*, vocalized blocks (blocks with concomitant audible struggle behavior), *sound interjections*, fast sound interjections, *word interjections, slow sound repetitions*, *slow syllable repetitions, slow word repetitions, phrase* repetitions and breathing irregularities. The disfluency types which were included

in the analysis for the PWNS are printed in italics. Mean percentage of agreement between two observers for judging different types of disfluencies was 83% (Sander, 1961).

Analysis of nonverbal behavior. Nonverbal behavior was defined as any observable movement of the orofacial structure that was not an integral part of the ongoing process of speech. Use was made of the 95-item Behavior Checklist (Brutten, 1974) to select nonverbal behaviors and to combine consistent categories. The following categories were employed: eye blinks defined as the fast closure of an eye or eyes, eyebrow movements defined as excessively raising the eyebrows or wrinkling the forehead, eyelid movements including complete and partial closing of the eyes and enlarged eye openings, head movements including movements back, down or to either side, mouth movements including pressing lips together, pursing lips and sideway lip movements and jaw movements, looking away and touching nose, hair or spectacle. Due to differences in reading time frequencies were calculated per minute. The videotapes were replayed by two experimenters as often as necessary to ensure the accuracy in identifying the nonverbal behaviors. Inter-observer reliability varied across nonverbal behaviors between r=.94 and r=.99.

Results

Disfluencies and nonverbal behaviors of PWS

Mean, median, standard deviation, and range are presented in Table 1 for each type of disfluency. The percentage of the total disfluency and the number of PWS who displayed the disfluency are presented respectively in the last columns of the table.

Table 1. Disfluencies of PWS (n=48)

Variables	Mean	Median	Standard deviation	Range	% of the total disfluency	Number of PWS
Fast sound repetition	9.31	4	17.61	106	15	38
Fast word repetition	0.67	0	1.58	8	1	15
Prolongation	9.10	2.5	12.81	48	14	36
Sound prolongation	3.17	0	19.90	138	5	6
Non-tense block	6.71	3	10.76	59	11	43
Tense block	9.96	1	21.57	134	16	25
Vocalized block	0.98	0	4.21	29	2	11
Sound interjection	5.10	1	9.76	42	8	28
Fast sound interjection	2.86	0	9.72	62	4	10
Word interjection	1.27	0	4.23	27	2	14
Breathing interjection	1.94	0	4.88	28	3	17
Slow sound repetition	2.83	1.5	3.54	12	4	33
Slow syllable repetition	2.27	1	2.99	13	4	28
Slow word repetition	4.58	3	5.14	21	7	41
Phrase repetition	3.23	2	3.75	18	5	36

The group of PWS displayed about 82% of the disfluencies that are related to sounds, 4 % syllables, 10% words, and 5 % phrases. Fast and slow repetitions of sounds take about 23 % of the total number of disfluencies and 58 % of the total number of repetitions. The percentage of disfluencies that occur 75 % or more are non-tense block, slow word repetition, fast sound repetition, prolongation, and phrase repetition. While the percentage of disfluencies that occur 25 % or less are: sound prolongation, fast sound interjection, and non-tense block with phonation.

Mean, median, standard deviation, and range are presented in Table 2 for each category of nonverbal behavior. The percentage of the total nonverbal behavior and the number of PWS are shown respectively in the last columns of the table.

Table 2. Nonverbal behaviors of PWS (n=48)

Variables	Mean	Median	Standard deviation	Range	% of the total nonverbal behavior	Number of PWS
Eye Blinks	7.71	6.6	5.80	26	46	47
Eyebrow movements	6.71	3	10.76	59	11	43
Eyelid movements	9.96	1	21.57	134	16	25
Head movements	0.98	0	4.21	29	2	11
Mouth movements	5.10	1	9.76	42	8	28
Looking away and touching Nose, hair or spectacle	2.86	0	9.72	62	4	10

The categories of eye blinks and eyebrow movements include about 70 % of all observed nonverbal behaviors. A comparison of our findings with those of Prins & Lohr (1968) is only partially possible due to different observation methods. Prins & Lohr observed 16 separate nonverbal behaviors using a frame-by-frame analysis of 10 filmed stuttered words of each of 23 PWS. The percentage of PSW that showed nonverbal behavior by Prins & Lohr and in our study are respectively 100 % and 98% for eye blinks, 48 % and 50 % for eyebrow movements and 22 % and 35 % for head movements.

Disfluencies and nonverbal behaviors of PWNS

Mean, median, standard deviation, and range are presented in Table 3 for each type of disfluency that was observed. The percentage of the total disfluency and the number of PWS are shown respectively in the last columns of the table.

Table 3. Disfluencies of PWNS (n=48)

Variables	Mean	Median	Standard deviation	Range	% of the total disfluency	Number of PWS
Fast sound repetition	0.13	0	0.33	1	1	6
Prolongation	0.06	0	0.32	2	0	2
Non-tense block	0.90	0.42	1.61	9	6	22
Sound interjection	1.13	1	1.08	4	7	33
Word interjection	4.85	3.64	5.49	31	31	41
Breathing interjection	0.10	0	0.59	4	1	2
Slow sound repetition	1.33	0.57	2.64	16	9	25
Slow syllable repetition	1.90	1.36	2.24	8	12	30
Slow word repetition	3.38	1.66	2.33	10	22	39
Phrase repetition	1.63	1.11	1.66	5	11	35

The figures in Table 3 show that the disfluency of the PWNS involves 24 % sounds, 12 % syllables, 53 % words, and 11 % phrases. About 10 % of the total disfluency concerns fast and slow repetitions of a sound and 17 % of all repetitions. It is of interest to note that only 2 % of the repetitions are fast repetitions, while 98 % are slow repetitions. Disfluencies that occur 75 % or more are word interjections and slow word repetitions. Less than 25 % of the PWNS demonstrate fast sound repetitions, breathing interjections and prolongations. Not observed in PWNS were sound prolongation, fast word repetition, tense block, vocalized block, and fast sound interjection.

Mean, median, standard deviation, and range are presented in Table 4 for each category of nonverbal behavior observed with the PWNS. The percentage of the total nonverbal behavior (and the number of PWNS are shown respectively in the last columns of the table.

Table 4. Nonverbal behaviors of PWNS (n=48)

Variables	Mean	Median	Standard deviation	Range	% of the total nonverbal behavior	Number of PWNS
Eye Blinks	2.93	2.22	2.42	11.45	43	46
Eyebrow movements	2.00	1.30	2.66	12.83	29	40
Eyelid movements	0.03	0.00	0.14	0.82	0	2
Head movements	0.91	0.60	1.21	4.40	13	27
Mouth movements	0.72	0.00	1.24	4.62	11	16
Looking away and touching nose, hair or spectacle	0.22	0.00	0.57	2.81	3	9

Except for two PWNS, the group of PWNS displayed eye blinks. Concerning the other categories of nonverbal behavior, there was an individual preference for certain nonverbal behaviors. Also, there appeared a considerable variation between subjects in the number of nonverbal behaviors. About 72 % of the total frequency of nonverbal behavior consisted of the categories of eye blink and eyebrow movements.

Differences between PWS and PWNS in disfluencies and nonverbal behaviors of PWS

Differences between both group of subjects in the frequency of total disfluency and the ten common, occurring disfluencies are shown in Table 5. Nonparametric Mann-Whitney t-tests a were used because of a deviation of the normal distribution of the variables.

Table 5. Differences in disfluencies between PWS and of PWNS (n1=48, n2=48)

Variables	Z-value	P value
Fast sound repetition	6.51	.001
Prolongation	6.10	.001
Non-tense block	5.73	.001
Sound interjection	1.20	.23
Word interjection	-5.83	.001
Breathing interjection	2.27	.03
Slow sound repetition	2.51	.01
Slow syllable repetition	0.01	.99
Slow word repetition	2.03	.04
Phrase repetition	1.85	.06
Total frequency of disfluency	5.83	.001

In PWS, a significantly higher frequency was found for the following variables: fast sound repetition, prolongation, non-tense block, breathing interjection, slow sound repetition, and slow word repetitions. While PWNS, in contrast with PWS, displayed a higher frequency of word interjections. No differences between both groups of subjects were found with sound interjection, slow syllable repetition, and phrase repetition.

Differences between both groups of subjects in the frequency of the six categories of nonverbal behavior are shown in Table 6. Nonparametric Mann-Whitney t-tests a were used because of a deviation of the normal distribution of the variables.

Table 6. Differences in nonverbal behavior between PWS and PWNS (n1=48, n2=48)

Variables	Z-value	P-value
Eye Blinks	5.25	.001
Eyebrow movements	1.11	.27
Eyelid movements	2.33	.02
Head movements	0.65	.51
Mouth movements	1.99	.047
Looking away and touching head, nose or spectacle	0.05	.96

A higher frequency of eye blinks, eyelid movements, and mouth movements was observed in PWS. The categories of eye blink, eyebrow movements consisted in PWS and PWNS, respectively of 70 % and 72 % of their total nonverbal behavior. Our findings show that nonverbal behavior during speech is not a characteristic of PWS. However, a crucial question is to what extent nonverbal behavior is an accessory of disfluency. Noteworthy is that no nonverbal behaviors were observed during the disfluencies of the PWNS. While about 59 % of the total nonverbal behavior of the PWS was

observed during a non-tense block with nonverbal behavior. The latter finding is suggested to be a characteristic of the PWS.

Summary and discussion

Classifications of disfluency concerning form (Johnson, 1961), primary and secondary stuttering (Blumel, 1957), type I and type II behavior (Brutten and Shoemaker, 1967) or motoric complexity (Van Riper, 1971) somewhat obscure the differences between PWS and PWNS. By using molecular analysis, explicit and significant differences were observed in disfluency and nonverbal behavior between both groups of subjects. Only PWS did show fast repetitions of one-syllable words and interjections, non-tense block, and vocalized block. Also in PWS a significantly higher frequency was observed of fast sound repetitions, prolongations, non-tense blocks, breathing interjections, slow sound repetition, and slow word repetitions. While PWNS displayed a higher frequency of word interjections in comparison with PWS. No differences between both groups of subjects were observed in sound interjections, slow syllable repetitions, and phrase repetition.

The disfluency of the PWS is generally located at the first sound of a word. While in contrast with this, the disfluency of the PWNS comprises predominantly syntactic units such as syllables, words or phrases. Although the latter type of disfluency was also observed in PWS. About 50 % of the disfluencies of PWS were located at the first sound of a word and comprised fast repetitions, tense blocks, or vocalized blocks.

The differences that were observed in disfluencies between PWS and PWNS do not support the hypothesis of Johnson (1967) and Bloodstein (1969) that stuttering is a development of the type of disfluency that occurs in normal speakers and comprises syllables, words, and phrases. In our opinion, it is more likely that the characteristic disfluencies of the PWS are due to a disruption of the sensomotoric program of speech movements. In this case, irregularities in the coarticulation and coordination of breathing, phonation, and articulation do manifest themselves at the first sound of a word. Some support for this interpretation is found in a study of Stromstra (1969) in which CWS who stuttered after ten years displayed limited formant transitions in their spectrogram, while that was not observed in the children who reached normal fluency. Also, Vaane (1975, 1976) studied the coordination of speech by comparing onset times of articulatory muscles, voice, and breathing in PWS and PWNS. Only in PWS an irregular coordination pattern was found during their fluent as well as their disfluent speech.

The characteristic disfluencies of the PWNS are suggested to be associated with deficits in syntactic skills such as delaying the decoding and for a short time memorizing of syntactic and meaningful parts of the reading text. Some support for this interpretation was found by Vaane (1979) who performed a phonetic analysis of the disfluencies of the 48 PWNS of our study and found that disfluency occurred predominantly at function words.

The PWS differs from the PWNS in the occurrence of nonverbal behavior during disfluent speech. The nonverbal behaviors that are associated with the PWS's disfluency may have the function of an instrumental escape or avoidance behavior. This explanation implicates that it is the aversive stimulus of disfluency that controls nonverbal behavior. Some support for this contention was found in a study by Janssen & Brutten (1974) where contingent punishment was applied to mouth and tongue movements of PWS which resulted in a reduction in the frequency of these behaviors. However, this does not indicate that these nonverbal behaviors are established originally by operant conditioning.

An alternative view is that the nonverbal behavior of the PWS is a reflection of an extreme muscle tension that occurred during the disfluency. As such the nonverbal accessory features of stuttering are viewed as the visible part of an increase in physical tension of the speech-related or neighboring muscles that may have resulted from deficits in fine motor control of speech muscle systems (Lanyon, 1978). The role of extreme muscle tension in the PWS's disfluency was illustrated in another study of Lanyon (1977) in which disfluency was reduced by a decrease of the tension of the articulatory muscles. Of interest concerning the onset and maintenance of stuttering is a phenomenon that was described by Bernstein (1967) in the acquisition of complex movements. In the process of learning complex movements, certain parts of the motoric system are fixated to reduce the total number of degrees of freedom. At a later stage, this artificial restriction disappears as more control of movements is attained. In the case of PWS, a frequent fixation of parts of the speech apparatus as a mechanism to cope with disfluency at the short term might hinder their acquisition of fluent speech in the longer term.

Nonverbal behaviors that occur in PWS, as well as PWNS, and are not associated with disfluency are suggested to have a communicative function.

It has to be noted that the interpretations mentioned above of disfluency and nonverbal behavior during speech are preliminary. It is probable that the same mechanisms control interrelated disfluencies. Following this, a crucial step in delineating the various functions of disfluency is to investigate the interrelationship of separate disfluencies in PWS as well as PWNS. The present state of affair is that too wide-ranging classifications of disfluency hinder the progress in our

understanding of stuttering. Specifically, in case different mechanisms rule the distinct disfluencies comprised in the advocated categories of disfluency.

A limitation of the present investigation is that only adolescents were studied. Since stuttering develops during its course and several learning processes may become involved, it is crucial to study the specific disfluencies of preschool children at the early onset of stuttering and other age groups of PWS.

References

Bernstein, N. (1967). *The coordination and regulation of movements*. New York: Pergamon Press, Inc.

Bloodstein, O. A. (1975). *Handbook of stuttering*. Chicago Ill: National Easter Society for Crippled Children and Adults.

Bluemel, C.S. (1957). *The riddle of stuttering*. Danville, Ill.: Interstate Publ. Co.

Brutten, G.J. (1973). Behavior assessment and the strategy of therapy. In Y. Lebrun & R. Hoops (Eds.), *Neuro-linguistic approaches to stuttering*. The Hague: Mouton and Co.

Brutten, G. (1974). The Behavior Checklist for Adults. Unpublished manuscript, Southern Illinois University, Carbondale, Illinois.

Brutten, E.J. & Shoemaker, D.J. (1967). *The modification of stuttering*. Englewood Cliffs, N.J.: Prentice-Hall.

Janssen, P. & Brutten, G.J. (1974).*The effects of response-contingent shock on stuttering behaviors.* Paper presented at the Annual Convention of the American Speech and Hearing Association, Las Vegas, Nevada.

Johnson, W. (1955). A study of the onset and development of stuttering. In W. Johnson (Ed.), *Stuttering in children and adults*. Minneapolis: University of Minnesota Press.

Johnson, W. (1961). Measurements of oral reading and speaking rate and disfluency of adult male and female stutterers and nonstutterers. *Journal of Speech and Hearing Disorders*. Monograph Supplement 7, 1-20.

Johnson, W. et al. (1967). *Speech handicapped school children*. New York: Harper and Row, 3rd edition.

Lanyon, R.I. (1978). Behavioral approaches to stuttering. In M. Hersen, R.M. Eisler, & P.M. Miller (Eds.), *Progress in behavior modification*. New York: Academic Press, Pp 47-83.

Prins, T.D. & Lohr, F.E. (1968). *A study of the behavioral components of stuttered speech*. The University of Michigan, Final Report project no 6-2382.

Prins, T.D. & Lohr, F.E. (1972). Behavioral dimensions of stuttered speech. *Journal of Speech and Hearing Research*, 15, 61-71.

Sander, E.K. (1961). Reliability of the Iowa speech disfluency test. *Journal of Speech and Hearing Disorders.* Monograph Supplement, 7, 21-30.

Stromstra, C.A. (1965). A spectrographic study of disfluencies labeled as stuttering by parents. *De Therapie Vocis et Loquela,* Vol I, 317-319.

Vaane, M.E. (1975). *Some motoric aspects of the stuttering moment*. Internal Report Department of Phoniatry, Academic Hospital Utrecht, the Netherlands.

Vaane, M.E. (1976). *Some motoric aspects of the speech production onsets: a comparison between stuttering and nonstuttering persons*. Progress Report Vol I, Number 2. Institute of Phonetics, University of Utrecht, the Netherlands.

Van Riper, C. (1971). *The Nature of Stuttering*. Englewood Cliffs, N.J.: Prentice Hall Inc.

Wingate, M.E. (1976). *Stuttering: Theory and Treatment*. New York: Irvington Publ. Inc.