Published in final edited form as:

Neurology. 2006 June 13; 66(11): 1648–1653.

Classification of partial seizure symptoms in genetic studies of the epilepsies

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Abstract

Objectives— To develop standardized definitions for classification of partial seizure symptoms for use in genetic research on the epilepsies, and evaluate inter-rater reliability of classifications based on these definitions.

Methods— The authors developed the Partial Seizure Symptom Definitions (PSSD), which include standardized definitions of 41 partial seizure symptoms within the sensory, autonomic, aphasic, psychic, and motor categories. Based on these definitions, two epileptologists independently classified partial seizures in 75 individuals from 34 families selected because one person had ictal auditory symptoms or aphasia. The data used for classification consisted of standardized diagnostic interviews with subjects and family informants, and medical records obtained from treating neurologists. Agreement was assessed by kappa.

Results— Agreement between the two neurologists using the PSSD was “substantial” or “almost perfect” for most symptom categories.

Conclusions— Use of standardized definitions for classification of partial seizure symptoms such as those in the Partial Seizure Symptom Definitions should improve reliability and accuracy in future genetic studies of the epilepsies.

We have been interested in the classification of partial seizure semiology for studies of genotype-phenotype correlations in familial focal epilepsies. Our interest was motivated by the discovery of autosomal dominant partial epilepsy with auditory features (ADPEAF), a genetic syndrome marked by the prominent occurrence of ictal auditory symptoms,^{1–4} and frequently caused by mutations in the leucine-rich glioma inactivated 1 gene (LGI1) on chromosome 10q24.^{5–7} Occurrence of ictal auditory symptoms in two or more family members with idiopathic epilepsy appears to be an effective simple screening method to identify mutations,⁷ although other symptoms are also found in these families (e.g., aphasia, visual symptoms).^{2–4,7,8} The importance of auditory symptoms in ADPEAF suggests that other familial focal epilepsy syndromes may also be marked by the familial clustering of semiologic features. Identification of such syndromes, and the genes that influence susceptibility to them, will require the use of valid methods for classification.

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Supported by NIH grants R01 NS36319 and R01 NS43472 (to R.O.), and K23 NS02211 and K02 NS050429 (to M.R.W.).

Disclosure: The authors report no conflicts of interest.

An important aspect of diagnostic validity is inter-rater reliability (consistency)—the ability of different diagnosticians to arrive at the same conclusions upon review of the same information. Establishment of guidelines for interpreting clinical information is essential to maximize reliability. Thus to facilitate reliable classification of partial seizure symptoms in our genetic studies, we developed the Partial Seizure Symptom Definitions (PSSD). The previously developed Seizure Semiology Classification (SSC)^{9,10} has been shown to have good inter-rater reliability,^{11–13} and is accompanied by ILAE guidelines for terminology.¹⁴ However, the SSC did not provide sufficient subcategories for our use in classifying symptoms within the auditory, visual, somatosensory, and autonomic categories. In the present study, we report on agreement between two epileptologists who independently classified partial seizure symptoms using the PSSD.

Methods

We selected 34 families containing multiple individuals with idiopathic or cryptogenic epilepsy from our database because they contained one subject with ictal auditory symptoms or ictal receptive aphasia. We focused on this group of families because of our special interest in ADPEAF, in which these symptoms are prominent. Fourteen previously described families that contained ≥ 2 subjects with auditory symptoms, selected from our database in the same way,⁷ are not included in this report. The 34 included families contained 110 individuals with idiopathic or cryptogenic epilepsy, of whom 75 had partial seizures.

The protocol for subject ascertainment, data collection, and clinical diagnosis has been described in detail previously.¹⁵ In brief, families were ascertained through our previous familial aggregation study, physician referral, or self-referral. Self-referrals were solicited through a Web site, flyers mailed to voluntary organizations, presentations at meetings, and the Epilepsy Foundation Gene Discovery Project.¹⁶ The subjects were screened for seizures in a telephone interview administered by trained lay interviewers. Those who screened positive were given a semi-structured diagnostic interview, administered by a neurologist or general physician with specialized epilepsy training, to obtain information on seizure symptoms and etiologic factors. Whenever possible, medical records were obtained from the patients' treating physicians; these frequently contained additional seizure descriptions, information about etiologic factors, and EEG and neuroimaging results. If a subject was deceased or otherwise unavailable, we interviewed the relative likely to be most knowledgeable about the seizure history. Children aged 13 years or older were interviewed directly; those aged 12 years or younger who were able to understand the questions were interviewed jointly with a parent or caregiver.

The diagnostic interview was developed in the late 1980s for phase 1 of the Epilepsy Family Study of Columbia University (EFSCU), our ongoing genetic study.^{17,18} The original interview contained a series of questions, lasting approximately 30 to 60 minutes in most patients, designed to distinguish between generalized onset and focal onset seizures and to classify seizure types within these broad categories. It was found to have good inter-rater reliability and good validity for this classification, compared with the diagnoses of expert epileptologists.^{17,18} However, with each new phase of the study we have attempted to refine our ability to characterize seizure semiology and thereby improve classification. Major revisions of the diagnostic interview were completed in 1992 when we began phase 2, and in 1997 when we began phase 3; below we summarize the most important changes that were made at these times. Among the 75 subjects included in the present study, clinical information was collected using the phase 3 interview version in 65, and the phase 2 version in the remaining 10.

The interview contains both open-ended questions that ask subjects to describe what happens during their seizures, with answers recorded verbatim, and closed-ended questions that address specific symptoms. Separate sections are included that address grand mal seizures and “small seizures.” In the grand mal section, open-ended questions ask subjects to describe how they feel before the seizure starts, during the seizure, and afterwards; another open-ended question asks them to describe any warning (or aura) they experience. In the original version, specific closed-ended questions addressed body movements occurring at onset of the seizure, and whether they were unilateral or bilateral, and unilateral numbness, unilateral weakness, and “difficulty thinking of words you want to use” after the seizure. In phase 2, the specific questions about symptoms at onset were expanded to include unilateral “numbness, tingling, or other unusual feelings,” “an unusual feeling in the stomach or chest,” and an “unusual taste or smell.” In phase 3, the specific questions about symptoms at onset were expanded again, to include auditory (“Before the seizures start, do you hear any unusual sounds, or have any change in your hearing? IF YES, What is the sound or change in your hearing?”) and visual symptoms (“Before the seizure starts, do you see anything unusual, or have any change in your vision? IF YES, What do you see, or what was the change in vision?”).

The small seizure section includes a series of questions that is repeated for each type of seizure the subject has experienced (with the subjects deciding what constitutes a “separate” type). Again, open-ended questions ask for a description of what happens or what the subject feels before, during, and after the event. The original interview contained specific questions about sudden jerking, limpness, other body movements (with supplemental questions asking for a description and addressing unilaterality), eyelid fluttering, alteration in consciousness, and automatisms (“Has anyone ever told you that you usually smack your lips or do any other unusual things without intending to during a small seizure?”). In phase 2, the syntax of the questions was changed to improve clarity. In phase 3, as with the grand mal section, specific questions were added to address “an unusual feeling in the stomach or chest,” “an unusual taste or smell,” “hearing unusual sounds or having a change in hearing,” and “seeing anything unusual, or having a change in vision.”

Two senior epileptologists (W.A.H., T.A.P.) reviewed all collected information to derive a final clinical diagnosis of seizure types and epilepsy syndromes, using the ILAE criteria.^{19, 20} To avoid bias, all information about other family members was excluded during the review. The EEG and neuroimaging reports in the medical records were separately assessed for the quality of information received. When an actual EEG tracing was available, we reviewed it directly. When only an EEG report was available, we assessed the quality of the report by determining 1) whether it was performed at an established epilepsy center, 2) whether the electroencephalographer was board certified, and 3) whether the description of the findings and clinical-electrographic correlation were appropriate; only reports of high quality were considered in the classification. The classification of seizure type and syndrome was carried out at meetings attended by both of the senior epileptologists in which they discussed the cases and agreed upon a final diagnosis; hence reliability of these diagnoses was not assessed.

To identify subjects likely to have ictal auditory symptoms, we screened the information from diagnostic interviews in our computerized database. The search included a screen of verbatim seizure and aura descriptions for key words such as “sounds,” “hear,” “buzz,” or “ring.” In addition, since subjects interviewed after 1997 were asked specifically about auditory symptoms, we screened this variable in interviews that included it.

The PSSD, developed by H.C. and M.R.W., described five major symptom categories (sensory, autonomic, psychic, aphasia, and motor) and subcategories within each of these (table). The process by which these categories were selected involved creating an initial list of symptoms identified in our previous review of ADPEAF families,⁷ and then expanding the list as needed

when new symptoms were identified. Whenever a symptom that had not previously been included was identified, the two epileptologists discussed the symptom and jointly arrived at a definition (without referring to the specific subject in whom it was identified).

For evaluation of inter-rater reliability, H.C. and M.R.W. independently used the PSSD to classify symptoms in each individual with partial seizures in the 34 included families. This classification was carried out after the consensus diagnoses of seizure type and epilepsy syndrome described above had been completed. As in the diagnoses of seizure type and epilepsy syndrome, the classification of partial seizure symptoms was based on a review of all of the data previously collected on each subject (i.e., diagnostic interviews with the subject and other family informants, and medical records). The two raters used the same information for classification. Neither reviewer was familiar with the data prior to the review, and neither had had personal contacts with the subjects or family members, with the exception that M.R.W. had administered the diagnostic interview to two subjects. A standardized data entry form was used to record the presence or absence of each partial seizure symptom. After independent reviews, the two reviewers discussed cases on which they disagreed and arrived at a consensus. Information on specific subjects was not discussed prior to these consensus meetings.

We evaluated agreement between the two raters in their initial classifications of partial seizure symptoms (prior to consensus meetings) using the kappa statistic (κ), which measures agreement between two independent reviewers after excluding agreement expected by chance. According to the criteria of Landis and Koch,²¹ agreement is considered almost perfect when $\kappa \geq 0.81$, substantial when $0.8 \geq \kappa \geq 0.61$, moderate when $0.6 \geq \kappa \geq 0.41$, fair when $0.4 \geq \kappa \geq 0.21$, slight when $0.2 \geq \kappa \geq 0$, and poor when $\kappa < 0$.⁴ All analyses were conducted with SPSS statistical software (Chicago, IL).

Results

The table shows the level of agreement between the two epileptologists who independently classified partial seizures in these 75 subjects using the PSSD. Non-chance agreement, assessed by kappa, was substantial or almost perfect for all five major categories (sensory, autonomic, aphasic, psychic, and motor), and for 35 of the 41 narrowly defined symptom types we examined.

Because of the variation in the questions used in the phase 2 and phase 3 versions of the diagnostic interview, we repeated the analysis after excluding the 10 subjects interviewed with the phase 2 version. The kappa values were almost exactly the same as in the analysis of all 75 subjects. For the six symptoms with less than substantial agreement, we also explored whether the proportion of subjects in whom the two reviewers disagreed varied according to the sources of information included in the review (direct interview: 66 subjects, interview with relative: 41 subjects, and medical record: 35 subjects). For complex auditory symptoms, the two reviewers disagreed more often for subjects who had not been interviewed directly than for those who had (% disagreement: 22% [2/9] vs 6% [4/66], $p = 0.15$, Fisher exact test), although the numbers were very small. Also, for diaphoresis/flushing/warmth/pallor, disagreement was greater for subjects without medical records (6/40 = 15%) than for those with medical records (0/35) ($p = 0.03$). No other differences were apparent for any of the other four symptom types with less than substantial agreement.

Most subjects had multiple partial seizure symptoms. For example, 59 (79%) of the 75 subjects with partial seizures had symptoms from two or more major categories (sensory, aphasic, autonomic, psychic, or motor). The number of major categories per subject averaged 2.4. Fifty-nine subjects had sensory symptoms, and of these, 28 (47%) had symptoms from two or more

categories within sensory (auditory, visual, somatosensory, olfactory, cephalic, gustatory, vertiginous). The number of sensory categories per subject averaged 1.7.

Discussion

We developed the PSSD for use in our genetic studies aimed at evaluating associations between partial seizure symptoms and epilepsy susceptibility genes. Our goal was to create a simple system for classification, with non-overlapping, clearly defined categories that encompassed the symptoms most frequently reported by subjects in our study. We also tried to divide symptoms into categories that reflected their neuroanatomic localization. The definitions were intended to maximize inter-rater reliability in classification by providing a guide to the interpretation of reported symptoms. The use of standard definitions can also improve consistency across studies by different investigators.

The PSSD is similar to the SSC^{9,10} in that it classifies seizure semiology independently of electroencephalographic data. This was essential for our study because most subjects are classified based on interview data alone. However, our system differs from the SSC in two important respects. First, we used more narrowly defined categories (e.g., separate classification of pain, tingling, and numbness within the somatosensory category). We were especially interested in subcategories of sensory symptoms, and subcategories of auditory symptoms in particular. This aspect of the PSSD represents an improvement upon the ILAE glossary, which does not provide subcategories of symptoms within the visual, auditory, somatosensory, and autonomic categories. On the other hand, we omitted some symptoms that are included in the SSC, because they were not observed in our dataset. As we continue to use this classification, we will probably need to expand it to include symptoms such as motor aphasia and additional psychic experiences (e.g., joy, sadness, euphoria).

Second, the SSC classifies seizures by the predominant semiologic feature, and then classifies patients by their predominant seizure type. In contrast, we documented all of the symptoms each patient had had during any partial seizure. This approach appeared more useful for our studies of genotype-phenotype correlation, since most patients experience multiple symptoms, and it is unclear which symptoms might be most predictive of genotype. Thus we were able to capture more details for genetic studies in which we are trying to detect familial clustering of semiologic features.

However, one difficulty with our approach is that our interview asks for the lifetime history of seizure symptoms experienced by the subject, rather than about the symptoms of a specific seizure that occurred recently. This is unavoidable in genetic studies, because clinical information often needs to be collected on family members with onset of seizures many years prior to interview, some of whom have not had seizures for a long time. It is quite different from the usual clinical context, where most patients who are evaluated have ongoing seizures. Thus in our study some reported symptoms are not clearly ictal phenomena, and conversely, some ictal symptoms may not be reported, especially in patients who have not had recent seizures. Also, symptoms experienced at the initiation of a seizure are likely to be most important for classification of the epileptogenic zone, and sometimes it is difficult to distinguish these from later occurring symptoms, which reflect spread to other brain regions.

Our standardized methods of clinical data collection and classification resulted in excellent agreement for most categories. However, disagreements arose where the interpretation of the information was particularly difficult. This was problematic in the six categories in which kappa ranged between 0.58 and 0.09 (reflecting moderate to slight agreement). Two of these categories, other somatosensory and other motor, were created for symptoms that the raters could not clearly classify, and were less clearly defined than the other categories. In the case

of complex auditory symptoms, subjects tended to describe sounds by likening them to familiar sounds, complicating the distinction between complex and simple sounds. For example, an individual might hear a whirring sound before seizures and describe it as “a whirring, like the sound of the fan in my bedroom,” but this would be classified as a simple sound. For cephalic symptoms, certain descriptions were difficult to distinguish between physical sensation localized to the head and symptoms of cognitive disturbance. For example, when subjects described their experience of alteration of awareness, they sometimes used words that referred to the head, such as feeling “foggy in the head.” For the two remaining symptoms with moderate-fair agreement (diaphoresis/flushing/warmth/pallor within autonomic, and dystonic posturing within motor) we found no obvious explanation for the lower agreement.

After the evaluation of agreement between the two reviewers, we augmented the definitions by developing rules for interpretation that could be applied consistently in future studies. For example, when symptoms were reported to have preceded the seizure by a long time interval (e.g., headache occurring 2 hours before seizure onset), it was unclear whether they were seizure-related. We therefore decided to restrict attention to symptoms that immediately (within seconds) preceded the seizure. Also, disagreements arose when the subject and a family informant differed in symptom reporting, especially if the seizure occurred during childhood. In these cases, we decided to rely on the parent’s report. Disagreements also arose in nonlocalizing and diffuse symptoms, such as whole body tingling or limpness. We decided to categorize such symptoms under other somatosensory or other motor, but these categories had low inter-rater reliability. Finally, the category vertigo posed difficulty, because many subjects used dizziness to describe their symptoms. We decided to classify dizziness as vertigo only if the sensation of spinning was reported. In the future, application of these rules should improve reliability further.

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Table

Partial seizure symptom definitions and inter-rater agreement

Symptom type	Definition	Rater agreement			Kappa	SE	Interpretation*
		Both yes	Both no	Disagreed			
Sensory		51	16	5	0.820	0.077	Almost perfect
Auditory	Auditory hallucination of simple, unformed sounds	33	40	2	0.950	0.038	Almost perfect
Simple		16	57	2	0.920	0.053	Almost perfect
Complex	Auditory hallucination of composite sounds such as music or speech	5	64	6	0.580	0.154	Moderate
Distortion	Alteration of existing sounds	15	58	2	0.920	0.055	Almost perfect
Reflex	Seizure triggered by sound	1	74	0	1.000	0.000	Almost perfect
Somatosensory	Pain localized to unilateral region	10	61	4	0.800	0.095	Substantial
Pain	Tingling localized to unilateral region	0	73	2	—	—	—
Tingling	Warmth or chill localized to unilateral region	7	65	3	0.800	0.111	Substantial
Warmth/chill	Loss of sensation localized to unilateral region	1	73	1	0.660	0.317	Substantial
Numbness	Seizures triggered by any kind of tactile stimuli	5	67	3	0.750	0.138	Substantial
Reflex	Nonlocalizing sensation or bilateral sensation	0	74	1	—	—	—
Other somatosensory	Visual hallucination of unformed images such as colors or spots	1	71	3	0.380	0.282	Fair
Visual	Distortion of actual sights, shapes, distance	22	47	6	0.820	0.070	Almost perfect
Simple	Seizure triggered by sights other than photosensitivity	7	65	3	0.800	0.111	Substantial
Complex	Perception of odor or aroma not caused by actual olfactory stimulus	3	69	3	0.650	0.190	Substantial
Distortion	Sensation referable to the head	13	57	5	0.800	0.087	Substantial
Reflex	Perception of taste not caused by actual gustatory stimulus	74	0	1	—	—	—
Olfactory	False sense of movement, either of oneself or of the environment. The feeling may involve the whole body or be limited to the head.	9	65	1	0.940	0.060	Almost perfect
Cephalic	Spinning sensation	2	70	3	0.550	0.226	Moderate
Gustatory	Shortness of breath, difficulty breathing, or sensation of increased respiration	3	70	2	0.740	0.179	Substantial
Vertiginous	Sensation of pain or tightness in chest	5	65	5	0.630	0.152	Substantial
Autonomic	Rising sensation localized to abdominal/chest area	30	37	8	0.790	0.071	Substantial
Dyspnea/hyperventilation	Sensation of increased heart rate (palpitation), irregular heart rate	6	67	2	0.840	0.108	Almost perfect
Chest tightness	Sweating, flushing, warmth, or pallor most visible in the face	1	74	0	1.000	0.000	Almost perfect
Visceral/epigastric	Erection of the hair of the skin	21	49	5	0.850	0.067	Almost perfect
Cardiac	Enlargement of pupils	0	75	0	—	—	—
Diaphoresis/flushing/warmth/pallor	Disturbance of the comprehension of speech in the absence of confusion or alteration of mental status	5	64	6	0.580	0.151	Moderate
Piloerection		0	75	0	—	—	—
Pupillary dilatation		1	74	0	1.000	0.000	Almost perfect
Aphasic		4	67	4	0.640	0.166	Substantial
Sensory aphasia		19	48	8	0.750	0.083	Substantial
Psychic							

Symptom type	Definition	Rater agreement			Kappa	SE	Interpretation *
		Both yes	Both no	Disagreed			
Fear/panic/anxiety	Intrusion of fear, panic, and anxiety not related to fear of an impending seizure	8	60	7	0.640	0.124	Substantial
Déjà vu	Sensation that the current experience has occurred before	9	66	0	1.000	0.000	Almost perfect
Jamais vu	Sensation of being unfamiliar with a person or situation that is actually very familiar	1	74	0	1.000	0.000	Almost perfect
Derealization/depersonalization	Feeling of detachment from oneself, unreality, or dream-like state	4	68	3	0.710	0.161	Substantial
Forced thoughts	Intrusion of thought	0	74	1	—	—	—
Motor	Forced deviation of head and/or eye to one side	36	25	14	0.630	0.087	Substantial
Head and/or eye contraversion	Focal rhythmic movement	8	60	7	0.640	0.124	Substantial
Tremor/clonic	Loss of motor strength localized to unilateral region	16	48	11	0.640	0.097	Substantial
Focal weakness	Repetitive, stereotyped motor activity of hands	0	72	3	—	—	—
Limb automatisms	Repetitive chewing or lip smacking	5	65	5	0.630	0.152	Substantial
Oral automatisms	Coordinated complex movements that may appear purposeful while cognition is impaired	11	63	1	0.950	0.051	Almost perfect
Complex behavioral automatism	Sustained contraction of muscles of limbs to produce twisting and abnormal posture of limbs	3	69	3	0.650	0.190	Substantial
Dystonic posturing	Rotating/spinning body while standing	1	70	4	0.320	0.243	Fair
Pirouetting	Sustained contraction of multiple body regions to produce twisting and abnormal posture	1	73	1	0.660	0.317	Substantial
Whole body posturing	Bilateral motor or nonlocalizing motor symptoms such as bilateral hand weakness or limpness	0	74	1	—	—	—
Other motor		3	51	21	0.085	0.113	Slight

* Interpretation according to the criteria of Landis and Koch.²¹

SE = standard error.