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Brain Research Reviews 31 (1999) 83–104

BRAIN RESEARCH REVIEWS

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Full-length review

Expletives: neurolinguistic and neurobehavioral perspectives on swearing

D. Van Lancker [a,b,*], J.L. Cummings [c]

[a] *Department of Neurology, University of Southern California, Los Angeles, CA, USA*

[b] *Department of Speech-Language Pathology and Audiology, New York University, School of Education, 719 Broadway, Suite 200, New York, NY, 10003, USA*

[c] *Departments of Neurology and Psychiatry and Biobehavioral Sciences, University of California at Los Angeles, Los Angeles, CA, USA*

Accepted 5 October 1999

Abstract

Severe aphasia, adult left hemispherectomy, Gilles de la Tourette syndrome (GTS), and other neurological disorders have in common an increased use of swearwords. There are shared linguistic features in common across these language behaviors, as well as important differences. We explore the nature of swearing in normal human communication, and then compare the clinical presentations of selectively preserved, impaired and augmented swearing. These neurolinguistic observations, considered along with related neuroanatomical and neurochemical information, provide the basis for considering the neurobiological foundation of various types of swearing behaviors.

Keywords: Neural basis of behavior cursing; Aphasia; Gilles de la Tourette's syndrome; Coprolalia; Basal ganglia; Limbic system

Contents

1. Background

Swearing, the use of deistic, visceral and other taboo words and phrases, has long held a unique and colorful status in language behavior. Public awareness of swearing is far keener than, say, interest in relative clauses or the semantic features of nouns, yet the topic is much less studied. Swearing and related verbal usage has ubiquitous social, legal and political implications, which have touched each and every person at some time or other. Laws against swearing in public still exist in some states and, informally, fines may be incurred in social settings [126]. Knowledge of swearwords takes hold early in child lan-

* Corresponding author. Department of Speech-Language Pathology and Audiology, New York University, School of Education, 719 Broadway, Suite 200, New York, NY, 10003, USA. Fax: +1-212-995-4356; e-mail: diana.vanlancker@nyu.edu

0165-0173/99/$ - see front matter
PII: S0165-0173(99)00060-0

guage development [117] and often quickly achieves a solid status in the second language learner [181]. Shortly after the Norman Conquest of England, King William of Orange was said to use his native language, French, except for swearing, which he did in English [65].

Even more dramatically, swearing takes a prominent role in various neuropathologies of language. For example, swearing is frequently one of a small set of speech functions — ''automatic speech'' — selectively preserved in the severely aphasic patient. Swearwords and phrases are produced with normal articulation and prosody, in stark contrast to the remaining speech and language disability. Some manifestations of swearing behaviors in clinical settings may be reactive to the disease condition. Excessive swearing occurs in traumatic brain injury [267] and in paraplegic, spinal cord patients [149]. It occurs in the elderly in association with depression [43,226], encephalitis [118], dementia [239] and klazomania [16]. Post-ictal swearing has been reported in epilepsy [50,221]. Tardive Tourettism, sometimes with coprolalia, has been reported following use of neuroleptics [15,73] including in a Japanese patient [141]. Pathological use of expletives and taboo words and phrases is a key feature of Gilles de la Tourette syndrome (GTS) [222] and certain other movement disorders, especially Sydenham's chorea, which has clinical similarities to GTS [144,264].

Despite its obvious role in normal and impaired communication, serious study of the neurology of swearing behavior is lacking. Neurological treatments of emotional behaviors discuss related phenomena, such as pathological laughing and crying, but not swearing (e.g., Ref. [20]). This neglect is due possibly in part to a universal negative response to use of swearwords, and in part to a belief that swearing is peripheral to more interesting aspects of communicative behaviors. Given the range and variety of observations, the topic appears to be linguistically and neurologically complex. Whatever the reasons for a traditional lack of explanatory commentary on swearing, addressing this question is warranted to advance understanding of the neurobiology of communicative behavior. Descriptive work on historical [123,181] and contemporary [80,101,124,130–132,139,210] normal swearing patterns has appeared, and sufficient observations from neurological patients have accumulated to merit an overview and exploration of the neurology of swearing.

2. Swearing in normal individuals

The definition, characterization and classification of swearwords is itself daunting. A useful division breaks the types of words used into the categories of ''deistic'' (religion-related) and ''visceral'' (body functions-related), but the actual array of expletives extends into many semantic domains. Data reviewed by Flynn [92] suggest that sex-related insults are a cultural universal. Particular attention is commonly paid to the genitals and related regions in insult behavior. Hughes [123] observes that ''Swearing draws upon such powerful and incongruous resonators as religion, sex, madness, excretion and nationality, encompassing an extraordinary variety of attitudes'' (p. 3). Gallahorn [101] divides his data on normal swearing into three categories: ''curse words,'' ''anal-erythral terms'' and ''genital words''. It is the use more than the item itself that determines the swear-like force of the expression.

In his book on the history of swearing, Montagu [181] distinguishes between swearing (''damn it''), cursing (''damn you''), and oaths (''by God''). He offers fourteen categories of swearwords that have been utilized through the ages: (1) Supernatural or infernal powers (e.g., ''God''); (2) Sacred matters of religion (e.g., ''holy mass''); (3) Saints; (4) Sacred places (e.g., ''Jerusalem''); (5) Future life (''Heavens''); (6) Ancestors and heroes; (7) Ruler or authority (e.g., ''by the royal robe''); (8) Oaths by natural objects (sun, German ''Donnerwetter'', [English ''thunderstorm'']); (9) Vulgar or obscene words (body parts); (10) ''Bloody'' and its variants; (11) Miscellaneous phrases having unusual force (''hang it'', ''gracious'', ''shiver my timbers''); (12) Classical divinities (''by Jove''); (13) Animals, plants, products (''goose'', ''mackerel''); (14) Name of valued personal attributes (e.g., ''maidenhead''). A 15th class may be added: social insults, including racial and ethnic slurs.

Euphemisms, flux of popular terms, and variations in social attitudes toward the words considered ''taboo'' further complicate the matter [97,123]. Although crosslinguistic surveys are few, observations by anthropologists suggest that most people in most cultures use expletives [181]; they do so at different times, in various contexts, with varying emotive content to the expressions. According to Hughes, [123], ''virtually all societies, even the most modern, retain some taboos against swearing'' (p. 8). For our purposes, and admittedly using a circular definition, it is sufficient to identify the group of words that are socially opprobrious, essentially because they are considered shocking or obscene. We call this large set of words ''expletives'', ''swearwords'' or ''taboo expressions'', and we refer to this activity as ''swearing'' or ''cursing.'' We will consider subdivisions as they are useful to this analysis.

Although etymologies and historical examples from literary sources are readily available, there are only a few sets of available recorded data on the incidence or frequency of use of taboo expressions across contemporary population samples. Steadman [240] approached the topic by asking subjects to compile lists of taboo words; males provided the greater number. de Klerk [139] investigated use of expletives by male and female adolescents of differing social and educational backgrounds, and found differences associated with gender and ''social power''. Foote and Woodward [94] asked college students to list words ''obscene to you'' using both written and tape-re-

corded response formats. Mode of production did not affect quantity of responses, but more examples of obscene language were produced by males than females. These authors classified the items into ''denotative classes'' called ''body process'', ''body part'', ''body product'', ''ancestral allusion'', ''religious blasphemy'', ''animal'', ''social deviation'', ''ethnic-racial slur'', and ''unclassified''. The most frequent exemplars of each class, in order of frequency, are given as (a) in Table 1.

A study by Gallahorn [101] tabulated and analyzed use of taboo words by psychiatric ward personnel at psychiatric staff meetings, consisting of the ward chief, four 1st-year residents, the head nurse, three staff nurses, five aides and occasional other nurses, aides, and social workers. Gallahorn noted daily events on ward, who attended the meeting, the time spent discussing a patient, and the taboo words used. He noted who used the words and to whom they were addressed. During 128 days, 372 taboo words were used, averaging 2.9 each meeting (see Table 1b). Twenty-eight different words were produced, which Gallahorn classified into ''curse words, analerythral, and genital words''. ''Curse words'' were most commonly produced, with more words on days with specific issues. Interestingly, expletive usage diminished during socially stressful periods on the psychiatric ward. A similar, briefer survey was conducted by Nuwer [192], who asked 30 neurologically normal subjects to list the words ''he or she would use when upset, but would not use in polite company or when speaking before an audience'' (p. 364). Twelve words resulted from this survey, which could be classified into two general types: ''religious profanities and obscenities related to physical acts and organs'' (p. 364) (shown as Table 1c).

The most extensive survey work has been done by Jay [130–132], giving frequency counts of specific expletives as correlated with speaker's gender, age, context, theme, and other variables. A large field study of cursing language used in public by speakers over the age of 45 revealed that most cursing is made up of 18 words (Table 1d), and that males curse more than females. Four most frequently used words (hell, god[damn], shit and Jesus [Christ]) account for 57% of the observations. Data from nursing home residents (over age 70) are similar (Table 1e). The top ten swearwords of West Coast speakers ages 70 and under obtained from field observations are shown in Table 1f [131]. To explore the words people use privately, survey questionnaires were administered to an elderly population in western Massachusetts, containing 26 taboo words derived from Jay's previous field studies [132]. Subjects were asked to rate the words for frequency of personal use and for offensiveness. The results are summarized in Table 1g. A wide variety of different types of swearwords occur among the 10 most frequently used.

Linguistic analysis of expletives has been sparse. Perusal of the grammar of expletives reveals that taboo words appear to function differently from other words. A linguistic analysis of swearing in Australian English noted that swearwords ''combine morphologically and syntactically with other items in a number of interesting ways, some of which are peculiar to them'', while others are merely ''preferred'' by them (Ref. [244], p. 18). To discuss the grammar of swearwords, Taylor utilized the notion of ''schemata'', or formulae, developed by Lyons (Ref. [162], p. 177). Each word, phrase, or sentence schema has its own shape and variations: for example, the phrase schema ''//in the//hell (heck)'' where the first slot can

Table 1
Data on normal occurrences of swearing (descending order of frequency, with counts in parentheses)

(a) Nine most frequent swear words by college students (Ref. [94], p. 270)	fuck (33), cunt (23), shit (33), bastard (25), God damn (15), son of a bitch (19), whore (10), nigger (8), fascist (2), fuckin' (2)
(b) Swear words spoken by psychiatric ward personnel in 6-month period (Ref. [101], p. 311)	damn (87), hell (84), crap (41), God (34), shit (33), bitch (17), Christ (16), screw (11), pissed off (10), ass (6), bastard (5), butt (3), can (3), whore (3), hot pants (2), slut (2), reamed (1), shaft (1), son of a bitch (1), balls (1), come (1), fuck (1), laid (1), piece of ass (1), pimp (1), shack up (1), wet dream (1)
(c) Normal usage survey (Ref. [192], p. 364)	shit, God, damn, ass, fuck, Jesus, hell, crap, cock, prick, bitch, fart
(d) ''Public production lexicon'' of 18 unique words by speakers over the age of 45 [132]	hell (45), God (damn) (33), shit (33), Jesus (Christ) (28), fuck (24), damn (22), ass (19), bitch (13), bastard (12), asshole (6), bullshit (4), balls (2), prick (2), blows (1), blowjob (1), dildo (1), Jew (1), motherfucker (1)
(e) Nursing home residents, over age 70 [132]	hell (60), damn (27), shit (15), ass (9), bitch (4), Jesus (Christ) (3), son of a bitch (2), bastard (1), piss (1)
(f) Top 10 swear words of West Coast speakers (ages 1–70) [131]	fuck (212), shit (129), God (68), hell (50), damn (45), bitch (25),motherfucker (23), ass (22), asshole (17), bullshit (15)
(g) 26 swear words, rated for frequency in personal use in an elderly population in western Massachusetts [132]. (frequency 1 meant ''never'' and 9 meant ''very often''.) Four nonswear words were included	hell(5.12), damn (5.11), goddamn (4.13), shit (3.86), bullshit (3.72), son of a bitch (3.52), ass (3.51), Jesus Christ (3.45), bitch (3.33), pig (3.30), bastard (3.28), fart (2.95), asshole (2.82), piss (2.76), whore (2.45);.tits (2.33), slut (2.32), queer (2.28), prick (2.23), fuck (2.05), nigger (1.98), cock (1.95), dipshit (1.93), fag (1.86), peckerhead (1.73), spic (2.63), danger (4.45), dirty (4.44), table (4.21), flower (4.17)

be filled by ''how'', ''what'', ''why'', etc., and the second with ''fuckin'', ''bloody'', ''flamin'', etc. Sentence schemata can be specified in the same way. Taylor concludes that people swear according to certain types of rules, and that the swearing behaviors in Australian English can be well specified for descriptive and pedagogical purposes.

Dong [79] argued that there are two words of the form ''fuck''; only one of these, the one with the meaning ''fornicate'', functions as a verb; the second, as in ''fuck you'', or ''fuck these problems'', although superficially appearing to be a verb, is not a verb. This conclusion is based on a number of linguistic arguments, including that when the word is combined with other words, the resultant phrase does not have the external syntax of a VP (verb phrase); for example, it is not possible to include adverbial elements (e.g., ''by midnight''). These expressions, including ''damn'' and ''Goddamn'', when used in apparently sentential frames, have ''neither a declarative nor interrogative nor imperative meaning. These utterances simply express a favorable or unfavorable attitude on the part of the speaker towards the thing or things denoted by the noun phrase'' (p. 6). This is a bold claim, because current linguistic theory characterizes the sentence (S), the basic unit of language, as being made up of a noun phrase (NP) and a verb phrase (VP); by definition, each VP has a verb (V). Thus, Dong [79] identified a category of words — certain expletives — that do not fit anywhere in this characterization. Rather than calling the utterances in which words like ''fuck'' and ''damn'' appear ''sentences'', Dong recommends the term ''epithet'', and that the taboo words themselves be called ''quasi-verbs''. Thus there is linguistic evidence that expletives form a separate class in human language.

3. Swearing in aphasia following stroke and left hemispherectomy

As stated by Jackson [128], ''The speechless patient may occasionally swear'' (p. 160). In his treatise ''On affectations of speech from disease of the brain'' in the section on recurrent utterances (pp. 172–204), he discusses a patient with one recurrent utterance who also ''swore when vexed'' (p. 173). Another patient said ''Oh, my God'' and ''Oh my goodness will''; still another's exclusive utterance was ''pooh''. Jackson also cites Trousseau's reports of patients saying ''sacre nom de Dieu'' (a French expletive, literally ''sacred name of God'', rather like ''Oh my God'' in English) and another the abbreviated version ''Sacon, sacon'' (p. 184). Jackson's interpretation of the use of recurrent utterances was that the severely aphasic patient had lost the ability to ''propositionalize'', leaving only expletives, interjections and oaths. In his view, a speechless patient may retain the word ''no'', and yet have only the interjectional or emotional, not the propositional, use of it (p. 160). Thus, expletives were deemed essentially to be ''involuntary''. Later, Critchley [64] elaborated on the notions of ''automatic'' and ''propositional'' speech, with the former being ''expressive'' and the latter ''communicative'' (Ref. [64], p. 229). But in discussing recurrent utterances, Critchley observed that the utterance repertory of the patient can ''largely fulfill the wishes and needs of the patient''. (Ref. [64], p. 230). This suggests, in contrast to the view of Jackson, that recurrent utterances, including swearing, can be used voluntarily.

In the decades since these early observations, it has been noted commonly that persons with aphasia emit preserved and fully intact utterances classified as ''automatic speech''. This observation is striking in global aphasia, where speech is almost nonexistent, and in nonfluent aphasia, where speech is effortful and limited to high frequency single words and short phrases, pronounced with errors in articulation and in speech melody. In varying combinations in different persons with aphasia, ''automatic'' material, including counting from one to ten and other serial speech (alphabet, days of the week), familiar expressions (how are you), pause-fillers (well, ya know), and expletives flow fluently with effortlessly normal articulation and prosody [248].

A chronically aphasic patient we studied made liberal use of the expression ''Jesus Christ'', produced fluently in comparison with his otherwise severe word finding difficulties and effortful speech. Another produced the term ''shit'' fluently and liberally. We have had reports of ''motherfucker'' as a recurrent utterance in American english speakers with severe aphasia. Patient R.N., diagnosed with global aphasia following a stroke that involved frontal, temporal and parietal areas of the left hemisphere, was unable to speak, name, or repeat, and his auditory–verbal language comprehension was severely limited. He produced no speech other than ''well'', ''yeah'', ''yes'', ''no'', and the two expletives ''goddammit'' and ''shit'' [256]. These words were produced with good articulation and prosody. R.N. used these expressions spontaneously and expressively, in answer to questions, and in attempts to talk. However, R.N. was unable to produce these utterances on command. When asked to read the written word ''shit'' aloud, although his affective response to the request indicated he had comprehended the written word, he was unable to produce the spoken word, despite intense effort and concentration over several attempts. R.N. sustained damage to the supplementary motor area on the left hemisphere, which is known to play an important role in speech initiation. Whether this damage is specific to the spontaneous (or automatic) versus elicited (volitional) discrepancy seen in R.N.'s swearing remains to be studied.

Following up on the anecdotal observations by Critchley [64] and Jackson [128] of aphasic swearing, investigators examining usage in British English and German have recently performed new surveys of residual expressions spoken by persons with severe aphasia (Table 2). Lum and

Table 2
Recurrent utterances in severe aphasia: British[a] and German[b] corpora

Swear words	
British	bloody hell, bloody hell bugger, fuck fuck fuck, fuck off, fucking fucking hell cor blimey, oh you bugger, oh boy
German	ach je (oh Lord), ach Gottchen (oh God), ach (oh/oh really)
Interjections and greetings	
British	alright, because, down, off, no, yep, yes yes yes, well I know, because, away away away, funny thing funny thing, goody goody, It's a pity pity pity, now wait a minute, pardon for you, so so, better better, sister sister
German	tja (well), natuerlich (of course), na also (there you are), siehste (you see), zacki zacki (quick quick), so (so), also (well), so so so (so, so, so), doch (but/yet), na na na (well/now), Hallo (hello), macht nix (doesn't matter), weiss es nicht (don't know), danke danke, ya, nein nein nein, nee (nope), ja ja (yes yes), ya yawohl (yes indeed), das ist alles hinten, (that is all behind us) nicht traurig sein (don't be sad), bitte sehr (please)
Numeral	
British	two two two, three three, I want to one two, I try one two, I think one two
German	drei (three)
Sentence-stems	
British	I bin to town, I can't, I can talk, I can try, I can talk and I try, I did not hear, I told you, I said, I want to, you can't
German	Ich bin (I am), I will arbeiten und lernen (I want to work and study)
Proper names	
British	Bill, Billy, John, Parrot, Percy's died, BBC
German	Heidi, Bayern, Mama-Oma (ma-grandma), Mama, Hans nein Hanni, Monika, Moni
Other	
British	I'm a stane, milk, money, off, oil, factory, policeman, on the corner, paper and pencil, piano, Wednesday, so and so, somewhere somewhere, time a time, tingaling, today, washing machine, sewing machine
German	Das war wesentlich wichtig gewesen (this was essentially important), Bauern (farmers), Reisen (trips), Mittag (noon), Sie Sie, Dir (you)

[a] Code [57].
[b] Blanken [24].

Ellis [160] studied nonpropositional speech in aphasia in British English using six tasks, carefully designed to permit a comparison with ''propositional'' speech ability. Nonpropositional tasks were counting 1–10, reciting the days of the week, months of the year, and nursery rhymes, repeating familiar phrases, and naming a picture with help of a familiar phrase, in 28 patients with anomic, Broca's, conduction, global or Wernicke's aphasia. The propositional match for counting, for example, was reading the individual Arabic numbers. Of the six tasks, counting 1–10 and naming a picture with the help of a familiar phrases reliably differentiated between nonpropositional and propositional speech behaviors. Six patients showed a clear ''nonpropositional advantage''. A similar investigation revealed superior sentence completion for familiar idiomatic expressions as a form of nonpropositional speech, compared with sentence completion for propositional expressions [252]. A functional imaging study compared counting 1–10 with generating names of animals. Results indicated that left anterior regions in and near Broca's area (areas 44 and 45) were activated during the animal naming task, but not during counting by normal subjects [254].

In the first actual catalogue of recurrent utterances, Code [57] reported on 69 ''real word recurrent utterances'' produced by 75 adult speakers of British English (39 male, 36 female), who suffered aphasia due to a cerebral vascular accident. From a survey study utilizing this patient population, Code tabulated a list of real word recurrent utterances, falling into seven categories. Pronoun + verb was the most common (present in 14 of 75 patients) and expletives formed the second most frequent (11/75). Other categories of recurrent utterances were proper nouns (5/75), yes/no (4/75), numbers (5/75), repetitions (14/75) and other (22/75) (see Table 2). In his overview of linguistic output observed in adults who have undergone a left hemispherectomy, Code [60] concluded that utterances of the isolated right hemisphere consist primarily of automatic and nonpropositional speech (p. 331). A second study of aphasic speech targeted native speakers of German [23–25]. The majority of ''lexical automatisms'' (these authors' terms for the term ''real word recurrent utterances'' used by Code) documented from 30 patients were emotional expressions, such as ''ach je'' (Oh Lord) and ''ach Gottchen'' (oh God) and interjections, such as ''tja'' (well), ''natuerlich'' (of course) and ''also'' (well). (see Table 2). (Nonlexical recurrent utterances also occur; see Refs. [27,58].

Although much has been written in clinical descriptions about preserved production of ''automatic speech'', little has appeared regarding the observe, impairment of counting, swearing, and other overlearned expressions. One exception comes from a case of a loss of some types of overlearned speech behaviors, following a stroke to the right basal ganglia [235]. A 75-year-old, right-handed man, bilingual in Hebrew and French, was unable, in contrast to prestroke function, to recite familiar verses, including well known prayers and blessings in his native language, Hebrew; count 1–20, or sing familiar songs. He could no

Table 3
Transcription of utterances by EC (adult left hemispherectomy) in a 5-min videotaped interview

Time	Expletive	Spont words	Pausefills	Sentence init	Naming target	Response	Rep target	Rep response	Nonverbal vocs
0	goddammit	one	un	I can't					
	goddammit	three	boy	that's a					
		I, no place	well						
		well, as					*book*	m-book	uh mm
	goddammit		uh				*house*	uh-house	duhh
							November		uh,duh
1			no				*develop*	de-ve-lop	
			eh				*remember*	sandwich	neah
			ah				*President*	Pres-en-dent	
							constitution	vegent-lich	
							develop		ugh
2	god–		uh				*remember*	No-vem	laugh
	goddammit		nah				*November*	November	sigh
									ah
			ah						sigh
			um						mmsigh
			mm						tsk
3			uh						whaa
			oh, yes		*safety pin*	sood	*safe*		nah
			no				*safety*	s-no	wha
			well, yes		*measuring tape*		*tape*	tape	
	shit		oh, yes				*tape meas-*		
4	goddammit			I don't					
			ah	I couldn't say in then					
			oh						
			ah		*watch*				laugh
	goddammit								
5		look-y							ahh
	goddammit				*clock*				

longer recite familiar blessings, some of which had been his habit to say daily since he was a young child. His attempts at longer prayers, such as ''shema Yisrael'', had correct rhythm but not the correct words, word order, or intonation (p. 1772). Although he had not used expletives a great deal prior to his brain lesion, postmorbidly he no longer cursed or swore; he also ''could not provide the correct expletive for situations described to him nor could he complete a curse'' (p. 1772).

Well-preserved swearing occurred in E.C., a right-handed adult, following neurosurgical removal of his left hemisphere, leading to near total extirpation of propositional speech. The surgery included removal of all four left cerebral lobes, limbic forebrain, left thalamus and basal ganglia [232,233], following development of an infiltrating tumor. E.C. was interviewed by N. Geschwind 5 months after neurosurgical removal of his left hemisphere (see Table 3). The patient was right handed, and there was no left-handedness in his family [266]. In the 6 min interview there is a discrepancy in speech production ability related to type of utterance. E.C. was unable to name any of 4 target items (safety pin, measuring tape, watch, clock); he repeated mono- and polysyllabic words (book, house, develop, November) with articulatory effort and errors (e.g., ''president'' was repeated as pres-en-dent). His spontaneous words were ''one'', ''three'', ''I'', and ''no place'', and pause fillers, such as ''um'', ''boy'', ''well, yes'', and ''well, no'', and many instances of ''ah'', and ''oh''. In addition, numerous nonverbal communicative vocalizations occurred during the interview, such as sighs, brief laughter, and ''tsk''. The most prevalent speech was swearing, featuring seven productions of ''Goddammit!'', one of ''God!'' and one instance of ''shit'' in the 5-min session (Table 3). Besides the greater quantity noted for expletives over other types of speech, the speech quality was better, and sounded normal, in comparison to other speech (spontaneous or repeated) which was usually effortful, uncertain and dysfluent. Similar observations were made by Zangwill [266] who interviewed E.C. 18 months after surgery, noting E.C.'s ability to swear.

4. Gilles de la Tourette syndrome (GTS)

GTS is a movement disorder first described by Itard [127] and Gilles de la Tourette [104], and brought to modern understanding by Shapiro and Shapiro [222], Com-

ings and Comings [63], and numerous others (for reviews see Refs. [44,56,86,88,106,109,112,129,146] [151,183,186, 195,218,220,239,247]. The vocal tics required for diagnosis of the disorder are classified as a hyperkinetic motor speech disorder [71]. The clinical symptom of coprolalia, or foul speaking, is present in approximately 25–50% of persons with GTS, depending on the nature and age of the population, and how the clinical population is sampled, whether in cross-section or longitudinally. Incidence analyses [223] performed in 146 GTS patients (Ref. [85] with coprolalia) documented the highest frequency terms and the range of terms that have been reported to occur, providing a listing of coprolalic expressions in order of frequency (Table 4). As clinicopathological correlates dis-

Table 4
Reported GTS expressions across languages
GTS = number of GTS patients with coprolalia.

UK[a]	fuck, cunt, bastard, piss, sod, cock, shit (descending order of frequency)
Spain[b]	puta (whore), mierda (shit), cono (cunt), joder (fuck), maricon (fag), cojones (balls), hijo (son) de puta, hostia (host)
Brazil[c]	merda, bosta (shit), fihlo de puta (son of a whore), bunda (ass), buceta (cunt), cacete, caralho (cock), porra (sperm), va tomar no cu (fuck off)
Denmark[d]	kaeft (shut up), svin (swine), fisse, kusse (cunt), pik (cock), rov (ass), pis (piss), gylle (manure), Sgu (by God)
Peru[e]	no seas malcreado (don't be bad), batidoras national, ajo ajo, carajo, serve me coffee
Germany[f–i]	Nutte, Hure, Prostituierte (whore); Arshloch (asshole), Scheisse (shit); Leiche (corpse), Tod (death) verfaulte Knochen (rotten bones), Eingeschlagene Schaedeldecke (smashed skull);
Hong Kong[j–k]	tiu (fuck), shui (bum), tui ma (motherfucker), tiu so (aunt fucker) tiu (fuck), ''shut up,'' ''behave properly,'' ''Why are you such a nuisance''
Sri Lanka[l]	shit (Indian English); hu, huththi (whore).
Italy[m,y]	taci, cretinaccio (shut up, stupid); smettila, imbecillaccio (stop it, imbecile) bastardo (bastard), rognoso scabby (with scabs), vaffan'culo (fuck you), riccione (faggot), figlio di puttana (son of a bitch), stronzo (piece of shit), minchia (cunt, fem. genitalia), minchione (stupid cunt), zoccola (whore, fem. rat)
Japan[n–p]	sukebe (lecherous), chin chin (cock), bakatara (stupid), dobusu (ugly), kusobaa (shit grandma), chikusho (son of a whore), (female sexual parts),
USA[q–w]	fuck, shit, cunt, mother-fucker, prick, dick, cocksucker, nigger, cockey, bitch, pregnant-mother, bastard, tits, whore, fu . . . , doody, penis, queer, pussy, coitus, cock, ass, shi . . . , bowel movement, Fangu (fuck in Italian), homosexual, screw, fag, faggot, schmuck, blow-me, wop (descending order of frequency)[q]
	God damn it, damn fool, ''other four-letter expressions''[r]
	(Fuck my (your) (fucking)) (fucking) (fucking) cunt[s]
	fuck, shit, ass, bitch, cock, fart, suck (descending order of frequency)[t]
	you fucking idiot, asshole[u]
	fuck you, shit on you[v]
	fucka, fu . . . [w]
	fuck, shit (American Sign Language)[x]

[a] Lees et al. [152] (20 GTS).
[b] Lees and Tolosa, 1993 (8 GTS).
[c] Cardoso et al. [48] (9 GTS).
[d] Reuger et al., 1986. (17 GTS).
[e] Asam [7] (1 GTS).
[f] Asam and Traeger [10] (1 GTS).
[g] Hering [120] (1 GTS).
[h] Beckers [18] (2 GTS).
[i] Marneros [165] (1 GTS).
[j] Lieh-Mak et al. [155] (9 GTS).
[k] Singer [231] (3 GTS).
[l] Perera [196], Perera (1983) (2 GTS).
[m] Escalar et al. [87] (2 GTS).
[n] Kuniyoshi et al. [141] (1 Tardive GTS).
[o] Nishida [189] (1 GTS).
[p] Nomura and Segawa [190] (4 GTS).
[q] Shapiro et al. [227] (85 GTS).
[r] Lucas [158] (4 GTS).
[s] Martindale [168,169] (1 GTS).
[t] Nuwer [192] (12 GTS).
[u] Caplan et al. [47] (1 GTS).
[v] Wallen and Areneta [258] (1 GTS).
[w] Milman [177] (4 GTS).
[x] Lang et al. [147] (1 GTS).
[y] de Divitiis [78].

tinguishing the various clinical manifestations of the movement disorder have not been established, and as the variants wax and wane within patients, it may be most useful to view verbal, vocal, and other motor tics in GTS as variants in a hyperkinetic syndrome.

Insight into the nature of swearing in GTS can be obtained by crosslinguistic investigation. Cross-cultural clinical commonalities in patients with GTS were observed as early as 1973. It was reported that approximately 60% of patients sampled in the US [193], France ($n = 107$), Germany ($n = 57$), United Kingdom ($n = 54$), Italy ($n = 46$), Eastern Europe ($n = 25$), Scandinavia ($n = 9$), India ($n = 5$), Japan ($n = 2$), Czechoslovakia ($n = 4$), Poland ($n = 2$) Hong Kong ($n = 2$) and Hungary ($n = 1$) had coprolalia [1,5], but the authors did not provide examples of specific vocalizations in the different languages. Boshes [32] described ''Jamie'', who ''swore continuously'' and ''spewed forth an uncontrollable string of obscenities'' (p. 715) but specific words are not listed. Pary [195] reports ''episodic cursing''. Many authors refrain in this manner from giving specific coprolalic examples. This practice retards our ability to perform linguistic analysis of the specific utterances. In this article, we document all specific instances to gain insight into the phenomena of neurological swearing; and we indicate when coprolalia was reported without specific instances. All examples gleaned from the international literature are given in Table 4.

An important contribution to our understanding comes from the American coprolalic linguistic corpus of Shapiro et al. [223]. Besides this work, several other authors have provided American English examples [47,107,110,158, 177,187,258] and coprolalic American Sign Language examples [147]. Lees et al. [152] provide a listing of British coprolalic utterances. The most frequent coprolalic items observed clinically in the UK are provided by Lees [151]. Cases have been described for English spoken in Australia [51,53], and for Canadian English, at least two studies have reported coprolalia in GTS [49] with one study reporting that 60% of the GTS subjects used coprolalic expressions [180]. The New Zealand English report speaks of ''four-letter obscenities'' in a GTS patient [114]. A child in Ireland displayed tics accompanied by cursing which was disruptive socially [161]. A British study includes the utterance ''maman'' (mama); this patient had French parents [89].

Several French cases indicate usage of coprolalia [119] or ''obscene words'' [153], but do not list the actual words; another gives the example ''trois fois par semaine'' (three times a week) [265].

Spanish examples are given in Singer [226]. Four Argentinean cases were described [175]; in another study, 28% of Brazilian GTS patients had coprolalia, with examples given [48], and a Brazilian patient with coprolalia and compulsive screaming is described without examples [111]. Other Portuguese language cases have been described [93]. A GTS patient from Guyana, South America, had coprolalia [81]. A few unusual examples from a Peruvian report include ''no seas malcreado'' (don't be bad) and ''serve me coffee'' [269] (see Table 4). Briones et al. [37] describe ''gritas y insultas; autenticas barbaridades; palabras soeces'' (''screams and insults; authentic barbarisms; vile words'' (pp. 16–17) all pointing to variants of expletives but lacking specific examples.

Chinese investigators reported on five [156] and then on 18 GTS patients [155,231] in Hong Kong, 60% of whom had single or multiple word coprolalic expressions. In Japanese patients, coprolalia is reported [136], and examples are given [48,141,189,190].

Numerous papers from Germany provide clinical descriptions and some offer specific coprolalic utterances [7–10,18,56,120,165,214]. Certain terms occur across several patients (Arshloch, [asshole], Scheisse, Nutte [prostitute]), while others occur in a single person (Leiche [corpse], Tod [death]). A Dutch coprolalic patient is described [238]. The Danish study of 65 patients lists specific coprolalic utterances [202].

Coprolalia has been reported in Italy [77] with examples [87]. A few such examples differ somewhat in that they take the form of imperatives (''taci, cretinnacio''; ''shut up, stupid'') that may be self-directed. de Divitiis [78] provided specific coprolalic examples of a 23-year-old male GTS patient in a letter responding to our request (see Table 4).

Three papers describe patients in Czechoslovakia [90,102,242]. Five reports of 38 Polish [29,140,209, 245,268] and Russian [11] patients mention ''bad'' or ''obscene'' words. A Russian report [172] reviewed eight patients from 9–13 years. GTS patients followed a stereotypical chronological sequence, with simple involuntary facial, head and shoulder movements, nonverbal vocalizations, screams, inarticulate sounds, and, in three patients, ''bursts of foul language''. However, the only examples given are the Russian words for ''yes, yes'' and ''no, no''.

Two patients in Sri Lanka were described by Perera [196], who responded to our inquiry by letter by providing the specific words in Indian English and Sinhalese spoken by his young subjects (given in Table 4). Eapen and Srinath [82] reported coprolalia in an Indian subject but no examples were given. GTS in the Middle East has been reported [85,203]. Clinical descriptions appear in publications from Israel [100,154]. A 37-year-old Turkish male with GTS and spinal muscular atrophy had coprolalia, but no examples were given [217].

Coprolalic signing has included signs for ''fuck'' and ''shit'' [147]. These signs are to be distinguished from copropraxia, the obscene gestures that also occur in GTS.

Perusal of Table 4 reveals that the vocalized words encountered as part of the clinical presentation in GTS, whether described as a category or in specific terms, are best characterized as obscene or socially taboo terms, primarily with sexual content, sometimes as social slurs or insults, with minor appearance of imperatives (shut-up),

phrases of morbid content (death), and a few other miscellaneous items.

5. Exploring coprolalia in GTS: does the Markov model work?

The claim that observed coprolalic utterances in English GTS speakers can be explained by elementary phonatory positioning [192] related to Markov processes of random sequencing has been championed in the GTS literature. This hypothesis suggests that randomly generated strings of letters or phonemes utilizing higher order probability tables, where more weight is given to those units with a higher probability of occurrence, can account for coprolalic productions. This claim is untenable for at least five reasons.

First, linguists have explained in detail why Markov processes, having exclusively transitional-probabilistic properties, are irrelevant to speech and language, which is structured on several hierarchical levels [54,122,176]. Even if that were not the case, the example given by Nuwer of ''third order probabilistic computer-generated strings of letters'' is unconvincing (p. 366).

> SE KIN HE SPER GOT IN THE WORSE FART YOUESS WELL DIN OPTION IN ITIMENTRAND TWO AS TO BE JURGAINS FART ASSE GIVE ONEGS LOVE BE HALLETURN MAY POCK MOUNT ME SAM WE SNOTLEAKETIFULN'T MIGH TOON'T MIT BAR SOMADE SAM SAY

It is unconvincing because only one of the phonetic combinations alleged to represent GTS vocalizations appears on the clinical coprolalic listings in Table 4, except for the list assembled by Nuwer [192], and the second randomly generated item (asse) only approximates a GTS vocalization, which occurs in a low position on the descending frequency lists in Table 4. Further, the hypothesis would have to explain why the other combinations (seen probabilistically) do not occur as part of the GTS repertory (or speech performances generally). The numerous other coprolalic utterances, including the multisyllabic expressions, are unaccounted for. The coprolalic productions of one GTS patient were analyzed by Martindale [168] (see Table 4), who found that the tics and tic strings (consisting of from 1–7 words) exhibited a complex syntax. These productions could not be described by ''a grammar in which any tic element may follow any other'' — a zero-limited grammar (p. 271). Nor could the coprolalic productions be characterized by a one-limited grammar (''one in which every word is constrained only by the preceding word''), because tic elements are constrained by more than merely the words preceding them. Thus the various permutations of the coprolalic utterance ''Fuck your (my) (your, my) fucking (fucking) cunt'' required a two-limited finite state grammar, which is a level of structure well beyond free combination of elements, and at least one step beyond immediately constrained transitional states.

Secondly, the phonetic composition of the most often observed GTS verbal tics in English does not consist of the most frequent phonemes in English. Numerous frequency listings make possible an objective evaluation of phonemes involved in frequent coprolalic utterances (e.g., Refs. [46,76,98,157]). An analysis of relative occurrence of speech sounds as determined from telephone conversations (Ref. [91], p. 95) reveals that w, t, th (as in then), y, d, and m are the six most frequent sounds in word-initial position, having ratings of 9.38 for w, 7.86 for t, 6.72 for th, 6.48 for y, 6.21 for d, and 5.89 for m (see Table 5). In contrast, the ''top'' three coprolalic words [223] (see Table 4 under USA) contain initial phonetic elements of f, sh, and k, which occur in 14th (rating = 3.96), 18th (rating = 1.74), and 9th (rating = 5.55) place, respectively on the phoneme frequency list. Similarly, the phoneme frequency data for conversational American English presented in Kent [137] calculates f at 3% of sounds, sh at 1% of sounds, and k at 5% of sounds. For coprolalic consonants in final position, k, t, and nt, Fletcher's chart [91] for final consonants places k at 2.85, t at 14.30, and nt at 4.40. Medial vowels are uh and ih. While ih is ranked highest (10.27) on a frequency table for spoken English, uh (at 4.14) is 11th out of a total of 18 vowels. Thus, the sounds of American coprobalic items are actually among the less probable to occur in American speech.

For British English, examine the three most common coprolalic utterances given in Table 4, noting their initial sounds are f, k and b. According to Fry's [98] analysis of the frequency of British vowels and consonants in conversation (reproduced in Refs. [105,65]), and a similar result appears for the consonants: f and k are 9th and 14th, respectively; the vowels are 1st and 9th. In summary, of 19 consonants and vowels making up the three most frequent coprolalic words in American and British English, 12 sounds rank between 9th and 18th in phoneme frequency counts. Of these 19 phonemes, only two vowels and the final t or d rank in the first three phonemes in phoneme frequency counts. Thus, facts derived from the statistical ranking of phoneme frequencies do not descriptively account for the phonetic shapes of the three most often used coprolalic utterances in either British or American English.

While too few German examples are available in the literature to determine a definitive frequency ranking of coprolalic utterances, a similar result appears from choosing the first 3 1–2 syllable words (Nutte [whore], Hure [whore], Arshloch [asshole], and comparing them to a mean frequency of occurrence of letters in a German text (Ref. [122], p. 99). We find that N is ranked 2, T is ranked 6, H is ranked 7, R is ranked 3, A is ranked 9, and L is ranked 11 (see Table 5). Again, relevant letter frequency is not among the highest for these words. Added to this range

of relatively low probabilities is the uniqueness of the letter combinations. We conclude that phoneme or letter frequency counts are not germane to coprolalic utterances. An occasionally expressed corollary of the Markov hypothesis was that coprolalic productions in English constitute ancient, ''Germanic'' utterances, formed of naturally vocalized, ''gutteral'' phonetic elements. Here, also, the facts do not meet the presumptions. Two highly popular coprolalic utterances, ''fuck'' and ''cunt'', are not attested in Old English [65].

A third counterargument against the Markov proposal arises from observations of semantic consistency. The variety of coprolalic utterances across languages as shown in Table 4, including nonIndoeuropean languages, constitute an obvious content category of obscene or taboo words of highly diversely configured phonetic composition. This fact of semantic category overrides any contribution of recurring or ''more frequent'' phonological elements to the classification. In rare cases where the coprolalic utterance falls outside of the semantic category of taboo words, (as in self-directed imperatives or morbid phrases), we nonetheless note that the phonetic elements form a coherent phrase (e.g., ''serve me coffee''), not a probabilistic string.

In addition, as a fourth point, actions and mental events conceptually related to the most common coprolalic semantic subcategory, sexual terms, co-occur with coprolalic productions. That is, copropraxic behaviors of sexual touching and obscene hand gestures are common. This co-occurring behavior lends further support to the notion that it is a semantic-cognitive category that is involved, not a probabilistic tendency toward an accidental concatenation of sounds.

Finally, the report of coprolalic signing [147] removes the symbolic output completely from the realm of letter or phonemic strings, and given the signed forms, supports the role of the semantic category (obscenity), not phonetic shape.

In conclusion, the Markov model is unable to account for coprolalic utterances, even the monosyllabic examples. It is the notion of a particular semantic category, that is, words with socially taboo and/or emotionally charged meanings, that accounts for nearly all coprolalic items. An explanation for swearing in GTS that is based in neurobiology and not involving probabilities is presented below.

Table 5
Phoneme and letter frequency tables

After Fletcher [91] American English conversation

Vowels		Initial consonants (articles excluded)		Final Consonant	
Sound-type	Rank	Sound-type	Rank	Sound-type	Rank
pin	10.27	w	9.38	t	14.30
pine	7.58	t	7.86	r	13.05
pan	6.89	th (then)	6.72	n	12.52
pen	6.60	y	6.48	l	8.40
peel	6.44	d	6.21	z	6.01
pool	6.26	m	5.89	m	5.48
pot	5.21	h	5.75	d	4.44
pane	4.78	k	5.55	v	4.23
pole	4.74	s	5.46	ng	3.57
pawn	4.15	n	4.99	s	3.13
pun	4.14	b	4.64	f	1.37
pull	2.96	g	4.33	th (with)	1.25
pout	1.69	l	4.31	p	1.24
par	1.31	f	3.96	ch	0.53
pair	1.09	r	2.78	b	0.42
purr	0.80	p	2.54	g	0.38
pew	0.26	th (thin)	2.02	sh	0.32
poise	0.19	sh	1.74	j	0.14
		v	1.25	th (myth)	0.04
		f	0.83	zh	0.01
		ch	0.55		
		z	0.34		
		zh	0.02		

After Fry [98], British english conversion

All consonants		All vowels	
Sound	%	Sound	%
n	7.58	sof*a*	10.74
t	6.42	b*i*t	8.33
d	5.14	b*e*t	2.97
s	4.81	b*i*te	1.83
l	3.66	b*u*t	1.75
th (then)	3.56	b*ai*t	1.71
r	3.51	b*ea*t	1.65
m	3.22	b*aw*d	1.45
k	3.09	f*a*ther	1.37
w	2.81	h*aw*ed	1.24
z	2.46	hoot	1.13
v	2.00		
b	1.97		
f	1.79		
p	1.78		
h	1.46		
ng	1.15		
g	1.05		
sh	0.96		
j	0.88		
dj	0.60		
ch	0.41		
th (thin)	0.37		
zh	0.10		

Table 5 (continued)

After Hoermann [122], German: written text

Letter	Frequency	Letter	Frequency
E	147004	G	26672
N	88351	M	21336
R	68577	O	17717
I	63770	B	15972
S	53881	Z	14225
T	47310	W	14201
D	43854	F	13598
H	43554	K	9558
A	43309	V	7350
U	31877	UE	5799
L	29312	P	4992
C	26733	AE	4907

6. Comparison of swearing in aphasia and GTS

Among speech pathologies, swearwords (taboo expressions) occur most prominently in aphasia and GTS. Here we explore the similarities and differences in swearword presentation in the two conditions. Swearwords have in common that they are socially taboo utterances, those to be avoided in ''polite company'', and that are therefore, mildly or intensely, ''offensive'' terms. Unfortunately, there is no available corpus of aphasic recurrent utterances for American English, and thus it is necessary to compare the larger GTS coprolalic corpus for American English [223] with the British corpus for aphasia provided by Code [57,59]. Listings for both speech pathologies are available in German for comparison. The overview of crosslinguistic coprolalic utterances provided above will help explore questions about the clinical presentation of vocalizations in GTS.

Differences are found in the manner and in the content of speech performance for these terms. In aphasia, swearing is selectively preserved in the context of severely impoverished speech; in GTS, swearwords are overproduced in the context of functional speech. In the aphasic and left hemispherectomized adult speakers, swearing is produced (nearly) normally in articulation, prosody, and fluency. In the GTS speaker, the coprolalic expression is defective in articulation and prosody, relative to the ongoing, conversational speech in which it is occurring. Many reports of coprolalic utterances in GTS describe them as distortions: they are overly loud, or ''shouted'', imprecisely articulated, expressed with aberrant voice quality, and sometimes unintelligible, while speech of the patient with GTS is otherwise normal (but see Ref. [159]).

Another difference lies in ''substitution'' behavior. Persons with coprolalia have been reported to utilize euphemisms in place of the socially offensive term [165], for example, using ''gut'', (''good'') ''schoen'', (''fine'') ''wunderbar'' (''wonderful'') for ''Scheisse'' (''shit'') and ''Arshloch'' (''Asshole''). Shimberg [225], giving an overview of GTS for the general public, states that some persons with GTS learn to mask words, saying, for example, ''fake'' for the more offensive word ''fuck''. A similar process may be underway in the observation that some persons with GTS ''shout'' words regularly occurring in sentences [50,212,220,259], possibly to accommodate the coprolalic inpulse in this other way. Neither a substitution process nor compensatory shouting is observed in aphasia.

Another important difference in manner of production between adult aphasia and GTS lies in the ''sensory'' factor proposed for tic behaviors in GTS. Patients report that they first feel an urge, which is very strong, to perform a movement (e.g., vocalization), and then they ''voluntarily'' perform the movement [41,143,145]. In a survey, [147] 71% of GTS patients were found to have a ''feeling that tics are imminent''; 76% experience a sensation preceding the tics; 25% feel that the sensation will be relieved by tics. Sensations are described as generalized, psychic, and focal, and if the sensations involve the pharynx or larynx, then ''vocalizations may be produced'' ([143], p. 733). One patient describing personal inner experiences stated that ''coprolalia is a response to the TS sensitization of the vocal tissues used in forming sounds; somewhere in the mouth or throat (lips, teeth, larynx, tongue), tissues and air impinge on each other to activate a single sensory site'' (Ref. [28], p. 1345). In another patient, coprolalic practice was reduced by injection into vocal folds of botulinim toxin, suggesting that GTS may involve a ''sensory reflex arc'' and that the effect of the injection is to reduce ''local build-up of tension or muscle contraction'' on the laryngeal area [219]. There is no evidence or suggestion of a comparable premonitory sensory component to swearing behavior in aphasia, but this has not been studied directly.

As coprolalic vocalizations often occur during ongoing conversation, several studies have evaluated whether or how their occurrence is related to linguistic structure. One study evaluating verbal tics in three GTS subjects reported that two of the subjects produced 70% of tics at natural pausing points, before and after clauses, while the third subject produced most tics within stressed words [95]. Martindale [169] studied the syntactic and semantic correlates of verbal tics in a two h sample of speech in a GTS subject. Tics were produced at the rate of 4.6 per minute, often in strings; they appeared to occur at points of low information or uncertainty, often before conjunctions (and, but) and pronouns. In another study, most vocal tics were produced at the beginnings or ends of a speech clause, somewhat less during the clause. A small number of tics were produced in silence [159].

Other questions pertain to how GTS vocalizations compare to vocal tics occurring in normal speech production. The notion of normal use of vocalizations has been described by Goffman [108], who states that ''the public utterance of self-talk, imprecations, and response cries constitutes a special variety of impulsive, blurted actions, namely, vocalized ones'' (p. 116) and by Darwin [72] who discusses the universality of sound emission as emotional expression. A comparison of GTS vocal (verbal and nonverbal) tics with measures of the same behaviors taken from normal speakers was conducted [159]. The nonverbal tic frequent in GTS was also observed in normal speakers, but verbal tics occurred only in GTS speakers (about 35%).

The volitional component of tics is said to distinguish GTS vocal tic production from abnormal motor behaviors in the choreas [145,193]. Swearing in aphasia is best explained by stating that the word choice is fixed but the use is somewhat volitional in spontaneous speech, in that the recurrent utterance can be used expressively, along with facial and other gesturing. What is not known is whether a typical recurrent utterance can be elicited from

the aphasic speaker- whether he/she can produce the utterance on command. In contrast, GTS patients have been repeatedly demonstrated to easily produce their coprolalic utterance at will and on command, without the sense of inner tension that accompanies spontaneous coprolalia, and without the phonetic distortion. One study utilized a habituation technique as therapy for coprolalia, eliciting numerous repetitions of the affected utterance, until the patient reported no longer being able to say the word. Following these therapeutic sessions, the compulsive vocal emissions were temporarily reduced [10]. Voluntary and spontaneous tics may use different underlying mechanisms; EEG studies [193] reported an absence of the pre-movement potential normally associated with voluntary motor acts prior to GTS tics, which suggested that the tics are not generated through normal motor pathways utilized for willed human movements (p. 113). Thus to the extent that we can locate swearing behavior on a spectrum from ''voluntary'' to ''involuntary'', significant differences appear in GTS versus aphasic swearing.

Longitudinal studies identify other differences between swearing in GTS and aphasia. Aphasic speakers generally emerge from the acute phase with a fixed repertory of recurrent utterances, which may change and grow somewhat with time, and which eventually may evolve to propositionally formed expressions [2]. In the chronic patient, by definition, little change in swearing occurs. In contrast, GTS vocal phenomena often are reported to begin as partial, soft and indistinct sounds, which develop eventually into louder and clearer vocalizations. Some authors have speculated that the process is one of a change from a willed act to a motor habit, that this process is more rapid in GTS sufferers than in normal persons, and that coprolalic behavior progresses from a stage of volition or semivolition to compulsion. Some patients report having a related thought (e.g., authentic semantic content) behind the utterance for a while, and then eventually the coprolalic utterance proceeds motorically, as it were, on its own. At the later stages, GTS patients may no longer be aware of the quantity of their vocalizations. Coprolalia in GTS has been reported to wax and wane [263]. While careful studies still are needed, aphasic swearing appears to maintain a more stable course.

Coprolalic signing has been reported [147] in a hearing young adult female with GTS and verbal coprolalia, who learned fluent sign in her late teens. Although studies of aphasic signing deficits following left hemisphere damage in deaf persons have appeared [121], there is no report of recurrent automatic speech or residual swearing in sign [19]. However, focused studies on this question have not yet been done.

Physiological versus psychiatric variables are of differing significance in GTS and aphasia. Even though the previously held exclusive role of psychoanalytic explanations for coprolalia, such as hostility toward a parent as the cause of the verbal tics, is no longer seriously held, some role of psychological factors is recognized by most persons working with GTS sufferers [125]. Onset of symptoms is often associated with a traumatic incident [263]. For example, in his case report of a 13-year-old Saudi female patient, El-Assra [85] states that ''her condition started seven years previously when she became extremely frightened one night by a group of cockroaches in a dark toilet''. (p. 397). The patient exhibited facial tics four days later, followed by multiple tics of neck, shoulders and hands; soon utterances appeared, and these developed into coprolalia.

Environmental conditions exacerbate or ameliorate the intensity of the symptoms [225]; for example, coprolalia may be ''worse at home when the individual feels safer'' (p. 31); or, in an opposite presentation, worse in the presence of others [85]. In discussing GTS symptoms, Bruun and Budman [38] observe ''fewer tics in the office setting than reported by history'' (p. 28), and they note the ability of children to mask their symptoms by use of social setting affects aphasic swearing. Cultural factors have been said to influence coprolalic output, with ''quasicoprolalia'' in Japanese and other Asian GTS cases [129,191], presumably attributable to lower acceptability of swearing in Asian culture. Similarly, in aphasia, though to a lesser extent, less swearing has been reported for German- than American-speaking aphasic patients, especially in the presence of the clinician [31].

Meyer and Rose [174] report psychological factors as contributing to the clinical picture in GTS. Milman [177] reported that three of four boys with coprolalia also had ''body anxiety and sexual anxiety'' (p. 894). Pitman and Jenike [199] studied a patient with obsessive-compulsive disorder (OCD) and coprolalia, seeing a role for psychological factors in the genesis of tic symptomatology. Indeed, OCD, a neuropsychiatric condition, often appears clinically in association with GTS [68,96]; many authors view an array of motor and behavioral abnormalities as constituting a spectrum of related phenomena (e.g., Refs. [62,241]) which include copropraxia. Beckers [18] gives a strongly psychodynamic interpretation of the clinical presentations of five patients, although he reported psychotherapy not to be useful in these cases. Lumsden et al. [161] reported a success of family therapy in reducing tics and coprolalic utterances in an 11-year-old child. Given that the content of the verbal tics is primarily the feature of social offensiveness, a significant interface between neurological and psychiatric features is compelling, and appears to be a much more significant factor in GTS than aphasia.

Tables of data on swearing in British, German and American samples in aphasia and GTS reveal little overlap in pathological swearing. In British, ''fuck'' appears in both pathological conditions; in American English, ''shit'' appears in both conditions. One or both words occur in various instantiations in most other languages reporting GTS examples: Spain, Brazil, Germany, Hong Kong, Sri Lanka, and American Sign Language. These two are the

words all groups have in common. However, there are differences in content of the swearword corpus for each group. Perusal of Tables 1–4 allow comparison of reported swearing (or coprolalic) behaviors of normal, aphasic, and GTS patients. Normal adults use the more mildly obscene terms in most surveys (Table 1).

In a further difference, aphasic recurrent utterances include social interjections, sentence stems, proper nouns, yes/no, numbers, and a large class of miscellaneous words and phrases (Table 2). In contrast, in GTS, linguistic vocalizations, visceral and sexually charged obscenities and insults predominate in a spectrum with nonverbal vocal and manual gestures (Table 4). We have previously concluded that specified semantic content is a key parameter in GTS coprolalia. This notion is consistent with frequent reports of sexual preoccupation and copropractic movements involving sexual gestures [62,69]. These kinds of words and these gestures are not characteristic of aphasic speech.

Taboo expressions are hyperactivated in GTS, and a subset of these are preserved in left hemisphere damage and removal. Aphasic speakers retain a set of ''automatic utterances'' which include swearwords as the second most common type, while GTS vocalizations concentrate on sexually offensive terms, extending sometimes to those not commonly used as swearwords (e.g., ''pregnant-mother'', ''homosexual''), but including an array of nonverbal vocal sounds. In left hemisphere dysfunction, taboo expressions emphasize swearwords ''of frustration'' (''fuck'', ''shit'', ''goddammit''). Behaviors in GTS extend to sexual content in copropraxia and mental coprolalia. No such associated behaviors are observed in focal left hemisphere disease. Thus the psychosocial dimensions associated with coprolalia are not present in aphasic swearing.

Persons with GTS are able to transmute, mask and postpone the vocalizations. Coprolalic frequency is influenced by social setting. While in aphasic swearing, crosslinguistic cultural differences in production frequency of expletives have been reported (cf. differences between English and German corpora), variability with social setting is not prominent, and masking of the form of the residual utterance in aphasia does not occur.

The clinical-linguistic observations are consistent with the notion of hyperactivation or release from inhibition of emotionally and sexually charged behaviors in GTS. For patients with left hemisphere damage, swearing most likely appears because it is stored and processed differently from newly created, propositional speech and thus remains uniquely available.

Studies of the linguistic vocalizations of GTS are complete enough to conclude that sexual-emotional content characterizes the coprolalia. Thus the notion of a hyperactivation of sexual-emotional processing in vocal and gestural behaviors is useful in accounting for many of the clinical symptoms. Habitual vocal–motor patterns may help originate and maintain the vocalizations. For focal damage to the left hemisphere, habitual ''island'' preservation of motor patterns appear to more essentially underlie the swearing behavior. In severe aphasia, we propose that overlearned motor patterns best explain these phenomena. Frustration, and the genuine expression of emotion, can and does often trigger the production of the expressions. Since selectively preserved swearing is seen in extensive damage to the left hemisphere as well in the left hemispherectomized adult, a role of the right hemisphere is likely. With one report of deficient swearing (and other automatic speech behaviors) in association with a right basal ganglia lesion [235], the notion of an interaction of basal ganglia and right hemisphere is attractive.

7. Emotional and prosodic processing

There have been ample reports of emotional processing by the right hemisphere [33,40,55,133,246,260] as well as proposals that right hemisphere dysfunction contributes to psychoaffective disorders [70]. Emotional changes also are associated with basal ganglia disorders [170]; there are numerous reports of changes in mood and motivation [22,61,66,70,170,173,201,211]. Heightened social awareness may be a right hemisphere property [237,250,251].

Prosody, the melody of speech, emerges importantly in emotional speech. This has been recently a major field of study, with findings of an effect of either left or right hemisphere and/or a basal ganglia damage on prosodic ability. Some greater role of the right hemisphere has been reported in prosodic performance, although the reason for this finding — whether attributable to cognitive, acoustic, or other factors — has remained elusive. Studies of emotional prosodic comprehension in GTS are rare. One study [75] using the Profile of Nonverbal Sensitivity (PONS) test of nonverbal communication [208] found no deficits in comprehension of emotional meanings in speech prosody in five patients with GTS and coprolalia. Other studies of persons with basal ganglia disease have reported deficient emotional-prosodic comprehension, whether the movements were of the hyperkinetic variety, as in Huntington's patients [234] or hypokinetic, Parkinson's disease [26,36,67].

Prosodic production in speech, although a highly active field of study in normal speakers [215,216] and in neurological subjects, has not been investigated in GTS. However, impressionistically, abnormalities involving loudness, timing, and pitch are observed in the pathological verbal–vocal expressions of GTS. Acoustic analyses of these expressions would be of great interest. As mentioned above, in studies of brain damage, changes in speech prosody production [138,255] and comprehension occur with damage to either hemisphere [257] as well as to subcortical structures [45,253]. Singing of familiar songs is often intact in aphasia, in adult left hemispherectomy and in selective anesthetization of the left hemisphere in Wada

testing [113]; reports of singing ability in GTS have not appeared. Singing, like swearing, appears to remain apart from propositional language function. Since data are available on prosodic function in various other neurological diseases, prosodic studies of coprolalia and swearing in aphasia would be of value and interest in understanding these behaviors.

8. Cerebral laterality

While the left hemisphere mediates most linguistic behaviors, the right hemisphere is important for broader aspects of communication [249–251]. Right hemisphere behavioral functions appear to differ from those mediated in the left hemisphere with regard to type of stimulus preferred [6,21,34]. In visual and auditory domains, cerebral laterality studies consistently show a superiority for right hemisphere processing of the configurational aspect of stimuli [30,236]. Simply stated, the left hemisphere specializes in analyzing sequences, while the right hemisphere gives evidence of a superiority in processing patterns. These generally accepted facts about hemispheric specialization pertain to our review of swearing, in that expletives make up a unitary, ''nonanalytic'' stimulus, which in all likelihood is stored and processed as a whole. In contrast, words making up propositional language are composed of the building blocks of phonemes, morphemes, and syllables, which can be rearranged in various ways. The differences between expletives and composed words and phrases, considered with known differences between left and right hemisphere processing, lead to a consideration of the right hemisphere as a more likely candidate in modulating the motoric production of expletives. This theoretical possibility is supported by the observations of intact swearing in severe aphasia (following extensive left hemisphere damage) and left hemispherectomized adult patients.

9. Pathological basis to GTS: a basal-ganglia disorder

While there is no doubt that brain damage underlies swearing behaviors in aphasia, it is only more recently agreed that a neurochemical/neurophysiological disorder underlies GTS [150]. The effectiveness of neuroleptics gave the first clue to these mechanisms [148]. Evidence for a genetic basis of the disease further supports this view [142,150,194].

Neuropathological studies of GTS are inconclusive [227]. Examination of three GTS patients at autopsy revealed meningitic thickenings in the region of exit of the facial nerve in one case, meningitic and vascular changes throughout the brain in the second case, and no changes in the third; others suggested that small cells in the corpus striatum were decreased in size and density [263]. Devinsky [74] proposed midbrain involvement as the site of damage; this proposal was based on metabolic abnormalities implicating the midbrain, similarities between GTS and encephalitis lethargica, and brain stimulation studies [135]; midbrain involvement, with a focus on the periaquaductal gray matter, was also later proposed from radiologic data [213]. A recent post-mortem study showed abnormalities in the globus pallidus with profoundly diminished dynorphin-like immuno-staining in this region [116]. A post-mortem study of three patients with GTS revealed significantly increased dopamine uptake carrier sites in the caudate and putamen [230]. Although no reproducible autopsy changes have been described that definitely localize the pathology of GTS to a basal ganglia region, several lines of evidence support the basal ganglia as the principal location of dysfunction in GTS.

Of many GTS patients studied with computerized tomograph (CT), only 10% have shown abnormalities, and these appear in various brain systems [17]. Despite these inconsistencies, there is increasingly compelling evidence that GTS is a basal ganglia disorder. Studies using magnetic resonance imaging show reduced volumes of the caudate nuclei, lenticular nuclei, putamen, and globus pallidum compared with controls [198]. Activated brain imaging findings are inconsistent, but also tend to implicate basal subcortical structures. Older studies reported higher glucose metabolism in the basal ganglia of GTS patients; other studies by the same group found glucose metabolic rates to be lower than normal subjects in frontal, cingulate insular cortex, and inferior corpus striatum [51]. Baxter and Guze [17] found higher glucose metabolic rates in the putamen of GTS patients compared to normal subjects. More recently, studies of brain metabolism and brain blood flow have shown diminished perfusion and glucose metabolic activity in the caudate nuclei and variably in the thalamus, anterior cingulate, and dorsolateral pre-frontal cortex [83,84,182,261]. Correlative hypometabolism appears in bilateral temporal lobes of GTS subjects [84]. Braun et al. [35] studied 18 GTS patients (aged 18–49) and reported an association of clinical symptoms with ''increasing, apparently dysfunctional synaptic activity in the medial, lateral, and caudal orbitofrontal cortices'' (p. 151). In vivo studies of dopamine receptor binding revealed increased D2 dopamine receptor binding in the head of the caudate nucleus and increased dopamine transporter activity in this same area [164,262]. Disordered biogenic amine metabolism also is supported by reduced levels of homovanillic acid in cerebral spinal fluid of patients with GTS [42,52,229].

Taken together with the clinical response to dopamine blocking agents such as pimozide evidenced by most patients with GTS [202], the available evidence strongly supports dysfunction of the striatal structures including caudate, globus pallidus, and putamen in patients with GTS [262]. Shapiro and Shapiro [222] and others point to the effectiveness of neuroleptics, especially those with

dopamine D2 blocking effects, as implicating dopamine dysfunction in GTS. Similarly, Singer [228] assigns an important role in GTS to frontal-subcortical circuits based on evidence from dopaminergic neurotransmission. Other disorders such as Sydenham's chorea, hemiballismus, carbon monoxide intoxication, and post encephalitic Parkinsonism, where coprolalia has been reported, also involve the basal ganglia. Thus, coprolalia of the involuntary, ego-dystonic type manifested in GTS appears to be at least partly a manifestation of basal ganglia dysfunction.

The basal ganglia are increasingly recognized to have important roles in cognitive, emotional, and behavioral functions as well as in motor activity. The effect of basal ganglia damage on speech and language function has been described [39,45,76]. In one model of basal ganglia function, the basal ganglia are said to provide an internal timing cue to the supplementary motor to release an action. Georgiou et al. [103] present evidence that GTS involves ''dysfunction of basal ganglia and interconnections with frontal lobes'' (p. (190). Studies of three cases of tic disorder associated with pediatric cerebral malignancies suggested a role for ventral striatum, corpus callosum, thalamus, midbrain as important in tics [197]. Following a notion first proposed by Balthasar [14] in 1957, Palumbo et al. [194] reviewed a large number of cases and proposed a ''developmental basal ganglia syndrome'' underlying GTS and related disorders.

10. Limbic system-basal ganglia hypothesis

The caudate, globus pallidus, putamen, and substantia nigra are positioned in frontal-subcortical circuits between frontal cortical regions and thalamic nuclei. These cortical-striatal-pallidal-thalamic circuits mediate executive function, motivation, social behavior, and diverse aspects of emotion [66]. The basal ganglia receive abundant projections from the limbic system, and the frontal-subcortical circuits integrate limbic input in the orbitofrontal-subcortical circuit and the anterior cingulate-subcortical circuit [115] forming at least five structurally and functionally separate ''circuits'' [3,66]. Thus, dysfunction of the basal ganglia simultaneously produces abnormalities of limbic system function and of limbically mediated emotional activities. Nespoulous and Lecours [188] propose a limbic source of coprolalic speech. A number of studies point to a disorder of the cingulate gyrus — a critical component of the limbic system — in GTS. Stimulation of anterior cingulate cortex in humans has been associated with licking, touching lips, and other stereotyped GTS movements, and it is known that the anterior cingulate cortex receives dopamine innervation from the midbrain [243]. Several patients have been treated by stereotaxic surgery directed toward the limbic system (e.g., [77]). Following successful treatment of GTS by bilateral limbic leukotomy, Robertson et al. [204] proposed the importance of cingulate cortex in the mediation of emotionally charged language.

The limbic system has been implicated in emotional vocalization in animals. In Macaque monkeys, emotional vocalization occurs with stimulation of the anterior cingulate gyrus, amygdala, diagonal band-substantia innominata, ventral septal region, hypothalamus, nucleus accumbens, ventral anterior and midline nuclei of the thalamus, and the tegmentum [205]. Similarly, studies with the squirrel monkey revealed that emotional vocalization occurred with stimulation of the hypothalamus, midline thalamus, amygdala, substantia innominata, septum, orbitofrontal cortex, cingulate cortex, and anterior inferior temporal cortex [134]. Ploog [200] reported from animal studies that vocalization following brain stimulation occurred only in subcortical cites, while human speech was considered to be primarily cortically represented. Based on his observations on animal vocalization, Robinson [25,206,207] has proposed two levels of the nervous system involved in human speech/language behavior: an older system, which terminates in cingulate gyrus at the bilateral, rostral end of limbic system, and which is capable of emotive speech behavior; and a newer system which is cortical, unilateral, and involved in planning. Myers [184] similarly proposed that (animal) vocalization and human speech are dichotomous.

A similar and related dichotomy is proposed for learning and memory. Simply stated, the two disparate systems proposed [178,179] are those for establishing habitual patterns or ''nondeclarative'' (also called ''procedural'') memories as distinctive from those for establishing new learning or ''declarative'' memories [4]. From many kinds of evidence, the basal ganglia are associated with motor programs that are well established [99,167]. Marsden [166] stated that ''the basal ganglia are responsible for the automatic execution of learned motor plans'' (p. 514). A recent review of behaviors associated with the basal ganglia included aspects of motor control, preparation for action, the formulation of strategies and responses, and the establishment and selection of emotional responses ([211], p. 20). Baev [12,13] proposes that the basal ganglia provide a ''model'' of the motor behavior to be executed. Basal ganglia function with integrated limbic components form a likely origin for expletives: these are habitual motor programs with emotional content.

The basal ganglia in concert with limbic activity account together for coprolalic production [185]; the coprolalic phenomena are thus attributed to a motivational disorder involving limbic projections to striatum. Copious interconnections between basal ganglia sensorimotor and limbic pathways are known from neuroanatomical studies: basal ganglia (caudate nucleus, putamen, globus pallidus, and substantia nigra) are richly interconnected with limbic structures. The nucleus accumbens receives inputs from several limbic structures: anterior cingulate, hippocampus, amygdala [115]. Parallel as well as multiple reciprocally connected structures lead to optimal conditions for ''cros-

stalk'', such that pathologies could produce ''a variety of symptoms relating to the motor, cognitive, and limbic function of the basal ganglia'' ([115], p. 261). The role of basal ganglia in initiating motor behaviors [167], and the known circuitry of frontal-subcortical connections [171], provide the basis for positing hyperactivated initiation of emotionally charged, overlearned vocal output as pathophysiological basis of coprolalia.

A similar view emerged from specific studies of GTS verbal behaviors. Following comparisons of language versus speech behaviors in GTS subjects, Ludlow et al. [159] proposed that the pathology may involve an imbalance between cortical and limbic systems for processing speech and language in GTS. These authors noted that the stereotypic speech, gestural and motor behaviors of GTS may be produced without inhibition by the cortical system, and therefore ''fail to be further modified into purposive behavior'' (p. 360). However, from their language studies, they also suggested that in GTS, the cortical system also may be impaired, resulting in ''paucity of speech, language, and written expression''. This may be due, in their model, to suppression of the supplementary motor area, while the ''production of stereotypic sets of behaviors is heightened through increased activation of the cingulate gyrus. The suppression of one region may be independent of the increased activation of the other, accounting for the independence of the two sets of symptoms'' (p. 360). A somewhat related proposal comes from Nauta [185], who suggested that GTS reflects a disorder not only in the motor domain, but in the motivational mechanisms of the limbic system. Baxter and Guze [17] focus on a functional neuroanatomical involvement of the basal ganglia, prefrontal cortex, and limbic system in GTS, pointing to well-known circuitry involved in the 'gating' and 'screening' of motor outputs, sensory inputs, and possibly even 'thoughts.' They propose that it is ''impairment in these gating and screening functions of the striatum'' which results the variety of expressed phenomena in GTS, which include both motor behaviors and sensations (p. 299).

11. Conclusion

Swearing is a common human act and is frequent in neurological disorders such as spinal cord injury, head trauma, and aphasia where patients experience frustration and evidence the emotion through cursing. This type of cursing differs from the involuntary ego-dystonic type of coprolalia, in which speech production is separate from personal intentionality. Ego-alien coprolalia is distinctly uncommon and is confined to a few neurological diseases. Coprolalia is most common in GTS, was well described in post-encephalitic Parkinsonism, and has been noted in cases of secondary GTS produced by herpes encephalitis, carbon monoxide poisoning, Sydenham's chorea, post-stroke hemiballismus, and head injury [16,224]. Despite the differences between normal cursing and coprolalia, there also are substantial shared features: both use some of the same words, the words have a highly emotional content, and both normal cursing and coprolalia depend on invoking the emotional signaling systems — use of verbal cries and/or taboo words — in the communicative act. Comparison of documented expletives for normal, aphasic, and GTS speakers provided in Tables 1–4 shows notable similarities as well as differences in the respective taboo word repertories. Too little is known about swearing in aphasia, with only the British and German corpora available, compared to fuller information in normal subjects speaking American English, and a now broad reportage of linguistic backgrounds for coprolalia. More complete information might change the picture. However, with the current data, it appears that the most frequent expletives (''damn'', ''shit'', ''fuck'') occur in all three conditions, while sexual taboo items predominate in normal and GTS speakers, with fewer such items uttered in aphasia.

With yet so little known of relevant neurological mechanisms, our conclusions about brain-behavior correlates are of necessity speculative. Comparison of animal and human communicative behaviors suggest that two functional systems, one for emotional vocalization and the other for propositional speech, may exist. The purpose of animal vocalization is nearly exclusively social in nature with some vocalizations indicating anger and warning and others facilitating social interactions [75,163]. From this perspective, coprolalia in humans might represent the abnormal release of vocalizations mediated by limbic system structures and normally intended to perform the social functions of repulsing intruders and expressing anger and dissatisfaction. The ego dystonic, alien nature of coprolalia in GTS and related syndromes stems from the involuntary occurrence of these vocalizations analogous to the involuntary occurrence of the motor tics. We hypothesize that coprolalia represents a limbic vocal tic whose unique content is informed by the social and emotional communicative purposes of limbic vocalizations. The considerable evidence of basal ganglia dysfunction in GTS implicates those structures in concert with limbic activity. The verbal form is unitary, not compositional (i.e., is not generated by combining smaller, permutable units, such as phonemes, syllables and morphemes), in contrast to words in the propositional language system, and thus possibly draws on right hemisphere cortical mechanisms for execution.

Voluntary normal cursing and cursing in aphasia may share the anatomy and physiology of coprolalia. Normal, aphasic and coprolalic cursing have in common the expression of certain identical linguistic productions, as well as the unitary, noncompositional structure of the stimulus. Persons suffering from aphasia, in whom left hemispheric areas mediating propositional speech are dysfunctional, may have access to structures mediating limbic vocaliza-

tion, modulated by basal ganglia structures and facilitated by right hemisphere cortical structures. Normal cursing typically occurs in periods of anger, frustration, and other intense emotional situations where limbic system structures are activated and limbic vocalizations may be facilitated. In many normal and aphasic individuals, cursing also occurs frequently as habituated verbal productions. The overlearned and emotive vocal-motor ''gestures'' of cursing are hyperactivated in GTS and remain residually available in the aphasic speaker.

Acknowledgements

We appreciate the help of Dr. Alexander Smirnof and Dr. Costintino Iadacola in translating articles from Russian and Italian. Cathleen Bannister-Marx assisted in library research and translation of Spanish articles. Videotaped recording of a hemispherectomized patient was provided by Dr. J.E. Bogen. Dr. Van Lancker is supported in part by a grant from the Pew-McDonnell Foundation. Dr. Cummings is supported by an NIA Alzheimer's Disease Research Center Grant, an Alzheimer's Disease Research Center of California Grant, and the Sidall-Kagan Foundation.

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