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1. Introduction

1.1 Background. Speech databases on Danish, Dutch, English, French, German and Italian are being set up as part of an Esprit-funded project, 'Speech Assessment Methods' (SAM), which is concerned with the establishment of standardized assessment methods for automatic speech recognition devices. An important aspect of this work is the devising of a standard set of conventions for the machine-readable phonetic transcription of these languages. This matter was discussed at a two-day meeting in London devoted to aspects of the organization of speech databases, which was attended by participants from SAM Partners in the five currently participating countries (Denmark, France, Italy, Netherlands, United Kingdom), together with representatives from the German Federal Republic. Participants agreed that a compromise based on the three existing multilingual proposals could be achieved: its broad outlines were agreed, while the elaboration of detail was left to the present author and this report.

1.2 Transcription and coding. It is important to distinguish clearly between transcription and coding.

TRANSCRIPTION is the use of appropriate alphabetic letters to represent the sounds of speech consistently and explicitly. A transcription system may be a 'respelling' system, using familiar orthographic conventions of the language in question, perhaps with special diacritical marks to remove what would otherwise be ambiguities; or it may be a 'phonetic' system using special phonetic symbols, whether IPA or otherwise.

CODING is the assignment of a bit pattern by which a given character (e.g. 'a', 'w', 'ɔ') can be represented internally in a computer, for purposes of transmission, storage, or data-manipulation. The standard code in modern computers is the ASCII code, also known as the ISO 7-bit coded character set (ISO 646) which is set out in Table 1. If special phonetic symbols are to be used in computing, it is necessary to map each of them onto an ASCII code value.

1.3 Coding. For our purposes, then, coding consists in the conversion of phonetic symbols into suitable ASCII code equivalents.

Codes can be expressed either in ordinary decimal notation, as shown at each position in Table 1, or, alternatively, in hexadecimal notation (derivable from Table 1 by taking the column number and then the row number). Upper-case 'M', for example, has the code 77 (decimal), 4D (hex). We shall normally express them here in decimal notation.

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TABLE 1

	2	3	4	5	6	7
0	32 SP	48 0	64 @	80 P	96	112 p
1	33 !	49 1	65 A	81 Q	97 a	113 q
2	34 "	50 2	66 B	82 R	98 b	114 r
3	35 #	51 3	67 C	83 S	99 c	115 s
4	36 $	52 4	68 D	84 T	100 d	116 t
5	37 %	53 5	69 E	85 U	101 e	117 u
6	38 &	54 6	70 F	86 V	102 f	118 v
7	39 ´	55 7	71 G	87 W	103 g	119 w
8	40 (	56 8	72 H	88 X	104 h	120 x
9	41)	57 9	73 I	89 Y	105 i	121 y
A	42 *	58 :	74 J	90 Z	106 j	122 z
B	43 +	59 ;	75 K	91 [	107 k	123 {
C	44 ,	60 <	76 L	92 \	108 l	124 ¦
D	45 -	61 =	77 M	93]	109 m	125 }
E	46 .	62 >	78 N	94 ^	110 n	126 ~
F	47 /	63 ?	79 O	95 _	111 o	127 DEL

ASCII / ISO 7-bit coded character set. ISO 646 leaves seven positions unassigned in the basic character set, and allows different national assignments of characters to three others. Moreover, position 36 in the 'International Reference Version' is occupied by the currency symbol ¤, but this is not used locally in the EC. In practice, the values shown above are replaced in local EC use as follows:

for Danish,		91 Æ	92 Ø	93 Å	123 æ	124 ø	125 å	
for French,	64 à	91 °	92 ç	93 §	123 é	124 ù	125 è	126 ¨
for German,	64 §	91 Ä	92 Ö	93 Ü	123 ä	124 ö	125 ü	126 ß
for Italian,		91 °	93 é	96 ù	123 à	124 ò	125 è	126 ì
for Spanish,	35 Pt	91 ¡	92 Ñ	93 ¿	123 ¨	124 ñ		
in the UK,	35 £							

Some of the proposals presented at the London workshop assign to ordinary alphabetic characters quite different codes from those the characters have in the ASCII (ISO-7) scheme. The majority, though, start from the principle that any phonetic character which is also a printable ASCII standard character (having an ASCII code between 33 and 126 inclusive) should retain the same code in the phonetic character set.

The majority assume, too, that it is desirable to associate special phonetic characters with codes (and hence standard characters and keyboard positions) with which they bear some MNEMONIC association. This is the reason for assigning 'ʃ' to code 83 (standard character 'S', keyboarded as shifted-'s'): the visual shape of the character 'ʃ' and its phonetic value are both similar to those of 's', the lower-case equivalent. This is clearly a user-friendly coding, whereas assigning 'ʃ' to, say, code 113 (standard character 'q'), as in the DIN proposal (below) is not.

One machine-readable phonetic character set (that used by the IBM-UK Science Centre) exploits ASCII codes with values exceeding 127. This implies in fact an 8-bit character set, rather than a 7-bit one, and is unsuitable for some text-oriented applications.

A minor problem arises out of the fact that a few standard ASCII characters have 'national' variants, differing according to country or language. In the recommendations below, we specify that phonetic 'ə' should be coded as '@', i.e. ASCII 64. But on French keyboards this code is assigned to the character 'à', and on German ones to '§'. An operator inputting phonetically transcribed data from a keyboard in a French-speaking or German-speaking country must act accordingly.

The codes we recommend for phonetic 'æ' and 'ø' are chosen specifically because of the national coding in Denmark and Norway of these same characters as used in the ordinary spelling of Danish and Norwegian.

1.4 Parsability. For computational purposes it is important that a string of phonetic characters be parsable without ambiguity. In some transcription systems this is not achieved, with the consequence that it has to be stipulated that successive phonetic characters be always separated by a space character. Where the transcription is such that all strings are uniquely parsable, this is not necessary, and there is a consequent abrupt reduction in the number of keystrokes necessary to input a string.

For example, one transcription system for the English vowels represents *feast* as /fiist/, and *fist* as /fist/. If *prettiest* is then transcribed as /pritiist/, an ambiguity obviously arises: is the string /ii/ to be interpreted as one token of /ii/, or as two successive tokens of /i/?

A related question is that of syllable boundaries and word boundaries (of 'juncture' in general, as it is sometimes called). The English string /əneɪm/ may correspond either to orthographic *a name* or to *an aim*. These two possibilities differ both articulatorily and auditorily (though channel noise may obscure this). They are appropriately shown in phonemic transcription as /ə'neɪm/ and /ən'eɪm/ respectively, where the position of the word boundary (and syllable boundary) is shown both by the space and by the location of the stress mark, which is conventionally always placed at the beginning of the syllable to which it refers. A transcription of English connected speech is not correctly parsable unless such boundaries are explicitly symbolized, whether by spaces or in some other way. In some languages, however - French and Spanish, for example - this problem hardly arises: word boundaries and syllable boundaries are typically not realized in any phonetic sense.

2. Computer phonetic alphabet proposals

2.1 Introduction. The workshop identified a number of different machine-readable phonetic alphabet schemes in use or under consideration in EC countries and elsewhere. We consider them here in order of country of origin. A synoptic tabulation of the principal current proposals is shown in Table 2.

2.2 Denmark: COST 209. A Computer (enterable) Phonetic Alphabet (proposal) identified by the reference COST 209 has been put forward in a mimeo typescript dated May 1987 by Peter Molbæk Hansen of the Institute of Phonetics, University of Copenhagen. It includes 'narrow' (allophonic, comparative) and 'broad' (phonemic) IPA transcription symbols for Danish, Dutch, English, French, German, Italian, Norwegian, and Swedish, together with keywords for each language. (Symbols relating solely to the latter two languages have not been included in Table 2.)

TABLE 2. Synopsis of machine-readable phonetic transcription proposals. A '!' in the third column draws attention to agreement between the COST, Esprit 291, and Alvey schemes. Codings in the DIN and ISO columns are in hex. 'l*' denotes lower-case 'L', 'I' denotes upper-case 'i'.

	IPA		COST	Esprit 291	Alvey	VL	BDSON	DIN	ISO	Allen
1	ɑ	!	A	A	A	A	a>	42		a (aa)
2	æ		{ 123	^/	&			44	71	ae
3	ɐ		7	R/	6			41		
4	ɒ		C		Q			43		ao
5	ɔ	!	O	O	O	O	o>	66	a5A	O
6	ç		c	C	C			48		c-
7	ð	!	D	D	D			4A	73	D
8	ɛ	!	E	E	E	E	e>	4D	a37	E
9	ə	!	@ 64	@	@	@	&	4C	a38	6
10	ɜ		3	@/	3			4E		3
11	ɣ	!	G	G	G	G		54	a3C	g-
12	ɪ	!	I	I	I			5A	a3F	I
13	ʎ		l*,	L	F			60		l*j
14	ɲ		n ,	N~	J		nj	64	a56	nj
15	ŋ	!	N	N	N	N	ng	63	a57	N
16	ø		¦ 124	q	{ 123	&	E	67	79	oe
17	œ		\ 92	Q	9	@	E>	68		oE
18	ɶ		&							OE
19	θ	!	T	T	T			73		T
20	ʃ	!	S	S	S	S	S	71	a5F	S
21	ʊ	!	U	U	U			77	a73	U
22	ʌ		V	^	V			79		A
23	ʏ	!	Y	Y	Y			3C		Y
24	ɥ			H	H		Y	57		
25	ʒ	!	Z	Z	Z	Z	Z	3E	a77	Z
26	ʔ	!	?	?	?			3F	a79	?
27	ʁ, ʀ		R	R	K		R	6D,6E		R
28	ɛ̃		E~	E~	E+~		IN	4D22		E, n
29	aɪ		A>I	a/	aI	(Y)		405A		ai
30	tʃ		t^S	T/	tS			7271		tS
31	ː	!	:	:	:			2A		:
32	ˈ		(ˊ)	ˊ	"			31		"
33	ˌ		(ˋ)	"	%			32		ˊ

It was of particular value in the present discussion in that it was the only scheme presented to the workshop that dealt explicitly with Danish. The reader is referred to Table 2 for the summarized details, in the column headed 'COST'.

Like several other schemes, COST 209 codes IPA 'e, ɛ' as 'e, E' and IPA 'o, ɔ' as 'o, O'. In line with local Danish keyboards and terminals, it extends the same principle to code IPA 'ø, œ' as 124, 92, which are typed on a Danish keyboard as 'ø, Ø' (but in other countries as ' ¦, \ ' or in various other ways - see Table 1).

Again in line with Danish keyboards, 'æ' is assigned code 123, which elsewhere appears as ' { ' or as various other characters.

Certain sound-types represented by single symbols in the IPA are assigned two-symbol representations in COST 209: they are the palatal sonorants (lines 13 and 14 in Table 2), the labiodental nasal, IPA 'ɱ', represented as 'm1' (not considered elsewhere in the present report since it is not known to have phonemic status in any language), and the retroflex consonants found in Swedish, IPA 'ʈ' etc., represented as 't6' etc.

The initial and final elements of ordinary 'falling' diphthongs are concatenated with '>', IPA 'ɔɪ' being symbolized 'O>i', 'ɑɒ' as '&>C'. 'Rising' diphthongs, however, in which the second element is more prominent than the first, are concatenated with '<', thus 'u<O' for the rising [uɔ] of Italian *uomo.* Affricates are concatenated with '^', thus 't^s' for the [ts] of German *ziehen.*

2.3 France. Two schemes are in use. They are used in conjunction with the projects BDSON and BDLEX. They were presented to the workshop by Genevieve Caelen-Haumont of GRECO.

BDSON in turn comprises two different notation systems, one for 'broad labelling' and the other for 'frequential perspective'.

The BDSON 'broad labelling', used in the evaluation of automatic speech recognizers, prescribes two ways of representing vowels, depending on position in the word. The entries in Table 2 reflect the system for final syllables, where the maximal distinctions are made. In non-final syllables, where the distinctions shown in IPA as /e - ɛ, o - ɔ, ø - œ, a - ɑ/ are neutralized, the notations 'AI, O, EU, A' are applied. This means that *fée, fait, maison* are written 'fe, fe>, mAIzON' respectively.

The nasalized vowels, IPA 'ɛ̃', 'ɑ̃' (or 'ã'), 'ɔ̃', 'œ̃' are written 'IN', 'AN', 'ON', 'UN'. Consonants are as in Table 2.

The 'frequential perspective' system is purportedly phonemic. In many respects it is a respelling system rather than a proper phonetic notation. With one exception, its alphabetic characters are all upper-case. It represents the oral vowel system, IPA 'i e ɛ a ɑ ɔ o u y ø œ ə', as 'i) (a A O 0 U Y EU OE E', and the nasalized 'ɑ̃ ɔ̃ ɛ̃ œ̃' as 'AN ON IN UN'. It also includes certain additional symbols: 'I', defined as /i/ *diésé* (sharpened); 'AE' for IPA 'æ'; and 'A(' for IPA 'ʌ'. The relevance of these latter to the French phonemic system is not clear to the author of the present report.

Consonants in the 'frequential perspective' notation are as follows. The semivowels, IPA 'w ɥ j', are written 'W YE IE'. French is shown as having three phonemic liquids, /l/ 'L', /ʀ/ 'R', and /r/ 'RR': but this must be a mistake, since the French *r grasseyé,* [ʁ], and *r roulé,* [r], are certainly not in phonemic contrast. Most consonants are written with the upper-case letter corresponding to their IPA symbol, thus 'P T K B D G F S H V Z M N'. IPA 'ʃ ʒ ŋ ɲ' are written 'CH J NG NJ'.

Successive symbols have to be separated by spaces, to avoid obvious parsing problems which would otherwise arise.

The BDLEX scheme, BDL3, represents the oral vowels, IPA 'i e ɛ a ɑ ɔ o u y ø œ ə' as 'i é è a à o< o> u y eu oe e' respectively. A quite elaborate system of neutralization symbols is provided. For non-final syllables the *é moyen* (as in *maison*) is written 'e´', and the corresponding *o moyen* as 'o´'. An unspecified member of the set {a à} (BDL3 notation) may be written as 'A', one of {o> o´ o<} as 'o', one of {eu e oe} as 'E', and one of {é e´ è} as '&'. The nasalized vowels, IPA 'ɛ̃ œ̃ ɑ̃ ɔ̃', are written 'i^ y^ a^ o^' (the French keyboard having no '~', since ASCII code 126 is assigned to '¨'). An unspecified member of the set {i^ y^} may be written 'e^'.

The BDL3 consonants are straightforward. The symbols 'j w l r n m p t k b d g f s v z' are identical with IPA. IPA 'ɥ ŋ ɲ ʃ ʒ' become '! ng g^ $ J'. Spaces are not needed between successive symbols, although words are spaced.

2.4 German Federal Republic: Esprit 291. The Computer Phonetic Alphabet devised for the Esprit project 'Linguistic analysis of the European languages' was presented to the London workshop by Marianne Kugler-Kruse of the Department of General Electrical Engineering and Acoustics at the Ruhr University, Bochum. It has been in use for two years or so and is designed to deal with Dutch, English, French, German, Greek, Italian, and Spanish. It is claimed to be 'becoming a standard outside the project as well', and is used for grapheme-to-phoneme and phoneme-to-grapheme work.

Its chief characteristics can be seen from Table 2. Where possible, it follows the IPA, but uses special conventions for diphthongs and affricates. It is illustrated with keywords from the seven languages mentioned, from which it can be seen that some of its symbols are intended allophonically rather than phonemically (these terms are not used in the source document). For example, IPA 'e' and 'ɛ' are both provided for in Spanish, as in the keywords *el, llover,* although these are clearly allophones of the single Spanish phoneme /e/.

The characters '/' and '~' are termed 'modifiers' and are used as follows. The modifier '/' is used for diphthongs and affricates, and also in one or two other cases where not enough single characters were available. For diphthongs, a small letter plus '/' denotes a diphthong ending with 'ɪ', a capital letter plus '/' a diphthong ending with 'ʊ' or 'ə'. For further discussion, see 3.5 below. The modifier '~' is used for nasalized vowels, and also in the coding 'N~' for the palatal nasal.

Symbols are provided for two types of pause, long ('_/'), and short ('_').

Special symbols are provided for the Greek prenasalized [m̆b] and [ŋ̆g], although it appears that these are not distinct in Greek from [mb] and [ŋg] respectively; the exactly comparable [n̆d] (*ndropi*) is not provided for.

The vowels of English pairs such as *beat, bit; boot, foot* are suitably coded as 'i, I, u, U', yet no provision is made for the vowel contrast of *naught, not,* the symbol 'O' being associated with *not.* There is a length mark available through which this problem might be resolved, though it would then be inconsistent not to symbolize the very considerable qualitative difference involved. The diphthong of English *boat* is assigned the IPA notation 'ɔʊ', although native English-speaking phoneticians do not use this clearly unsuitable transcription.

There are various other phonetic inaccuracies - of fact, terminology, and symbolization - in the document presented to the workshop. It is regrettable that apparently no person trained in classical linguistic phonetics was involved in drawing up the scheme.

2.5 German Federal Republic: DIN 31 641, 31 642. A scheme now under consideration by DIN, the German standards institution, was presented by Rüdiger Pfeiffer-Rupp.

It has a background not in speech technology but in typography, bibliography and linguistic phonetics. The basic coding scheme covers 94 IPA symbols (including sixteen diacritical signs). They are assigned to ASCII codes 33-126 in an alphabetical order determined by the shapes of the characters (rather than by the sounds they symbolize). For example, the range 96-111 (hex 61-6F) covers 'ʎ m n ŋ ɲ o ɔ ø œ p q r ɹ ʀ ʁ ɾ'. (The corresponding ASCII range is the grave accent and then lower-case 'a' to 'o' - see Table 1.) They are presented in a variety of typestyles, selected by specified control characters: superscript, italic, semibold, small-cap, and with various other modifications and extensions to the basic character set, including characters incorporating the palatalization, retroflexion, velarization and nasalization diacritics.

This is thus a system designed for sophisticated computerized typesetting requiring an exhaustive set of phonetic symbols, rather than a system for immediate keyboard input in speech research applications.

2.6 Netherlands: Veenhof and Lammens. This scheme for Dutch was presented to the workshop as a mimeoed article entitled 'Computerleesbare fonetische transcriptiesystemen: het wiel heruitgevonden' ('Computer-readable phonetic transcription systems: reinventing the wheel') by Ton Veenhof and Jo Lammens.

The authors criticize the illogicality of various schemes for Dutch previously proposed, in particular a scheme known as CELEX ('the square wheel'). They complain, for example, of parsing ambiguities and of the absence of any simple algorithm for locating the nth phoneme in a given string.

They then offer a list of the qualities an ideal system should in their view have: it should be uniquely parsable, internally consistent, and readily legible by human users; it should allow for phonological and/or phonetic form, lexical stress, and syllable and morpheme boundaries. It should be capable of extension and be universally usable ('at least for the Netherlands').

The scheme they then go on to outline has a number of original and ingenious qualities. The actual codings can be inferred from Table 2, which includes nearly all the phoneme symbols which are not straightforward IPA symbols from the standard ASCII set. The three phonemic diphthongs of Dutch are transcribed by single characters, 'Y J W' for IPA 'ɛɪ œʏ ɔʊ'. Marginal phonemes of Dutch require two characters: they include the long [ɛ: ɔ: œ:] of French loanwords, written 'E: @: O:'.

Each phoneme character must be followed by a space, to make possible a straightforward segment count algorithm. This space may, however, be replaced by explicit symbols for syntactic, allophonic, or other purposes. Thus odd-numbered characters contain the phonemic information, even-numbered ones other information. Stress is shown by a four-digit numerical word prefix specifying the segment on which primary stress and secondary stress (if any) fall. Syllable boundary and morpheme boundary information is shown by a similar numerical suffix.

The wheelwrights sign off with the blithe claim that 'the same system can without any problems be adapted to other languages, except that partly different phoneme symbols would probably then have to be selected' [my translation — JCW].

TABLE 3. Symbols for English vowel phonemes in some computer-coded phonetic alphabet schemes. The transcription system labelled 'IPA' is that used in Jones/Gimson *English Pronouncing Dictionary*, 14th edition (1977).

IPA	keyword	JSRU	MRPA	Alvey	Klatt
iː	*beat*	EE	ii	i:	IY
ɪ	*bit*	I	i	I	IH
e	*bet*	E	e	e	EH
æ	*bat*	AA	a	&	AE
ɑː	*cart*	AR	aa	A:	AXR
ɒ	*cot*	O	o	Q	AA
ɔː	*caught*	AW	oo	O:	AO
ʊ	*put*	OO	u	U	UH
uː	*boot*	UU	uu	u:	UW
ʌ	*cut*	U	uh	V	AH
ɜː	*curt*	ER	@r	3:	ER
ə	*away*	A	@	@	AX
eɪ	*bait*	AI	ei	eI	EY
əʊ	*boat*	OA	ou	@U	OW
aɪ	*bite*	IE	ai	aI	AY
aʊ	*bout*	OU	au	aU	AW
ɔɪ	*voice*	OI	oi	OI	OY
ɪə	*beer*	IA	ir	I@	IXR
eə	*bare*	EI	er	e@	EXR
(ɔə	*bore*	OR			OXR)
ʊə	*poor*	UR	ur	U@	UXR

2.7 United Kingdom: pre-Alvey schemes. The author of the present report outlined a number of other schemes in use in the United Kingdom or elsewhere.

The Joint Speech Research Unit uses a respelling scheme in the text-to-speech system devised by John Holmes. The symbols are case-independent (i.e. may be written as capitals or small letters without change of meaning). They are set out in Table 3. The scheme also includes symbols for brief silence ('Q') and pause ('QQ'). One item described as an allophone is included in Edward (1982), on which this summary is based, although it really constitutes an archiphoneme in a position of neutralization: namely 'EY' for the final vowel of *happy*. Primary stress is symbolized by '"' (inverted commas), secondary stress by '''. To facilitate intonation, special symbols are used to mark the start of (a) content words and (b) function words. The punctuation marks ', . ?' symbolize tones.

John Laver of Edinburgh was the first to raise the issue of a proper machine-readable phonetic alphabet. His MRPA, too, is summarily presented in Table 3. Its symbols are case-independent, capitals being used for special (allophonic) purposes. It implies a transcription system reminiscent of Daniel Jones's 'Simplified' notation, which was designed to require a minimal number of non-Roman letters; 'h' and 'r' are used essentially as diacritics.

2.8 United Kingdom: Alvey. The 'Alvey' scheme was formulated by Bladon and Wells in 1985 after workshop discussions in the course of a conference in Edinburgh attended by most of the leading British phoneticians involved in speech research. It comprises a recommendation for the transcription of English (the adoption of the system used in the 14th edition of *English Pronouncing Dictionary*), together with recommendations for coding not only these symbols but also the most widely used general-phonetic symbols from the IPA chart.

The scheme was presented by Wells at the Speech I/O Conference organized by the Institute of Electrical Engineers, London, in 1986 (see Wells, 1986).

Selected coding recommendations are contained in Table 2. There are also codings for all the intonation marks of the O'Connor and Arnold (1973) system for English. Provision is made for composite symbols such as IPA 'd̥' (devoiced [d]), coded as 'd+0' (see 3.8 below), for 'compressed' symbols (ligatures), and for extending the system at will by means of a 'combiner' character to allow for finer subclassification. In practice the convention for composites has been disliked and hardly used.

The system fails to meet the requirements of the EC languages only in respect of the IPA symbol 'ɶ', if this is in fact needed for Danish. On the positive side, it is the only scheme presented to the London workshop to provide for the Welsh voiceless lateral, IPA 'ɬ'. The character 'ʉ' for Dutch has to be coded as a composite 'u+-'. The coding of r-sounds has been criticized.

The author of the present report has keyboarded tens of thousands of pronouncing dictionary entries using this system. He can declare it generally easy to use and memorize. For his dictionary work he has felt it appropriate to extend it by a number of further symbols and conventions.

The system has been implemented on the Masscomp installation at University College London, which is programmed to display on-screen IPA characters.

2.9 Other schemes: ISO, IBM, Klatt, Allen. Two *International Standards* are worthy of mention. They are ISO 5426-1983, Extension of the Latin alphabet coded character set for bibliographic information interchange (= British Standard BS 6474: Part 1: 1984, Coded character sets for bibliographic information exchange, Part 1. Specification for extension of the Latin alphabet coded character set), and ISO 6483-1983, Documentation - African coded character set for bibliographic information interchange (= British Standard BS 6474: Part 3: 1984, Coded character sets for bibliographic information interchange, Part 3. Specification for African coded character set).

As the titles imply, these are ASCII-type codings for special characters (including diacritics) used in the Latin-alphabet orthography of European and African languages respectively. They include codings for 'æ' and 'ø' (Danish), 'ð' (Icelandic), and various other characters which are also used as phonetic symbols (see Table 2, where a prefixed 'a' in the ISO column refers to the African-language standard). But they seem to bear no relation to each other or to the standard ASCII character set, and were felt at the London workshop to be irrelevant to our purpose.

The *IBM*-UK Science Research Centre at Winchester uses a system in which phonetic symbols for English, including intonation marks, are coded in the range 128-254 (mainly 128-175). For example, 'ŋ' has the coding 8C hex (= 140 decimal), which in standard ASCII means 'form feed' and in IBM's own 'World Trade' character set is assigned to circumflexed 'i'.

The impressive 'MITalk' text-to-speech system uses a scheme known as the '*Klatt* symbols'. These show a resemblance to the JSRU scheme, which is used for the same kind of work; but Klatt is oriented exclusively towards American English. As in the JSRU system, there are symbols to mark the beginning of a content word or a form word, and a symbol for 'potential breath pause'. The symbols do not denote 'phonemes', but 'phonetic segments'; special provision is made for the American voiced tap in *butter* ('DX') and for a 'pseudo-vowel' defined as plosive release ('AXP').

George *Allen* of Purdue University, Indiana, has just announced 'PHONASCII: an ASCII-based system for detailed phonetic transcription'. It comprises 'an IPA-to-ASCII system [...] developed to permit the archiving of highly detailed transcriptions', notably for child language acquisition data. It provides for everything on the IPA chart, often through two-character symbols. For example 'lr' = retroflex lateral, IPA 'ɭ'; 'td' = dental plosive, IPA 't̪'. Various symbols for secondary articulations, boundaries, syllable weight, and intonation are also included. Allen rejects the '@' coding for 'ə' which has found such wide acceptance in Europe, preferring '6': 'I prefer to stay away from '@' as the symbol for schwa, not only because it requires two key presses but also because it makes such a nice 'pointer' for aligning phonetics and orthography'.

3. Towards a recommended standard

3.1 A basis for agreement. As is immediately evident from Table 2, the three schemes COST 209, Esprit 291, and Alvey have a great deal in common. The Veenhof and Lammens scheme, too, coincides at several points, while the tentative Allen scheme is in any case based on Alvey. It is evident, therefore, that a future standard European phonetic transcription scheme must have COST 209, Esprit 291, and Alvey as its starting-point.

This implies adopting the principle formulated in Esprit 291 as follows: ASCII characters in the IPA alphabet [remain] the same; non-ASCII characters [are as far as possible] assigned the capital ASCII character they resemble most.

Given this, inspection of Table 2 reveals that we have immediate agreement on the following characters:

IPA	ɑ	ɔ	ð	ɛ	ə	ɣ	ɪ	ŋ	θ	ʃ	ʊ	ʏ	ʒ	ʔ	:
coded as ASCII	A	O	D	E	@	G	I	N	T	S	U	Y	Z	?	:

('@' here implies the character with code 64, which may vary in different countries - see 1.2 above.)

They are set out, along with the other recommendations, in Table 3, where they are furnished with phonetic labels appropriate to the sounds they symbolize. They form the basis of what we may call SAM-PA - the Speech Assessment Methods Phonetic Alphabet.

3.2 Further readily agreed codings. There are five further IPA symbols where agreement on coding can easily be reached.

For 'ç', two of the three schemes select the obvious equivalent 'C'. COST 209, though, uses plain 'c' (no doubt because 'c' is not required as a phonemic symbol in the languages we are dealing with). But since 'c' is after all an IPA symbol, with a meaning different from 'ç' (voiceless palatal plosive, as against voiceless palatal fricative), it seems right to select the coding 'C'.

The vowel symbol 'ɜ' is used only in transcribing RP English, where in the transcription now most customary it denotes the long mid central vowel of *bird.* The ASCII character with the greatest visual resemblance is '3'. The Esprit 291 coding '@/' is not consistent with the logic of that scheme (since [ɜ] is not a diphthong). Hence the coding '3' is to be preferred.

Another vowel sound needed only for English (among the languages considered here) is 'ʌ'. In spite of its Cardinal Vowel definition as a back half-open unrounded vowel, this symbol is well established as the representation of the vowel of English *love, cup,* which is nowadays not back but central. The ASCII upper-case 'V' was chosen as its code equivalent by COST and Alvey on the grounds of visual similarity (albeit with inversion). Esprit 291's '^' has greater visual similarity, but suffers from the disadvantage of being generally regarded either as a diacritic (circumflex) or as an up-arrow - both of which are logically inappropriate. Some other schemes propose 'A', which is suitable from the point of view of visual similarity and indeed phonetic relatedness; but we have already agreed on 'A' as the representation of IPA 'ɑ'. For IPA 'ʌ' we therefore select the coding 'V'.

IPA 'ɥ' is needed for the semivowel of French *huit.* Esprit 291 and Alvey agree in coding it as 'H'; COST 209 omits it. We select the coding 'H', with its visual similarity.

The standard French r-sound is a uvular fricative or roll. The IPA furnishes distinct symbols for these two possibilities, [ʁ] and [ʀ], although there appear to be no languages where the difference between them is phonemic. Furthermore, although the French sound is usually a fricative, hence properly IPA [ʁ], the custom is now well established of transcribing it with the symbol 'ʀ' (or the typographically easier, but not strictly IPA, 'R'). This is no doubt an oddity of transcription, but there is no strong reason for us to reject it: we may continue to transcribe the French phoneme as IPA 'ʀ', for which COST 209 and Esprit 291 give the obvious coding 'R', while Alvey makes no provision (but codes IPA 'ʁ' as 'K'). We adopt the coding 'R'.

Danish and most types of German also have a uvular r-sound, though in these languages it is usually an approximant rather than a fricative. (The IPA cannot distinguish between uvular approximant and uvular fricative except with the help of diacritics. No language has a phonemic distinction between them.) In phonemic notation there seems to be no case for insisting on the use of IPA 'ʁ' rather than the simpler 'ʀ', and we may use the coding 'R' for ALL types of uvular r-sound.

It remains true that in a simple transcription system, as opposed to a comparative one, we would write plain /r/ for all three languages: French, Danish, and German.

There are of course no grounds for using IPA 'ʀ' or 'ʁ' in the phonemic transcription of English, Greek, Italian, or Spanish: in these languages /r/ is an alveolar or post-alveolar, and should be transcribed /r/. Dutch is more problematic, since both alveolar and uvular realizations are widely used. Simplicity demands that we normally transcribe the Dutch phoneme as /r/.

Thus we have:

IPA	ç	ɜ	ʌ	ɥ	ʀ or ʁ
coded as ASCII	C	3	V	H	R

3.3 Other straightforward coding recommendations. For a number of other IPA symbols the three schemes, COST 209, Esprit 291, and Alvey, disagree on their coding recommendations.

The characters 'æ' and 'ø' are included on Danish keyboards and appear in the Danish character set with the ASCII codes 123 and 124 respectively. These are represented on other keyboards as '{' and '¦', or in various other ways. It is clearly right to take account of the convenience of Danish keyboard operators and hence to assign codes 123 and 124 to IPA 'æ, ø'. This is supported, furthermore, by the German character set, where they appear as 'ä', 'ö', and by the Italian one, where they appear as 'à', 'ò' - in each case helpfully mnemonic.

In the coding we have already established for 'ɛ' and 'ɔ' we see a general principle of writing a half-close vowel with the ordinary lower-case Roman-alphabet symbol ('e', 'o') and the corresponding half-open vowel with the corresponding upper-case letter ('E', 'O'). The half-open vowel corresponding to half-close 'æ' is 'œ'. Extending the same principle to the pair 'ø, Ø' in the Danish character set, we arrive at the logical coding 92 (otherwise '\') for IPA 'œ'.

IPA 'ɐ' does not appear in Esprit 291, although it is the symbol used by the standard German pronouncing dictionary (Mangold, 1974) in the transcription of a word such as *Ufer* /ˈuːfɐ/. It is also appropriate in the transcription of a Danish word such as *bider* /ˈbiːðɐ/, though an alternative notation would be /ˈbiðɒ/. The coding of 'ɐ' is arbitrary: we recommend the Alvey '6', which has some visual resemblance.

IPA 'ɒ' is ignored by Esprit 291, although it is the usual symbol for the vowel of English *lot* and is also needed in Danish. We have already pre-empted the COST 209 suggestion 'C', and accordingly now recommend the Alvey coding 'Q', which also has the advantage of some visual similarity.

As long as we transcribe phonemically, Danish does not appear to require the symbol [ɑ]. Neither Esprit 291 nor Alvey makes provision for this vowel. We likewise ignore it.

The Dutch vowel in *puf* is problematic, with various symbols in use by phoneticians. We tentatively propose the notation 'ʉ' (barred 'u'), a symbol which will also be needed for Swedish, Norwegian and various other languages. The most appropriate coding seems to be 125, '}' in the International Reference Version of the ASCII character set, which is a conveniently mnemonic 'ü' on the German keyboard.

Italian requires symbols for two palatals, IPA 'ʎ' and 'ɲ'. The latter, the palatal nasal, is sometimes symbolized instead as 'ñ', which is its orthographic representation in Spanish; but this is not recognized IPA usage, and goes against the Association-approved use of the diacritic '~' to denote nasalization (a usage which we adopt for nasalized vowels, below). It is no doubt the origin of the Esprit 291 coding 'N~'. It would be possible to adopt two-character representations for the two palatal sonorants, 'lj', 'nj'; but this is unsatisfactory in Italian, where the corresponding sequences also occur. We suggest the codings 'L' for IPA 'ʎ' (as in Esprit 291) and 'J' for IPA 'ɲ' (as in Alvey).

The IPA stress marks are ' ˈ ' (primary stress) and 'ˌ' (secondary stress), as exemplified in the English word *seventeen* /ˌsevnˈtiːn/ (primary and secondary often being interchanged in connected speech, thus *seventeen things* /ˈsevnˌtiːn ˈθɪŋz/). These marks are conventionally placed at the beginning of the syllable to which they refer. As a coding for ' ˈ ', COST and Esprit 291 suggest '´' (acute accent/ apostrophe), a symbol used to denote primary stress in certain non-IPA systems of notation. It seems preferable, however, to retain this mark in its IPA meaning 'rising tone', in line with the general principle that IPA symbols already present in the ASCII character set are retained unaltered. Hence '´' cannot be used as the coding for ' ˈ '; we propose instead the Alvey recommendation ' " ' (inverted commas, ASCII 34). For secondary stress, IPA 'ˌ', similar arguments apply. In IPA '`' (grave accent) denotes 'falling tone', and should be retained in that meaning. We suggest the Alvey recommendation, '%' (percentage sign), as the coding of the secondary stress mark: it has some mnemonic appropriateness, since secondary stress can be seen as a 'percentage' of primary stress.

If the recommendations in this section are adopted, we have:

IPA	æ	ø	œ	ɐ	ɒ	ʉ	ʎ	ɲ	ˈ	ˌ	´	`
coded as ASCII	{	:	\	6	Q	}	L	J	"	%	´	`

3.4 Nasalized vowels. A serious issue of principle which came to light at the London workshop concerned cases where a single phonetic/phonemic entity may be symbolized by a string of two or more characters. The issue arises most importantly in the case of diphthongs and affricates (see 3.5 below). We consider first, though, the question of nasalized vowels, whose transcription and coding presents somewhat similar problems.

In French, the vowels of *un bon vin blanc* are nasalized, that is to say they are articulated with a lowered soft palate, which allows the air to escape through the nose (as well as simultaneously through the mouth). These are thus from the articulatory point of view single segments, and are transcribed accordingly in IPA notation: [œ̃ bɔ̃ vɛ̃ blɑ̃]. (In the view of some phonologists the sounds in question are to be considered as representing an underlying phonemic sequence of vowel plus nasal; but we are not concerned here with that view.) These symbols consist of a basic vowel symbol with an accompanying nasalization diacritic written on top. Two general methods have been proposed for the coding of complex symbols such as these. In one (exemplified by COST 209 and Esprit 291), they are coded straightforwardly as two-symbol sequences, vowel symbol followed by nasalization symbol (already provided for at ASCII 126, '~', though in some national character sets this position is occupied by a local variant). Thus IPA 'ɛ̃' is coded 'E~'. In the other, represented in this case by Alvey, explicit provision is made for the fact that the two characters are to be superimposed in ordinary hand-written or printed notation, and denote simultaneous phonetic events. This is achieved by a special 'overstrike' symbol, for which Alvey defined the '+' character. Thus IPA 'ɛ̃' is shown in Alvey as 'E+~'.

This Alvey recommendation has not been well received. The symbol '+' would be useful for other purposes, and the ASCII non-printing character BS (Backspace, ASCII 8) already has the function defined.

It thus seems preferable to adopt the first solution, writing IPA 'ɛ̃' as 'E~', or alternatively '~E' (and similarly for other nasalized vowels). We have to recognize a convention whereby any sequence of two symbols in which the second is '~' is interpreted as a unit. We refer to this as the UNITARY INTERPRETATION OF A CHARACTER SEQUENCE. It is applicable not only to nasalized vowels, but to any sequence ending in a character denoting a diacritic. As discussed in the next section, it seems also to offer the best solution to the problem of diphthongs and affricates.

3.5 Diphthongs. A diphthong is a sequence of two vowel-like segments that form part of the same syllable. In some languages, e.g. Spanish, it is appropriate to analyse some or all phonetic diphthongs as the realization of phonemic sequences of vowels. In some other languages, however, e.g. English, such an analysis is not satisfactory, since the diphthongs behave as units, having the same phonotactic (combinatory) properties as long monophthongs, being subject to the same rules (e.g. duration rules) as long monophthongs, and having component qualities which are not identifiable with those of simple vowels (the first part of English *I* [aɪ] is phonetically different from all the relevant English monophthongs, [ʌ, æ, ɑː]). In speech synthesis, too, current practice treats diphthongs as single units rather than concatenating them out of smaller units. It is no doubt with this in mind that Veenhof and Lammens propose to transcribe the Dutch diphthongs with single-character symbols. And this is why the Esprit 291 scheme uses a special modifier, '/', to create diphthong symbols.

In phonetic transcription, the IPA provides for diphthongs normally to be written as sequences, e.g. [eɪ]. The diacritic [˘] is available to show that the less prominent part of the diphthong has a non-syllabic function, thus [eɪ̆] for the falling (diminuendo) diphthong of English *say*; but it is only rarely used, since the sequence notation is usually unambiguous and unproblematic. Scholars differ in their views on how to phonemicize the diphthongs of particular languages, and these differences are reflected in transcriptional practice. Some analysts of English, particularly in the United States, adhere to a 'binary' analysis of diphthongs, identifying their second half with the semivowels and hence phonemicizing *say* [seɪ] as /sej/ (compare *yes* /jes/). The usual European view is that English /eɪ/ is a unit phoneme.

A word such as English *yes* begins phonetically with a rising diphthong (i.e. one with crescendo prominence); it can be shown as [ɪ̆es]. But in this instance all analysts agree that the phonetic diphthong is to be phonemicized as semivowel plus vowel, and in IPA notation to be phonemically transcribed /jes/.

Analysing phonetic rising diphthongs as semivowel plus vowel offers a satisfactory resolution of ambiguities which might otherwise arise in Italian (and many other languages). Thus *piano* 'gentle', with two syllables, is best analysed /ˈpjano/, while *Piano* 'relating to Pius', with three syllables, is /piˈano/.

The usual IPA notation of diphthongs as a sequence of two vowel symbols without diacritics is ambiguous only if one or both of the following is true of the language in question:

(i) *there is a diphthong that contrasts phonemically with the* corresponding sequence of simple vowels;

(ii) there is a falling diphthong that contrasts phonemically with the corresponding rising diphthong.

Either of these possibilities gives rise to an obvious ambiguity of parsing.

Such ambiguities do very occasionally arise in the languages we are dealing with here. German has a type (i) possibility in the word *intrauterin,* where orthographic *a* and *u* correspond to short vowels, each of which is independently syllabic, giving a phonetic sequence distinct from the diphthong in *Haus.* We note, though, that the standard German pronouncing dictionary (Mangold, 1974) represents this word as 'ɪntra¦uteˈriːn'. Here the symbol '¦' is defined as standing for the glottal stop, IPA [ʔ] (Stimmritzenverschlußlaut, 'Knacklaut'), which regularly functions in German to mark the beginning of a new syllable. Thus the parsing ambiguity can be readily resolved by the inclusion in the transcription of an explicit symbol to show syllable boundaries and/or the glottal stops which mark them.

English has a type (ii) possibility, in one analysis, in a case such as *windier* v. *reindeer.* The first, the comparative of the adjective *windy,* ends in a phonetically rising diphthong, [ɪə], while the second ends in an ordinary falling [ɪə̆]. It may be noted, though, that the contrast, though real enough to the speaker, has been demonstrated to be perceived by the hearer with only slightly better than random success; and that most scholars reject the 'rising diphthong' as a PHONEMIC account of the latter part of *windier,* preferring rather to recognize a sequence of vowels (which merely makes this a type (i) problem rather than a type (ii)). Furthermore, if we analyse *windier* as having three syllables, the vowel of the second syllable represents a neutralization of the opposition /iː/ - /ɪ/. Several recent writers on English phonetics have adopted the special archiphoneme symbol 'i' for these environments of neutralization, and this has the welcome side-effect of resolving the possible ambiguity we are here concerned with. We may agree to transcribe /ˈwɪndiə/, /ˈreɪndɪə/, and code accordingly.

The schemes considered at the London workshop offer a number of different ways of symbolizing diphthongs. COST 209 uses concatenators, '>' and '<' for falling and rising diphthongs respectively. Esprit 291 uses a modifier '/', with the convention that a lower-case letter plus '/' denotes a diphthong ending in [ɪ] (in practice, also with [ʏ]), while an upper-case letter plus '/' denotes a diphthong ending in [ʊ] or [ə]. The author of the present report would argue that both of these are essentially proposals for transcription rather than for coding.

The COST 209 suggestion is open to two objections:

(a) Rising diphthongs do not occur with separate phonemic status in the languages of Western Europe, and perhaps never need to be indicated in phonemic notation for any language in the world; the convention is therefore unnecessarily complex.

(b) *It necessitates the use of three keystrokes for every* diphthong, although a perfectly satisfactory symbolization is available using just two. In languages in which diphthongs are frequent in running text (e.g. English), this is a serious consideration.

The Esprit 291 treatment is open to the objection that it cannot deal with any language in which there are contrasting diphthongs differing from each other only by first elements which are otherwise distinguished in coding as lower-case vs. upper-case. According to the analysis offered in the COST 209 document, Danish is such a language, with [eʊ] distinct from [ɛʊ]: under the Esprit 291 rules both have to be coded 'E/'.

In English words such as *fire* the disyllabic sequence diphthong plus monophthong, /aɪ/ plus /ə/, is subject to optional synaeresis into a single syllable, giving a triphthong [aɪə], which may in turn be subject to 'smoothing' into a diphthong [aə] (and thence possibly into a monophthong [aː]). Some scholars recognize a triphthong /aɪə/, or a smoothed diphthong /aə/, as independent phonemes.

It is not clear how entities such as these could be represented under the Esprit 291 scheme: triphthongs are not catered for, and 'A/' is preempted for /aʊ/, which renders it unavailable for a possible /'aə/. As we bring further languages into consideration, problems of this kind will make the Esprit 291 scheme, as it stands, increasingly unworkable. To rescue it, it would be necessary to define distinct modifiers for each possible direction of diphthongal movement, and to abandon the convention about upper-case and lower-case notation in the first element of a diphthong.

The Alvey scheme considered but rejected the provision of a concatenator character for diphthongs (and affricates). It was rejected on the grounds that 'it would demand an extra character for each such [diphthong] ... ', and that the unitary interpretation would 'apply (at least in phonemic transcription) to almost all instances of the character dyads [...], and account can readily be taken of this fact by software.' Instead, the Alvey scheme defined a DISJUNCTOR character (the hyphen, '-') 'to be used only in those rare instances where one of the character dyads in question is NOT to be interpreted as a single unit'.

Conflicting views were put forward at the workshop. There were some who wished to preserve the Esprit 291 characteristic of giving a notation to diphthongs which is clearly distinct from that of vowel sequences. Others wished to preserve the usual IPA convention of writing diphthongs by simple juxtaposition of vowels, claiming that this has not proved ambiguous in practice.

We choose the Alvey approach, and recommend that diphthongs be written as simple two-character sequences, e.g. IPA 'aɪ' coded as 'aI', IPA 'ʊə' coded as 'U@'. For a disjunctor character, see 3.8 below.

3.6 Affricates. An affricate is a close-knit sequence of plosive and homorganic fricative, i.e. a plosive with a slow release during which homorganic friction is heard. Examples are the palato-alveolar [tʃ] and [dʒ] of English *chip, jump,* and the alveolar [ts] and [dz] of German *zehn* and Italian *zelo.* As in these examples, their simplest IPA representation is as a sequence of two characters, reflecting the stop and fricative phases respectively. The IPA chart also offers the option of writing them with a slur mark to make their affricate status wholly explicit: [t͡ʃ], [d͡ʒ] etc. There is also the possibility of writing them with a single symbol, [c] etc., though the number of symbols then may require considerable augmentation of what is provided in the IPA alphabet. Many linguists use non-IPA notations such as [č, ǰ] for [tʃ, dʒ].

Ambiguity arises with two-character transcription of affricates only where the possibility exists of the corresponding sequence of plosive plus fricative. A well-known case in point is Polish, where *czy* [tʃɨ] 'whether' contrasts with *trzy* [t-ʃɨ] 'three'. In the languages of Western Europe the problem is very restricted. For example, IPA 'dʒ' can never be ambiguous in standard Italian, because the fricative [ʒ] never occurs independently in that language. In English and German the possibility does arise of the sequence [t] plus [ʃ] as distinct from the affricate [tʃ]. But the affricate is always within a single syllable, whereas the sequence always straddles a syllable boundary (and a morpheme boundary, and usually a word boundary): thus English *why choose* /waɪ tʃu:z / vs. *white shoes* /waɪt ʃu:z /; German *Klatsch eint* /klatʃ aint/ vs. *Klatt scheint* /klat ʃaint/.

In the transcription and coding of affricates, much the same arguments apply as with diphthongs. COST 209 writes them with a concatenator '^', so that IPA 'tʃ' appears as 't^S'. Esprit 291 uses the '/' modifier, so that IPA 'tʃ' appears as 'T/'. (It is not clear to the writer of this report why it should be 'T/' rather than 't/' - after all, 'T' otherwise represents IPA 'θ'. For the alveolar affricate, IPA 'ts', Esprit 291 prescribes the arbitrary 'C/'.) COST 209 requires an extra keystroke for every affricate, with little compensating advantage; Esprit 291 is unmnemonic and involves arbitrary decisions to avoid confusion (as in the examples quoted above).

The Alvey document concludes that the best notation for affricates is simple juxtaposition of characters, e.g. 'tS' for IPA 'tʃ'. It provides the disjunctor '-' for occasional cases of non-affricate sequences of of /t/ plus /ʃ/, etc.

For affricates, as for diphthongs, we choose the Alvey approach and recommend that they be written as simple two-character sequences, thus 'tS' for IPA 'tʃ' etc. See below for a possible disjunctor character.

There are some phonetic affricates where analysis as a consonant cluster (sequence) is taken for granted. Examples are the English consonants in *try* and *dry,* which are phonetically voiceless and voiced post-alveolar affricates. It is obvious that phonemically they are to be identified as the clusters /tr, dr/. (In speech synthesis, however, concatenating a /t/ ot /d/ with a token of /r/ as in *rye* does not give satisfactory results.)

3.7 Syllabic consonants. In some languages consonants may be syllabic, and contrast with their non-syllabic counterparts. This applies in English and German, where examples of syllabic [n] are to be heard in English *suddenly* ['sʌdnli], German *hatten* ['hatn], and of syllabic [l] in English *bottle* ['bɒtl], German *nadeln* ['na:dln].

The IPA provides the diacritic ' ̩' to show syllabicity in a consonant, thus ['sʌdn̩li, 'na:dl̩n]. In practice, transcribers often leave syllabicity unmarked, so that it has to be inferred from the context.

Syllabic consonants were not discussed at the London workshop, though decisions do have to be made about how to transcribe and code them. They do have potential contrastive function: *gluttony* can be pronounced ['glʌt ən i] or ['glʌt n̩ i], and possibly in very fast speech ['glʌt ni]; but *chutney* can only be ['tʃʌt ni]. The same difference, albeit potentially neutralizable, distinguishes *lightening* 'making lighter' from *lightning* 'atmospheric phenomenon'.

The usual view among phonologists is that English and German syllabic consonants are realizations of an underlying phonemic sequence /ə/ plus a non-syllabic consonant, thus /ˈsʌdənli /, /ˈhatən/. This view is supported by the fact that in some styles of speech the phonetic sequence [ən] actually occurs, and also by the fact that some syllabic consonants clearly derive from such underlying sequences across word boundaries (English *get along* being sometimes pronounced as [get l̩ɒŋ], where [l̩] denotes a syllabic [l] of greater duration than its non-syllabic counterpart in *get lost*). The realization rules for styles in which the syllabic consonants are used would then include a rule that reduces two segments to one in appropriate contexts.

An alternative phonemicization would hold that some syllabic consonants, at least, are straightforwardly derived from non-syllabic consonants in phonetic environments where a non-syllabic consonant is barred by the phonotactics. In the citation form of words both in English and German, syllabic consonants occur only in the environment where the preceding segment is a consonant and the following one is either a consonant or a word boundary (in English, also a morpheme or syllable boundary, this being exemplified word-internally in the three-syllable pronunciation of *threatening* [ˈθret n ɪŋ]).

Provided the boundary is explicitly symbolized in these relatively rare cases, it is unambiguous to write syllabic consonants with the simple consonant symbol. This solution is probably the easiest one for speech technology purposes.

3.8 Disjunction. As we have seen in 3.5 and 3.6, rare cases arise where it is desirable to show explicitly that a sequence of vowel characters does not denote a diphthong (in a language that has phonemic diphthongs), or that a sequence of characters symbolizing a plosive plus a fricative does not denote an affricate (in a language that has phonemic affricates).

As a character to symbolize this disjunction, a space will normally suffice. If the disjunction occurs across a word boundary, then writing spaces between successive words resolves the problem. If not, explicit symbolization of syllable divisions may do so. This, too, could be achieved by using the 'space' character (ASCII 32). Alternatively, some scholars have used the hyphen '-' (ASCII 45) or the dollar sign '$' (ASCII 36) for this purpose (Jones 1955).

But the problem is wider than diphthongs and affricates. It seems to reflect a general typological difference in the phonetics of different languages.

Some languages regularly impose a syllabification on phonetic strings such that word boundaries become inaudible. Examples of such languages are French and Spanish, where phrases are usually resyllabified in such a way as to maximize the incidence of the preferred CV syllable structure, e.g. *les Etats Unis* /lez etaz yni / → /le ze ta zy ni/.

Other languages do not do this, but preserve the audibility of word boundaries by making the selection of allophones sensitive to them. English is such a language, and it offers a large number of minimal pairs of the type *an aim* /ən eɪm/ vs. *a name* /ə neɪm /, *great ape* /greɪt eɪp / vs. *grey tape* /greɪ teɪp /. In the latter case, for example, /t/ is normally unaspirated, and can be glottal, when word-final in *great*, but is aspirated, and cannot be glottal, when word-initial in *tape*. In *great*, but not in *grey*, the diphthong /eɪ/ is subject to 'pre-fortis clipping' (shortening of its duration, without change of quality).

There are smaller differences, more easily lost under conditions of channel noise, in pairs such as *selfish* /'self ɪʃ/ vs. *shellfish* /'ʃel fɪʃ/, *bonus* /'bəʊn əs/ vs. *slowness* /'sləʊ nəs/ (with spaces symbolizing what in the present author's analysis are syllable boundaries).

For English, therefore, but probably not for French, we need to symbolize phonetic boundaries explicitly: not only word boundaries, but also certain morpheme boundaries or syllable boundaries. Certainly in English the affricate problem discussed in 3.6 is just a special case of this more general problem.

We recommend, therefore, that in English and similar languages a disjunctor symbol be used to symbolize those boundaries which have potential phonetic correlates. Either the space or the hyphen character appears to be adequate for this function.

4. Final comments

The coding recommendations outlined in this report are summarized in Table 4.

TABLE 4: Coding recommendations

IPA	SAM-PA		Description
Vowels			
a	a		open front unrounded
ɑ	A		open back unrounded
æ	{	123	raised open front unrounded
ɐ	6		raised open central unrounded
ɒ	Q		open back rounded
ɔ	O		half-open back rounded
e	e		half-close front unrounded
ɛ	E		half-open front unrounded
ə	@	64	mid central
ɜ	3		(long) mid central
i	i		close front unrounded
ɪ	I		laxed close front unrounded
o	o		half-close back rounded
ø	¦	124	half-close front rounded
œ	\	92	half-open front rounded
u	u		close back rounded
ʊ	U		laxed close back unrounded
ʉ	}	125	close central rounded
ʌ	V		(laxed) half-open back unrounded
y	y		close front rounded
ʏ	Y		laxed close front rounded

Consonants

b	b	voiced bilabial plosive
c	c	voiceless palatal plosive
ç	C	voiceless palatal fricative
d	d	voiced dental or alveolar plosive
ð	D	voiced dental fricative
f	f	voiceless labiodental fricative
g	g	voiced velar plosive
ɣ	G	voiced velar fricative
h	h	voiceless glottal fricative
j	j	voiced palatal approximant
k	k	voiceless velar plosive
l	l	voiced alveolar lateral approximant
ʎ	L	voiced palatal lateral
m	m	voiced bilabial nasal
n	n	voiced dental or alveolar nasal
ɲ	J	voiced palatal nasal
ŋ	N	voiced velar nasal
p	p	voiceless bilabial plosive
r	r	voiced (post-)alveolar trill (etc.)
ʁ, ʀ	R	voiced uvular fricative or trill
s	s	voiceless alveolar fricative
ʃ	S	voiceless palato-alveolar fricative
t	t	voiceless dental or alveolar plosive
θ	T	voiceless dental fricative
v	v	voiced labiodental fricative
w	w	voiced labial-velar approximant
x	x	voiceless velar fricative
ɥ	H	voiced labial-palatal approximant
z	z	voiced alveolar fricative
ʒ	Z	voiced palato-alveolar fricative
ʔ	?	glottal plosive

Two-character symbols

ɛ̃	E~ or ~E	(example of) nasalized vowel
aɪ	aI	(example of) diphthong
tʃ	tS	(example of) affricate

Length, stress and intonation marks

ː	:	(length mark)
ˈ	"	(primary stress mark)
ˌ	%	(secondary stress mark)
´	' 39	rise (pitch, tone, intonation)
`	` 96	fall (pitch, tone, intonation)

Participants at the London workshop were anxious to emphasize the point that the recommendations made must be interpreted as to some degree language-specific. The coding 't', like the IPA symbol 't', covers a number of rather different articulatory and acoustic entities in different languages; the coding 'O', IPA 'ɔ', implies noticeably different qualities in Italian *cosa*, French *bonne*, German *Gott*, English *caught*, Dutch *bod*, and Danish *rusten*. Like all phonemic symbols, they need in any case to be interpreted in the light of language-specific realization (allophone) rules.

It was felt to be important to circulate these proposals widely, and in particular to consult the International Phonetic Association, whose sponsoring of its Alphabet has been the principal reason it has gained such worldwide acceptance. Mention was made of the fate of the recommendations of the Copenhagen conference on phonetic symbols of 1925: of the many proposals made there, only those subsequently adopted by the IPA (e.g. the stress mark 'ˈ') have succeeded in gaining general adoption, while others (such as 'ŋ' to mean a PALATAL nasal!) have sunk without trace. It was auspicious that both the present Secretary of the Association (Peter Roach) and his predecessor (John Wells) were present at the London workshop.

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