A Blueprint for a Comprehensive Australian English Auditory-Visual Speech Corpus

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Abstract

Large auditory-visual speech corpora are the grist of modern research in speech science, but no such corpus exists for Australian English. This is unfortunate, for speech science is the brains behind speech technology and applications such as Text-To-Speech (TTS) synthesis, Automatic Speech Recognition (ASR), speaker recognition and forensic identification, talking heads, and hearing prostheses. Advances in these research areas in Australia require a large corpus of Australian English. Here we describe a blueprint for building the Big Australian Speech Corpus (the Big ASC), a corpus of over 1,100 speakers from all over Australia, urban and rural; speakers of non-indigenous, indigenous, ethnocultural, and disordered forms of Australian English; each sampled on three occasions in a range of speech tasks designed by the researchers who would be using the corpus.
Key terms: The Big Australian Speech Corpus (Big ASC) Auditory-Visual Speech, DADA-HCS, HCSNet, Speech Corpora.

1. Introduction and Rationale

Contemporary speech science is driven by the availability of large, diverse speech corpora. Such infrastructure underpins research and technological advances in various practical, socially-beneficial and economically-fruitful endeavours, from Automatic Speech Recognition to hearing prostheses. Unfortunately, speech corpora are not easy to come by because they are both expensive to collect and are not favoured by the usual funding sources as their collection *per se* does not fall under the classification of 'research'. Nevertheless they provide the *sine qua non* for many avenues of research endeavour in speech science.

The only publicly available Australian speech corpus is the 12-year-old ANDOSL database (Millar *et al.*, 1990), which is now outmoded due to its small number of informants, just a single recording session per speaker, low fidelity, and audio-only rather than auditory-visual data; plus its lack of disordered speech and limited coverage of indigenous and ethnocultural Australian English (AusE) variants. There are more up-to-date UK and US English language corpora, but these are mostly audio-only, and use of these for AusE purposes is not optimal, and results in inaccuracies.

2. Purpose of the Big Australian Speech Corpus (The Big ASC)

In Australia we have significant research strengths in speech science that require an extensive AusE AV speech corpus. However, currently there is none. Here we describe a blueprint for establishing the **Big Australian Speech Corpus (the Big ASC),** a corpus of over 1,100 speakers from all over Australia. With the support of the Human Communication Science Network and the Australasian Speech Science and Technology Association, speech science experts from across Australia have banded together to plan the recording of large quantities of AV speech from many locations and multiple sessions using (i) standard recording equipment, (ii) a standard collaboratively-designed protocol, and (iii) storage and annotation in an existing/developing Distributed Access and Data Annotation system. With a projected lifespan of at least two decades, the Big ASC would engender and enhance Australian research in a range of human communication and speech science areas. A representative selection of these areas is set out below.

2.1. Phonetics and linguistics

The Big ASC is essential to describe the variation of AusE over geographical area (Butcher, 2006; 2008; Cox & Palethorpe, 1998; 2001; 2004), ethnocultural and social background, and speech style (Ingram, 1989); changes to the language since the collection of the outmoded ANDOSL database; and to provide greater access to information on speech production (Fletcher *et al.*, 2004).

2.2. Psycholinguistics

The Big ASC would have applications in projects on psycholinguistic models for word processing (Cutler & Carter, 1987; Cutler, 2005); young children's perception of phonetic variability and dialectal variation in spoken words (Best *et al.*, 2009); the effect of pronunciation on written language (Kemp, 2009); and hearing training programs for children and adult users of cochlear implants (Dawson *et al.*, 2000; Mok *et al.*, 2006).

2.3. Engineering – Spoken Language Processing

The corpus would support research projects in Automatic Speech Recognition (ASR) and AV ASR (Lewis & Powers, 2005; 2008; Saragih & Goecke, 2007); the Thinking Head project (see 4.3 and http://thinkinghead.edu.au/); speaker authentication and localisation based on a fusion (Lewis &

Powers, 2005; 2008) and separation (Li & Powers, 2001) of multiple signals including voice acoustics and facial image in particular (Tran *et al.*, 2004; Tran & Wagner, 2002); automatic real-time visual biometric systems robust to variations; development of more robust systems for authentication or identification (e.g., Government and commercial services such as Centrelink and telephone banking) available in 4G mobile telephony (Naseem *et al.*, in press); cochlear implant sound processing for improved perception of speech in noise and access to speaker identity and intonation (Bavin, Grayden, Scott & Stefanakis, T., in press; Talaricoa *et al.,* 2007); and emotion detection applications, e.g., determining 'choice points' for automatic user service systems switching to a manual operator, or Talking Heads switching between language and dialog models (McIntyre & Goecke, 2007; Yacoub *et al.*, 2003; Vidhyasaharan *et al.*, 2009); and auditory-visual TTS synthesis (Kuratate, 2008).

2.4. Language technology and computer science

In this area, various interfaces would be enabled, e.g., ASR tailored for Australian English and its variety of accents and emotional tones/textures/expressions (Powers *et al.*, 2008), speech dialogue management (Dale & Viethen, 2009; Viethen & Dale, 2006) and AV user-centric/context-aware/ask-once/ask-nonce information retrieval and monitoring (Powers & Leibbrandt, 2009); as well as web search and training products and guides based on grounded speech understanding (Huang & Powers, 2008; Pfitzner *et al.*, 2008ab).

2.5. Speech pathology

Corpora of disordered speech *and* representative Australian speech are critical to describe and analyse disordered speech, understand the disorders, and develop intervention treatments and devices (Butcher, 1996; Arciuli & McLeod, 2008).

2.6. Forensic speech science

Spontaneous speech from multiple sessions would allow estimation of between- and within-speaker variability across different recording sessions. This allows estimation of the strength of evidence with a Likelihood Ratio using Bayes theorem (Rose, 2002). The Big ASC would be of great use in testing forensic speaker recognition approaches and conducting real-world casework, as well as identifying individuality in speaker behaviour (Butcher, 2002; Loakes & McDougall, in press).

3. Design of the Big ASC: An overview

Input from Australian experts who would be using the Big ASC is crucial for the construction of a comprehensive, maximally applicable corpus. To date, 29 speech scientists from 11 Australian universities have contributed their disciplinary expertise to devise optimal equipment and protocols. The Big ASC infrastructure would provide a significant boost to speech research in Australia now and well into the future because it would incorporate contemporary and rigorous design features as follows.

3.1. Tight Control

Standardisation in equipment and data collection procedures is essential. A Standard Speech Science Infrastructure Black Box and a Standard Speech Collection Protocol would be used at each collection node to ensure that speech collection conditions are controlled and documented.

3.2. High-fidelity

Two-channel AV recording would allow spatial localisation, and both auditory scene analysis and 3D imaging.

3.3. Size and Distribution

Large speech corpora (e.g., Smits, Warner, McQueen & Cutler, 2003) are essential in order to cover idiosyncrasies and variation. Here speech from over 1,100 speakers from 11 collection nodes from every state and territory of Australia would be collected.

3.4. Multiple sessions (within-speaker variation)

Each speaker would be recorded on three separate occasions (Σ=3384 sessions) to capture within-speaker variability over time.

3.5. Diversity (between-speaker variation*)*

Representative sampling from 11 different nodes would reflect *regional* (all states & territories), *indigenous* (varieties of Aboriginal English & 2 creoles), and *ethnocultural* (AusE from Greek, Italian, Lebanese, & Chinese background speakers) variation, and degree of *intactness* (disordered speech).

3.6. AV data

The increased power of modern computers, the overwhelming evidence of efficacy of visual speech information in disambiguating speech and speaker recognition (Benoît *et al*, 1992; Girin *et al.*, 2001; Potamianos *et al.*, 2004), and the currency and topicality of auditory-visual avatars and embodied conversational agents in Talking Heads mean that it is now *de rigueur* for speech corpora to be auditory-visual (note, for example, the AVAtech project at the Max Planck Institute for Psycholinguistics; AVAtech, 2009).

3.7. Efficient management

The Big ASC would use and extend an existing/developing language data storage system, DADA-HCS (see 4.4) to provide shared access to the corpus and the collective annotation and other metadata associated with every recording.

3.8. Australian

This would be the first Australian speech corpus to meet the demands of modern speech science and would sample widely and appropriately from the breadth of AusE variations.

4. Support for the Big ASC

The Big ASC blueprint builds on, is supported by, and will support relevant associations, networks, and projects as set out below.

4.1. Australasian Speech Science and Technology Association (ASSTA)

ASSTA advances the understanding of speech science and technology both within Australia (e.g., biennial Speech Science and Technology (SST) conference and a range of

research funding initiatives) and internationally via interaction with the International Speech Communication Association (ISCA). Within ASSTA, two sub-committees would provide leadership and specialist knowledge: the National Spoken Language Database (NSLD) sub-committee in the main, as well as the Forensic Speech Science sub-committee (FSSC) where forensic matters are concerned.

4.2. Human Communication Science Network (HCSNet)

HCSNet is an Australian Research Council (ARC) research network jointly run by the University of Western Sydney and Macquarie University. HCSNet brings together a wide mix of researchers who work on speech, text and sonics, including those working on the Big ASC project. In addition to this corpus project, HCSNet has spawned other large projects such as the DADA-HCS and the Thinking Head project.

4.3 ARC/NHMRC Special Initiatives Thinking Systems project 'From Talking Heads to Thinking Heads'

This project brings together human communication scientists from six Australian and three international universities, and integrates best-practice talking-head science and technology with behavioural evaluation and performance art to provide a plug-and-play Thinking Head research platform. Within this, speech science applications relying on speech corpora (ASR, Text-to-speech (TTS) Synthesis, dialog, animation) can be compatibility tested and evaluated for user satisfaction and engagement.

4.4 Distributed Access and Data Annotation for the Human Communication Sciences (DADA-HCS)

DADA-HCS was spawned by HCSNet and has been adopted by the Thinking Head project for data management. It will also be used here for data storage, annotation, and access (see 5.5).

5. Main components of the Big ASC

5.1. Sampling variation

For a good speech corpus with wide applicability a surfeit of speech variation is mandatory (Smits *et al.*, 2003). The Big ASC would incorporate a wide range of speakers and locations (see Table 1 for possible data collection sites and sampling breakdown). The rationale for the variation in sampling informants and procedures for obtaining representatives samples are detailed below:

5.1.1. Regional and ethnocultural variation

A representative sample of adult male and female speakers of Non-Indigenous AusE across the country in three age groups (<25, 30-45, >50) and two socioeconomic levels would be collected. In Adelaide, Sydney, Perth, Brisbane, Melbourne, Hobart (+ some regional areas) and Canberra 16 speakers (8 females, 8 males) would represent the 6 age x socioeconomic combinations (n=96), a total of N=672 speakers. In each of 2 regional areas in NSW, and in Townsville, data would be collected from 4 males and females from the 3 age groups (n=24, N=72). Finally, the 4 largest ethnocultural groups of Australian born citizens with parents from non-English speaking countries - Italian (11%), Greek (6%), Chinese (6%)

and Lebanese (3%) (Australian Bureau of Statistics 2006 census) - would be sampled in Sydney (Chinese & Lebanese) and Melbourne (Italian & Greek) from males and females in three age groups (n=48, N=192). This is a total of 744 speakers incorporating regional variations of Standard AusE and 192 with ethnocultural variations.

Table 1: *Possible Data Collection Sites and Roles Involved in Establishing the Big ASC.*

Site	Data Collected *or Role*
Hobart	Standard AusE (n=72)
	Regional AusE (n=24)
Perth	Standard AusE (n=96)
Adelaide (1)	Standard AusE (n=96)
Adelaide (2)	Aus Indigenous Eng. (n=48)
	AusE-Indig. Creoles (n=48)
Melbourne	Standard AusE (n=96)
	Italian AusE (n=48)
	Greek AusE (n=48)
Canberra	Standard AusE (n=96)
	Standard AusE (n=96)
Brisbane	Standard AusE (n=96)
	Regional AusE (n=24)
Sydney (1)	Standard AusE (n=48)
	Chinese AusE (n=48)
Sydney (2)	Disordered AusE (n=96)
Sydney (3)	Standard AusE (n=48)
	Regional AusE (n=48)
Sydney (4)	*DADA Implementation*
	& Annotation HQ
Sydney (5)	Lebanese AusE (n=48)
	Project Administration

5.1.2. Aboriginal English variation

The majority of Australia's 455,000 strong Aboriginal population speak some form of Australian Aboriginal English (AAE) and it is the first (and only) language of a large number of Aboriginal children. Thus their language is somewhere on a continuum from something very close to Standard AusE through to creole. There are two distinct creoles – one spoken in the Torres Strait (TS) Islands and TS Islander communities in Queensland (23,000 speakers), and the other, 'Kriol', on the mainland from the Kimberley through the Barkly Tableland to the Queensland gulf country (20,000 speakers; National Indigenous Languages Survey report, 2005). Like all other creoles, these are languages in their own right with complex, rule-governed codes and extensive vocabulary. Recordings would be made in Darwin, Alice Springs, Fitzroy Crossing (12 AAE & 12 Kriol speakers, 6 male, 6 female) and on Waibene (Thursday Island) (12 AAE & 12 TS Creole speakers, 6 male, 6 female).

5.1.3. Disordered speech variation

In the USA occupations are voice-dependent for 34% of workers (87.5% of workers in large urban areas) and the economy cost of communication disorders is $154.3-186B pa (Ruben, 2000). There are no equivalent data for adults in Australia, but a recent study of 14,5000 Australian primary

and secondary school students suggests prevalence of around 13% (McLeod & McKinnon, 2007). One particularly common speech disorder is stuttering, which develops unpredictably and rapidly during early childhood, disturbs peer interactions (Langevin, Packman, Thompson, & Onslow, 2009), and can be associated with occupational under-achievement, impaired oral communication, and a high level of social phobia (USyd Australian Stuttering Research Centre cohort; Menzies *et al.*, 2008). Speech data from 96 stutterers would be collected representatively, if possible, from the 3 age groups x 2 socioeconomic areas, and the greater incidence of stuttering in males than females may be reflected in the final sample.

5.1.4. Informants and field trips

A total of 1,100 informants would be required with an approximate budget of around $1000 per recording node for advertising/recruitment and reimbursement of travel expenses (with 3 visits per informant). Field trips would be essential for the required diversity of Big ASC, probable locations including (a) Adelaide to Darwin, Alice Springs, Fitzroy Crossing, and Waibene (Thursday Island) for the collection of Australian Aboriginal English data and AusE-Indigenous creoles; (b) Sydney to Broken Hill and Longreach for regional AusE; (c) Brisbane to Townsville for regional AusE and (d) Tasmania for regional AusE data collection.

5.2. Standard Speech Science Infrastructure Black Box (SSSIBB)

Standardisation is also necessary with regard to equipment; a Standard Speech Science Infrastructure Black Box (SSSIBB) would be established at each participating recording site. This integrated piece of hardware would be comprised of a portable computer, stereo cameras and stereo microphones, and a 360° camera to ensure compatibility of audio and video data streams between recording sites and a record of the wider recording context.

5.3. Standard Speech Collection Protocol (SSCP)

A variety of tasks appropriate for different applications would be completed across 3 separate recording sessions (see Table 2.) As literacy in English (or creole) cannot be assumed for the Australian Indigenous sample, some variation of the protocol would be necessary: sentences and word lists would be orally prompted, the map tasks and transcript readings replaced by alternative tasks such as story telling, and the 'Emotional' speech task could be modified or omitted. Importantly, all the word-level and natural sentence-level material would be retained. The rationale for particular components of the SSCP is set out below.

5.3.1. Phonetic and style variation

Comprehensive demographic, family and historical data would be collected in the first session to document the regional and ethnocultural dialect variations of each speaker. Informants would be recorded on three separate occasions to allow natural variation in voice quality in a range of speech situations. The time between sessions would be short (1 week between sessions 1 & 2), and longer (4 weeks between 2 & 3) (some reductions could be required on field trips). Core data

collection tasks would elicit formal speech and contain standard digit and word lists (the HvD task) and phonetically balanced 'Read Sentences' material, the latter both in natural and emotional speech. Non-core data collection would capture unguarded dialogue, conversational speech, and style shifting. A particularly good indicator of style shifting would be the spontaneous narrative in Session 2 (elicited after the Interview by a request to relate a particularly dangerous or exciting anecdote or experience) versus a version of the same text in Session 3 spoken in 'newsreader' style from a transcript of the narrative made by a Research Assistant (RA) between the second and the third session.

5.3.2. Forensic speaker recognition (FSR)

The yes/no elicitation item would provide natural variations for, 'yes' ("yes, yeah, yep"), 'no' ("no, nah"), 'um' ("ah, mm"), words very useful in forensic casework (Rose, 2002; Arciuli, Mallard & Villar, in press). The map task involves two people, visually shielded from each other, each having access to a map which has some information common to both maps and some peculiar to each with one informant guiding the other to a particular destination. (Only one informant will be recorded audio-visually using the standard SSSIBB apparatus (see 5.2), while the other will be just audio-recorded. The map task will conducted at the end of a session for informant A, and the start of one for informant B, and will be repeated in sessions 1 and 2, so A and B can be the subject of AV or just audio recording in each session.) Incorporated into the task are long, difficult place names with informants being asked to spell these, and fictional addresses and names to elicit speech segments in a spontaneous yet controlled fashion. Telephone speech is important for forensic applications. Telephones severely attenuate low frequencies of speech, including the fundamental, so pitch must be perceived via upper harmonics - the 'missing fundamental effect'. They also severely attenuate high frequency components, which contain speaker-specific information for example in third and higher formants. Telephone speech would be obtained by passing 'Read Sentences' speech through various filters (codecs for regional and commercial variations of mobile phones, landlines).

5.3.3. Speech/speaker recognition

In the 'Read Sentences' task, varied consonant/vowel co-articulation combinations are important for extraction of diphones for acoustic models in ASR, as is the repeated HvD task, and the digits task is important for speaker verification in voice password situations. The 'Map Task', and the 'Interview' and 'Spontaneous Narrative' (in which the RA would ask open questions to allow spontaneous speech, then segue to the elicitation of a spontaneous narrative) are essential for collecting connected spontaneous speech for constructing prosody models and setting up language models for ASR and dialog management. The 'Speech-in-Noise' task involves the informant speaking through multi-speaker babble, resulting in hyperarticulated speech. The 'Read Sentences' task would be used for comparison with clear speech. Speech-in-noise data are particularly useful for training ASR and systems in sub-optimal (real world) conditions.

	Session			Annotation
	1st	**2nd (1 week later)**	**3rd (4 weeks later)**	
Initial	Demographic, consent, ethno-cultural questionnaire			
Core Material	Calibration (sound & light, time readings)	Calibration (sound & light, time readings)	Calibration (sound & light, time readings)	
	AV speech calibration	AV speech calibration	AV speech calibration	
	Digits	Digits	Digits	Word
	HvDs* (+laterals & nasals)	HvDs (+laterals & nasals)	HvDs (+laterals & nasals)	Vowel
	Read Sentences	Read Sentences	Read Sentences	Phoneme
	Emotion Sentences	Emotion Sentences	Emotion Sentences	Phoneme
	Yes/No elicitation	Yes/No elicitation	Yes/No elicitation	Word
x 1 Extra Material			Speech-in-noise	Word
		Interview		Turns
x 2 Extra Material		Spontaneous narrative	Reading transcript of previous narrative	Transcript
	Map Task #1	Map Task #2		Transcript
* HvD word task - 'h'-vowel-'d' words e.g., 'had', 'hid', etc				

Table 2: *Standard Speech Collection Protocol (SSCP) for sessions at all recording nodes*

5.3.4. Emotional speech

As an extension of 'Read Sentences', informants would be requested to read a given sentence according to one of 7 emotions (neutral, anger, happiness, sadness, fear, boredom, and stressed). Then, as a variation of the Interview task, informants would be asked to converse naturally with the RA in each of the 7 emotions (as in the Read Sentences task). Given the time required for this latter task, it would be conducted only at one Sydney site with the 48 speakers of standard AusE to be tested there. In many cases, time (1-2 mins) would be required for informants to practice producing a given emotion, and this protocol has been used in previous less extensive studies (LDC Emotional Prosody Speech corpus, 1992).

5.3.5. AV speech

AV speech data are essential for many applications, e.g., ASR and speaker recognition, biometric password applications. All data (except ½ of the Map Task on each occasion) would be AV-recorded, and the initial lateral head movements (AV calibration) would facilitate recording AV speech. The 'Speech-in-Noise' and the 'Emotion' tasks are of particular interest for mapping between auditory and visual components of hyperarticulated speech and emotional speech respectively, and the development of smarter ASR and talking heads.

5.4. Annotation

A base level of annotation of data would be conducted by Node RAs at each site. For recordings that are read (digits, read sentences etc.) this would mark the start and end of each word while for the longer unscripted recordings this would be a transcript of what is said aligned at the phrase or sentence level. In addition, the node RAs would transcribe the informants' spontaneous narrative in Session 2 to allow a 'newsreader' version of the same text in Session 3. Validation of the basic node level annotation, together with more detailed annotation would be conducted by the central Annotation Team. Consistent principles and protocols for annotation would be determined. The Annotation Team would, for example, mark up aspects of dialogue, intonational, syntactic and rhetorical structure as appropriate. Annotation will involve variants of the Emu and ELAN tools, which will be interfaced with the shared annotation server running the DADA-HCS system to be used by all annotators in the project in order to build the corpus collaboratively and consistently.

5.5. Distributed Access & Data Annotation for the Human Communication Sciences (DADA-HCS)

The Distributed Access and Data Annotation for the Human Communication Sciences (DADA-HCS) project has developed a distributed data store designed to make shared access to large collections of language data easier. DADA-HCS (ARC Grant SR0567319; Cassidy & Ballantine, 2007; Cassidy, 2008) allows data to be shared efficiently among project members and manages shared access to annotations on the data so that multiple parties can develop a definitive annotation collaboratively. The Big ASC would support and be supported by the DADA-HCS system, using and extending it to provide shared access to the corpus. Not only would the Big ASC form an intact piece of infrastructure but one that is embedded in the DADA-HCS system that affords future augmentation by the project investigators (using the hardware used and protocols established in this project) and by others, so that further sub-samples, e.g., child speech, may be included later.

5.6. Servers and back-up

A Central/Primary Data Store/Server is essential to hold the very large amounts of AV data. It would have the appropriate RAID disk storage devices and media, and would also be

used for software development and quality control. A back-up Secondary Data Store/Server would also have the appropriate RAID disk storage devices and media, and be used for e-annotation.

5.7. Personnel

A Project Manager/Software Engineer would be essential to coordinate corpus collection; to direct and support its annotation and subsequent dissemination; oversee the technical coordination of the project; and provide assistance to individual sites where needed. A Programmer would be required to build software for the data collection, including AV recording and entry of metadata for each recording session. The programmer would extend the DADA-HCS system to support collaborative annotation of the data, and integrate the DADA-HCS back-end with the Emu Speech Database System (Cassidy, 1998) to provide annotation tools for the project. They would be responsible for the central data store and support the collaborative annotation of the data. Research Assistants would be required for general administration, running recording sessions, constructing the first level of metadata, and conduct some transcription and labelling of the recorded data. For the more difficult continuous speech samples, a small band of Annotation Specialist RAs would be required. At each node there would be a Chief Investigator for overseeing the project, co-ordinating hardware and space issues for testing, and supervising the RA.

6. Funding the Big ASC

The total cost of building the Big ASC is estimated to be in excess of $1.5 million. A possible funding source is the ARC Linkage Infrastructure and Equipment (LIEF) scheme, and an application will be submitted for this scheme in 2009, requesting 75% of the project costs with the other 25% coming from participant universities.

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