

Appendix A: List of Homophones

Homophones are words that sound the same but have different meanings. They are usually spelt differently, so that when written they are clearly distinguishable, but in a speech-based interface they have the potential to cause ambiguity and confusion and are best avoided. It is worth consulting this list when designing spoken utterances as it is easy to become blinkered, thinking only of the particular meaning one has in mind and forgetting that a homophone might exist.

The following list is based on Alan Cooper's Homonym List (http://www.cooper.com/alan/homonym_list.html), and is used here with his permission. The original list attempts to be comprehensive, but this one is rather more selective and has been edited to include words that seem more likely to occur in speech-based devices. It has also been modified to reflect British pronunciations and spellings, and includes a number of words that are not strict homophones but are close enough in pronunciation to cause confusion.

A

acts	things done
axe	chopping tool
affect	to change
effect	result
air	<i>see: err</i>
aisle	<i>see: I'll</i>
allowed	permitted
aloud	spoken

altar	raised centre of worship
alter	to change
ant	insect
aunt	parent's sister

ascent	the climb
assent	to agree
ate	past tense of eat
eight	8
aught	anything
ought	should
aural	of hearing
oral	of the mouth

B

ball	playful orb
bawl	to cry
band	a group
banned	forbidden

bare	naked	bolder	more courageous
bear	wild ursine	boulder	large rock
baron	minor royalty	born	brought into life
barren	unable to bear children	borne	past participle of bear
berry	small fruit	bound	a small stream or boundary
bury	to take under		
base	foundation	bough	tree branch
bass	the lowest musical pitch or range	bow	front of a ship; respectful bend
bases	plural of base	buoy	navigational aid
basis	principal constituent of anything	boy	male child
basses	many four-stringed guitars	brake	stopping device
be	to exist	break	to split apart
bee	insect	breach	to break through
beat	to hit	breech	the back part
beet	edible red root	bread	a loaf
berth	anchorage	bred	past tense of breed
birth	your method of arrival	brewed	fermented
bight	middle of a rope	brood	family
bite	a mouthful	bridal	pertaining to brides
byte	eight bits	bridle	horse's headgear
billed	has a bill	broach	to raise a subject
build	to construct	brooch	an ornament fastened to clothes
blew	past tense of blow		
blue	colour of California sky	buy	to purchase
boar	wild pig	by	near
Boer	a South African of Dutch descent	bye	farewell
boor	tasteless buffoon	C	
bore	not interesting	ceiling	<i>see</i> : sealing
board	a plank	E	
bored	not interested	effect	<i>see</i> : affect
bold	brave	eight	<i>see</i> : ate
bowled	knocked over		

elicit	to draw out
illicit	unlawful
ere	eventually
err	to make a mistake
e'er	contraction of "ever"
air	gas we breathe
heir	one who will inherit
ewe	<i>see</i> : yew

F

facts	objective things
fax	image transmission technology
faint	pass out
feint	a weak, misdirected attack to confuse the enemy
fair	even-handed
fare	payment
feat	an accomplishment
feet	look down
find	to locate
fined	to have to pay a parking ticket
finish	to complete
Finnish	from Finland
fir	evergreen tree
fur	animal hair
furr	to separate with strips of wood
flea	parasitic insect
flee	to run away
flour	powdered grain
flower	a bloom

for	in place of
fore	in front
four	number after three
foreword	introduction to a book
forward	the facing direction
foul	grossly offensive to the senses
fowl	domestic hen or rooster
frees	releases
freeze	very cold
frieze	a wall decoration

G

genes	a chromosome
jeans	cotton twill trousers
gild	to coat with gold
gilled	having gills
guild	a craft society
gilt	gold-plated
guilt	culpable
gorilla	large ape
guerrilla	irregular soldier
grate	a lattice
great	extremely good
grease	lubricant
Greece	Mediterranean country
grill	to sear cook
grille	an iron gate or door
groan	reaction to hearing a pun
grown	has become larger
guessed	past tense of guess
guest	a visitor

H

hair	grows from your head
hare	large rabbit
hall	a large room
haul	to carry
hangar	garage for aeroplanes
hanger	from which things hang
hear	to listen
here	at this location
heard	listened to
herd	a group of ruminants
heir	<i>see: err</i>
heroin	narcotic
heroine	female hero
hold	to grip
holed	full of holes
hole	round opening
whole	entirety
hour	sixty minutes
our	possessed by us

I

idle	not working
idol	object of worship
illicit	<i>see: elicit</i>
I'll	contraction of "I will"
isle	island
aisle	walkway
incite	to provoke
insight	understanding
innocence	a state without guilt
innocents	more than one innocent

it's	contraction of "it is"
its	possessive pronoun

J

jeans	<i>see: genes</i>
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K

know	to possess knowledge
no	negation
knows	<i>see: noes</i>

L

lead	heavy metal
led	guided
leak	accidental escape of liquid
leek	variety of onion
lessen	to reduce
lesson	a segment of learning
loan	allow to borrow
lone	by itself
loch	a lake
lock	a security device

M

made	accomplished
maid	young woman
mail	postal delivery
male	masculine person
maize	corn
maze	puzzle
manner	method
manor	lord's house
marshal	to gather
martial	warlike

massed	grouped together
mast	sail pole
meat	animal flesh
meet	to connect
mete	a boundary
medal	an award
meddle	to interfere
mince	chop finely
mints	aromatic sweets
mind	thinking unit
mined	looked for ore
miner	one who digs
minor	small
missed	not hit
mist	fog
moan	to groan
mown	the lawn is freshly cut
mode	condition
mowed	a lawn in a well-trimmed condition
moor	swampy coastland; to anchor
more	additional
morning	AM
mourning	remembering the dead
muscle	fibrous, contracting tissue
mussel	a bivalve mollusc

N

naval	pertaining to ships and the sea
navel	pertaining to the belly button

no	<i>see: know</i>
noes	"The noes have it..."
nose	"Plain as the nose on your face..."
knows	"Only the shadow knows..."
none	not one
nun	woman of God
nose	<i>see: noes</i>

O

oar	boat propulsion system
or	alternative
ore	mineral-laden dirt
one	singularity
won	victorious
oral	<i>see: aural</i>
ordinance	a decree
ordnance	artillery
ought	<i>see: aught</i>
our	<i>see: hour</i>

P

packed	placed in a container
pact	agreement
pail	bucket
pale	light coloured
pain	it hurts
pane	a single panel of glass
pair	a set of two
pare	cutting down
pear	bottom-heavy fruit
passed	approved; moved on
past	before now

patience	being willing to wait	presence	the state of being
patients	hospital residents	present	present
pause	hesitate	presents	what Santa brings
paws	animal feet	pride	ego
peace	what hippies want	pryed	opened
piece	morsel	pries	wedging open
peak	mountain top	prize	the reward
peek	secret look	principal	head of school
perique	ruffled pride	principle	causative force
pedal	foot control	Q	
peddle	to sell	quarts	several fourths-of-gallons
peer	an equal (a captain at sea has no peer)	quartz	crystalline rock
per	wharf (a captain at sea has no pier)	R	
pi	3.1416	racket	illegal money-making scheme
pie	good eating	racquet	woven bat for tennis
place	a location	rain	precipitation
plaice	a flounder	reign	sovereign rule
plain	not fancy	rein	horse's steering wheel
plane	a surface	raise	elevate
pleas	cries for help	rays	thin beams of light
please	good manners	raze	to tear down completely
pole	big stick	rapped	knocked sharply
poll	a voting	rapt	spellbound
poor	no money	wrapped	encased in cloth
pore	careful study; microscopic hole	read	having knowledge from reading
pour	to flow freely	red	a primary colour
praise	to commend	rest	stop working
prays	worships God	wrest	take away
preys	hunts		
precedence	priority		
precedents	established course of action		
presidents	commanders-in-chief		

retch	call Ralph on the porcelain telephone	scull	rowing motion
wretch	a ragamuffin	skull	head bone
review	a general survey or assessment	sea	ocean
revue	a series of theatrical sketches or songs	see	to look
right	correct	sealing	closing
rite	ritual	ceiling	upper surface of room
wright	a maker	seam	row of stitches
write	to inscribe	seem	appears
ring	circle around your finger	seas	oceans
wring	twisting	sees	looks
road	a broad trail	seize	to grab
rode	past tense of ride	sects	religious factions
rowed	to propel a boat by oars	sex	if you have to ask, you're too young
role	part to play	sew	needle and thread
roll	rotate	so	in the manner shown
root	subterranean part of a plant	sol	musical note
route	path of travel	sow	broadcasting seeds
rose	pretty flower	shall	is allowed
rows	linear arrangement	shell	aquatic exoskeleton
rote	by memory	shear	to cut or wrench
wrote	has written	sheer	thin; abrupt turn
S		sign	displayed board bearing information
sail	wind powered water travel	sine	reciprocal of the cosecant
sale	the act of selling	slay	kill
saver	one who saves	sleigh	snow carriage
savour	to relish a taste	sleight	cunning skill
scene	visual location	slight	not much
seen	past tense of saw	soar	fly
		sore	hurt
		soared	to have sailed through the air
		sword	long fighting blade

solace	comfort	T	
soulless	lacking a soul	tacks	small nails
sole	only	tax	governmental tithe
soul	immortal part of a person	tail	spinal appendage
		tale	story
some	a few	tare	allowance for the weight of packing materials
sum	result of addition	tear	to rip
son	male child	taught	past tense of teach
sun	star	taut	stretched tight
soot	black residue of burning	tea	herbal infusion
suit	clothes	tee	golf ball prop
stair	a step	team	a group working together
stare	look intently	teem	to swarm
stake	wooden pole	tear	eyeball lubricant
steak	slice of meat	tier	a horizontal row
stationary	not moving	teas	more than one herbal infusion
stationery	writing paper	tease	tantalize
steal	take unlawfully	tees	more than one tee
steel	iron alloy	tense	nervous
storey	the horizontal divisions of a building	tents	more than one temporary shelter
story	a narrative tale	their	belonging to them
straight	not crooked	there	a place
strait	narrow waterway	they're	contraction of "they are"
suede	split leather	threw	to propel by hand
swayed	curved; convinced	through	from end to end
suite	ensemble	throes	spasms of pain
sweet	sugary	throws	discharging through the air
summary	precis	throne	the royal seat
summery	like summer	thrown	was hurled
sundae	ice cream with syrup on it		
Sunday	first day of the week		

APPENDIX A

tide	periodic ebb and flow of oceans	Wales	Western division of UK
tied	passed tense of tie	whales	a pod of ocean mammals
to	towards	war	large scale armed conflict
too	also	wore	past tense of wear
two	a couple	ware	merchandize
toad	frog	wear	attire
toed	having toes	where	a place
towed	pulled ahead	way	path or direction
toe	forepart of the foot	weigh	to measure weight
tow	to pull ahead	whey	watery part of milk
told	what was spoken	weak	not strong
tolled	a bell was rung	week	seven days
tracked	having tracks	weather	meteorological conditions
tract	a plot of land	wether	a castrated ram
trussed	tied up	whether	if it be the case
trust	faith	wet	watery
V		whet	prime
vain	worthless	whined	past tense of whine
vane	flat piece moving with the air	wind	what you do to a clockwork
vein	blood vessel	wined	drank well of spirits
verses	paragraphs	who's	contraction of "who is"
versus	against	whose	belonging to whom
W		whole	<i>see</i> : hole
waist	between ribs and hips	won	<i>see</i> : one
waste	make ill use of	wood	what trees are made of
wait	remain in readiness	would	will do
weight	an amount of heaviness	wrapped	<i>see</i> : rapped
waive	give up rights		
wave	undulating motion		

wrest *see: rest*

wretch *see: retch*

wright *see: right*

write *see: right*

wring *see: ring*

wrote *see: rote*

Y

yew a type of tree

you the second person

ewe female sheep

yoke oxen harness

yolk yellow egg centre

yore the past

you're contraction of
 "you are"

your belonging to you

Appendix B: Words with More than One Meaning

The words listed below can take different meanings depending upon the context in which they are used.

Many English words can take several related meanings and function as more than one part of language without a change in the way they are spoken. Words which can be used as different parts of language but refer to the same object or function (for example camp, which can be used as either a verb or a noun) are not included in this list since they pose few problems in the design of speech dialogues. Provided a clause is correctly structured, the way in which the word is being used will be clear to the listener.

However, where a word can take more than one meaning while functioning as the same part of language (for example jet which, when used as a noun, can mean either a stream of liquid or an aircraft) it must be used with care in order to avoid ambiguity.

The following list contains a selection of such words, but is not exhaustive.

Word	Meanings
Air	gaseous mixture, melody
Bark	outer sheath of tree trunk, sound made by animal (e.g. dog), abrade
Bill	demand for money, act of parliament, beak of web-footed bird
Deal	fir or pine wood, business agreement, distribution of playing cards or other items
Die	numbered cube used in games of chance, mould used to stamp shape in metal, cease living
File	instrument used to shape or smooth materials, collection of papers or records, line of people or objects
Fly	move through the air, run away, two-winged insect
Jet	stream of liquid, black lignite, aircraft
Jig	lively tune or dance, device for holding work-piece in machine tool

Joint	junction between two parts, portion of animal prepared as food, in common
Just	merely, precisely, in accordance with justice
Keen	sharp-edged, enthusiastic
Kit	personal effects, equipment or clothing needed for particular task, set of components
Lace	fine fabric, cord used for fastening shoes, etc., act of fastening using cord
Lap	front of thighs of a seated person, overhanging edge, e.g. of floorboard, single turn around, e.g. race track, cable reel, etc.
Left	remaining, opposite direction to right
Let	hinder or obstruct, allow or enable, hire
Lie	make a false statement, adopt a horizontal position, shape or pattern or distribution (e.g. of land)
Lock	secure fastening, portion of hair
Mass	celebration of the Eucharist, coherent body of matter
Match	competitive endeavour, short piece of wood with combustible tip, equal or complementary
Mean	stingy, equidistant from two extremes, have as purpose
Mine	excavation in earth, explosive device, statement of possession
Mould	fungal growth, pattern or template, give shape to
Neat	tidy, undiluted
Page	leaf of book, boy employed as servant, summon
Palm	inner surface of hand, tropical tree
Peer	one who is equal in some respect, noble person, look intently
Pen	writing instrument, enclosure
Pole	stick, magnetic pole, native of Poland
Quarry	place from which stone is extracted, object of hunt
Race	ethnic group, competition by speed, strong current
Rail	abuse or react strongly against, enclose with rails, bars placed horizontally and/or in continuous series
Rank	line or queue (e.g. of taxis), position within hierarchy, loathsome, corrupt, sort by some criterion
Rear	breed, cultivate, rise up, hindmost part
Right	correct, good, opposite of left, entitlement
Sack	dismiss from employment, pillage, large bag of coarse fabric
Sage	herb, wise person

Saw	observed, cut using a to-and-fro motion, device for cutting, old saying
Scale	horny plate forming skin of fish or reptile, graduated continuum against which value is measured, device for measuring weight, sequence of musical notes
Shy	move away suddenly in alarm, throw object, diffident, uneasy or wary in company
Slip	unintentional failing (e.g. error, loss of balance), loose cover (for person, furniture, etc.), artificial slope, travel unobserved
Table	item of furniture, information organized in columns
Tablet	slab of stone, drug in solid form
Tap	draw supplies or information, hit lightly, valve controlling flow (e.g. of water), sound (produced, e.g. by light knock on door)
Tend	incline towards, look after
Wake	funeral ritual, disturbance resulting from passage, e.g. of ship or aircraft, rise from sleep
Watch	period of wakefulness especially at night, personal chronometer, observe
Wax	sticky substance such as that produced by bees, apply such substance (e.g. to clean or protect surface), grow or increase
Vice	immoral or distasteful conduct or habit, device for securing object while working upon it
Yard	unit of measure, small enclosed area
Yarn	tale, thread

Appendix C: Words with More than One Pronunciation

The words listed below can take more than one spoken form depending upon how they are used. In general a change of vowel sound signifies a change of meaning; for example, the word “tear” can mean either a drop which falls from the eye (pronounced teer) or a break, rip or wound (pronounced tare). Changes in the placement of the stress generally indicate a change of usage from one part of language to another; for example, the word “record” is pronounced re-cord when it is used as a noun or an adjective but becomes re-cord when it is used as a verb.

The list below is not exhaustive, but is intended to give some idea of the range of such effects found in spoken English.

Absent	<u>ab</u> -sent	ab- <u>sent</u>
Abstract	<u>ab</u> -stract	ab- <u>tract</u>
Addict	<u>add</u> -ict	add- <u>ict</u>
Adept	<u>ad</u> -ept	ad- <u>ept</u>
Ally	<u>al</u> -ly	al- <u>ly</u>
Annex	<u>ann</u> -ex	ann- <u>ex</u>
Attribute	<u>att</u> -ri-bute	att- <u>ri</u> -bute
August	<u>aug</u> -ust	aug- <u>ust</u>
Bow	bo	bôw
Collect	<u>col</u> -lect	col- <u>lect</u>
Combat	<u>com</u> -bat	com- <u>bat</u>
Combine	<u>com</u> -bine	com- <u>bine</u>
Deliberate	de-lib-er-ate	de-lib-er-âte
Detail	<u>de</u> -tail	de-tail
Finance	<u>fi</u> -nance	fi- <u>nance</u>
Imprint	<u>im</u> -print	im- <u>print</u>
Incline	<u>in</u> -cline	in- <u>cline</u>

Indent	<u>in</u> -dent	in- <u>dent</u>
Insult	<u>in</u> -sult	in- <u>sult</u>
Intake	<u>in</u> -take	in- <u>take</u>
Intern	<u>in</u> -tern	in- <u>tern</u>
Interrupt	<u>in</u> -ter-rupt	in-ter- <u>rupt</u>
Intimate	inti-mate	inti-mâte
Lead	leed	lêd
Live	live	lîv
Mandate	<u>man</u> -date	man- <u>date</u>
Minute	<u>mîn</u> -it	mi- <u>newt</u>
Object	<u>ob</u> -ject	ob- <u>ject</u>
Perfect	<u>per</u> -fect	per- <u>fect</u>
Pervert	<u>per</u> -vert	per- <u>vert</u>
Read	reed	rêd
Rebel	<u>re</u> -bel	re- <u>bel</u>
Record	<u>re</u> -cord	re- <u>cord</u>
Row	ro	rôw
Second	<u>se</u> -cond	se- <u>cond</u>
Tear	tair	teer
Use	rhymes with fuse	rhymes with loose

Guide to Pronunciation

a = a as in ate

â = a as in at

e = e as in bead

ê = e as in bed

i = i as in lie

î = i as in lit

o = o as in go

ô = o as in brow

References

- Allen J, Hunnicutt MS and Klatt DH (1987) *From Text to Speech: The MITalk System*, Cambridge University Press.
- Arons B (1993) SpeechSkimmer: Interactively skimming recorded speech, *Proceedings of the Sixth ACM Symposium on User Interface Software and Technology*, Atlanta, USA, 3–5th November 1993, 187–196.
- Ayres TJ, Jonides J, Reitman JS, Egan JC and Howard DA (1979) Differing suffix effects for the same physical suffix, *Journal of Experimental Psychology: Human Learning and Memory*, 5, 315–321.
- Baber C, Arvanitis TN, Haniff DJ and Buckley R (1999) A wearable computer for paramedics: Studies in model-based, user-centred and industrial design, in *Proceedings of Interact 99*, MA Sasse and C Johnson (eds), IOS Press, Edinburgh, 126–132.
- Baddeley AD (1966) Short term memory for word sequences as a function of acoustic, semantic and formal similarity, *Quarterly Journal of Experimental Psychology*, 18, 362–365.
- Baddeley AD (1993) *Your Memory: A User's Guide*, Prion (Multimedia Books Ltd), London.
- Bartlett FC (1932) *Remembering*, Cambridge University Press.
- Begault DR and Erbe T (1994) Multichannel spatial auditory display for speech communications, *Journal of the Audio Engineering Society*, 42, 819–826.
- Blattner M and Greenberg RM (1992) Communicating and learning through non-speech audio, in *Multimedia Interface Design in Education*, ADN Edwards and S Holland (eds), Springer-Verlag, Berlin, 133–144.
- Blattner MM, Sumikawa DA and Greenberg RM (1989) Earcons and icons: their structure and common design principles, *Human-Computer Interaction*, 4(1), 11–44.
- Blenkhorn P (1995) Producing a text-to-speech synthesizer for use by blind people, in *Extra-ordinary Human-Computer Interaction: Interfaces for Users with Disabilities*, ADN Edwards (ed.), Cambridge University Press, New York, 307–314.
- Bly S (1982) *Sound and computer information presentation*, PhD Thesis, Report UCRL53282, Lawrence Livermore National Laboratory.

- Bower GH, Clark MC, Lesgold AM and Winzenz D (1969) Hierarchical retrieval schemes in recall of categorized word lists, *Journal of Verbal Learning and Verbal Behaviour*, 8, 323–343.
- Bransford JD and Johnson MK (1972) Contextual prerequisites for understanding: Some investigations of comprehension and recall, *Journal of Verbal Learning and Verbal Behaviour*, 11, 717–726.
- Brewster SA (1994) *Providing a structured method for integrating non-speech audio into human-computer interfaces*, DPhil Thesis, Department of Computer Science, University of York, UK.
- Brewster SA, Raty V-P and Kortekangas A (1995) *Representing complex hierarchies with earcons*, Technical report, ERCIM-05/95R037, ERCIM.
- Brewster SA, Wright PC and Edwards ADN (1992) A detailed investigation into the effectiveness of earcons, auditory display, sonification, audification and auditory interfaces, in *Proceedings of the First International Conference on Auditory Display*, Santa Fe Institute, Santa Fe, G Kramer (ed.), Addison-Wesley, 471–498.
- Broadbent DE, Cooper PJ and Broadbent MH (1978) A comparison of hierarchical matrix retrieval schemes in recall, *Journal of Experimental Psychology: Human Learning and Memory*, 4, 486–497.
- Brown G (1983) Prosodic structure and the given/new distinction, in *Prosody: Models and Measurements*, A Cutler and DR Ladd (eds), Springer-Verlag, Berlin, 67–77.
- Buxton W (1989) Introduction to this special issue on non-speech audio, *Human-Computer Interaction*, 4(1), 1–10.
- Buxton W, Gaver W and Bly S (1991) *Tutorial Number 8: The Use of Non-speech Audio at the Interface*, ACM, New York.
- Chafe WL (1970) *Meaning and the Structure of Language*, Chicago University Press, Chicago.
- Conrad R (1960) Very brief delay of immediate recall, *Quarterly Journal of Experimental Psychology*, 12, 45–47.
- Conrad R (1964) Acoustic confusion in immediate memory, *British Journal of Psychology*, 55, 75–84.
- Cowan N, Litchi W and Grove T (1988) Memory for unattended speech during silent reading, in *Practical Aspects of Memory: Current Research and Issues*, Vol 2, *Clinical and Educational Implications*, MM Gruneberg, PE Morris and RN Sykes (eds), John Wiley & Sons, Chichester, 327–332.
- Crowder RG (1967) Prefix effects in immediate memory, *Canadian Journal of Psychology*, 21, 450–461.
- Crowder RG and Morton J (1969) Precategorical Acoustic Storage (PAS), *Perception and Psychophysics*, 5, 365–373.

- Crystal D (1987) *The Cambridge Encyclopedia of Language*, Cambridge University Press.
- Crystal D (1988) *Rediscover Grammar*, Longman, England.
- Dahl O (1976) What is new information?, in *Reports on Text-Linguistics: Approaches to Word Order*, NE Enkvist and V Kohonen (eds), Text Linguistics Research Group, Abo.
- Dallett KM (1965) Primary memory: The effects of redundancy upon digit reproduction, *Psychonomic Science*, 3, 237–238.
- Darwin CJ, Turvey MT and Crowder RG (1972) An auditory analogue of the sperling partial report procedure: Evidence for brief auditory storage, *Cognitive Psychology*, 3, 255–267.
- Duez D (1972) Silent and non-silent pauses in three speech styles, *Language and Speech*, 25, 11–28.
- Dutoit T (1997) *An Introduction to Text-to-Speech Synthesis (Text, Speech and Language Technology, V3)*, Kluwer Academic.
- Edwards ADN (1991) *Speech Synthesis: Technology for Disabled People*, Paul Chapman, London.
- Edwards ADN (1998a) Surfing and driving don't mix, *Interactions*, 5(3), 80 (<http://www.acm.org/pubs/articles/journals/interactions/1998-5-3/p80-edwards/p80-edwards.pdf>).
- Edwards ADN (1998b) Access to mathematics for blind people: The maths project, *Maths & Stats*, 9(2), 14–15.
- Edwards ADN (1998c) Mathematical access for technology and science for visually disabled people, <http://www.cs.york.ac.uk/maths/>
- Edworthy J, Loxley S and Dennis I (1991) Improving auditory warning design: Relationships between warning sound parameters and perceived urgency, *Human Factors*, 33(2), 205–231.
- Edworthy J, Loxley S, Geelhoed E and Dennis I (1989) The perceived urgency of auditory warnings, *Proceedings of the Institute of Acoustics*, 11(5), 73–80.
- Engle RW (1974) The modality effect: Is precategorical audio storage responsible?, *Journal of Experimental Psychology*, 102, 824–829.
- Gaver WW (1989) The SonicFinder: An interface that uses auditory icons, *Human-Computer Interaction*, 4(1), 67–94.
- Gaver WW (1997) Auditory interfaces, in *Handbook of Human-Computer Interaction*, MG Helander, TK Landauer and P Prabhu (eds), Elsevier Science, Amsterdam, 1003–1042.
- Gaver WW, Smith RB and O'Shea TM (1991) Effective sounds in complex systems: The arkola simulation, *Proceedings of CHI '91*, New Orleans, Addison-Wesley, 85–90.
- Gill JM (1993) *A Vision of Technological Research for Visually Disabled People*, The Engineering Council, London WC2R 3ER.

- Glucksberg S and Cowan GN (1970), Memory for non-attended auditory material, *Cognitive Psychology*, 1, 149–156.
- Goldman-Eisler F (1972) Pauses, clauses, sentences, *Language and Speech*, 15, 103–113.
- Grice HP (1975) Logic and conversation, in *Syntax and Semantics 3: Speech Acts*, P Cole and JL Morgan (eds), Seminar Press, New York.
- Grosjean F and Deschamps A (1973) Analyse des variables Temporelles du Francais Spontane II Comparaison du Francais Oral dans la description avec l'Anglais (description) et avec le Francais (interview radiophonique), *Phonetica*, 28, 191–226.
- Halliday MAK (1963) The tones of English, *Archives of Linguistics*, 15, 1–28.
- Halliday MAK (1967a) Notes on transitivity and theme in English, part 2, *Journal of Linguistics*, 3, 199–244.
- Halliday MAK (1967b) *Intonation and Grammar in British English*, Mouton, The Hague.
- Halliday MAK (1970) *A Course in Spoken English: Intonation*, Oxford University Press, Oxford.
- Jenkins JJ and Russell WA (1952) Associative clustering during recall, *Journal of Abnormal and Social Psychology*, 47, 818–821.
- Johnson-Laird PN (1970) The interpretation of quantified sentences, in *Advances in Psycholinguistics*, GB Flores and WJM Levelt (eds), North-Holland, Amsterdam.
- Keller E (ed.) (1994) *Fundamentals of Speech Synthesis and Speech Recognition: Basic Concepts, State of the Art and Future Challenges*, John Wiley & Sons.
- Lodge N (1995) Television without the pictures: The work of audetel, *Technical review of the Asia Pacific Broadcasting Union*, 159 (http://www.itc.org.uk/uk_television_sector/accessibility/index.asp).
- Loomis JM, Klatzky RL, Golledge RG, Cicinelli JC, Pellegrino JW and Fry PA (1993) Non-visual navigation by blind and sighted: Assessment of path integration ability, *Journal of Experimental Psychology: General*, 122, 73–91.
- Luce PA (1982) Comprehension of fluent synthetic speech produced by rule, *Journal of the Acoustical Society of America*, 71, 1208–1221.
- Luce PA, Feustel TC and Pisoni DB (1983) Capacity demands in short-term memory for synthetic and natural speech, *Human Factors*, 25(1), 17–32.
- MacKay DG (1966) To end ambiguous sentences, *Perception and Psychophysics*, 1, 426–436.

- Miller GA (1956) The magical number seven, plus or minus two: Some limits on our capacity for processing information, *Psychological Review*, 63, 81–97.
- Moray N, Bates A and Barnett T (1965) Experiments on the four-eared man, *Journal of the Acoustical Society of America*, 38, 196–201.
- Morton J and Long J (1976) Effect of word transition probability on phoneme identification, *Journal of Verbal Learning and Verbal Behaviour*, 15, 43–51.
- Mukherjee R (1997) *The recognition of document categories based on non-speech audio*, MSc(IP) Project Report, Department of Computer Science, University of York, UK.
- Murray DJ (1966) Vocalization at presentation and immediate recall with varying recall methods, *Quarterly Journal of Experimental Psychology*, 18, 9–18.
- Mynatt ED, Back M, Want R and Frederick R (1997) Audio aura: Lightweight audio augmented reality, in *Proceedings of the Fourth International Conference on Audio Display (ICAD '97)*, J Ballas and E Mynatt (eds), Xerox, Palo Alto, California, 105–107.
- Nakatani LH and Schaffer J (1978) Hearing words without words: Prosodic cues for word perception, *Journal of the Acoustical Society of America*, 63, 234–244.
- Nass C and Lee KM (2001) Does computer-synthesized speech manifest personality?, *Journal of Experimental Psychology: Applied*, 7(3), 171–181.
- Nass C and Moon Y (2000) Machines and mindlessness: Social responses to computers, *Journal of Social Issues*, 56(1), 81–103.
- Nusbaum HC and Pisoni DB (1985) Constraints on the perception of synthetic speech generated by rule, behaviour research methods, *Instruments & Computers*, 17(2), 235–242.
- Patterson RD (1982) *Guidelines for Auditory Warning Systems on Civil Aircraft*, Report Paper 82017, Civil Aviation Authority.
- Patterson RD (1989) Guidelines for the design of auditory warning sounds, *Proceeding of the Institute of Acoustics, Spring Conference*, 11(5), 17–24.
- Penney CG (1975) Modality effects in short term verbal memory, *Psychological Bulletin*, 82, 68–84.
- Penney CG (1979) Interactions of suffix effects with suffix delay and recall modality in serial recall, *Journal of Experimental Psychology*, 5, 507–521.
- Penney CG (1989) Modality effects and the structure of short term verbal memory, *Memory & Cognition*, 17(4), 398–422.
- Pitt IJ (1996) *The principled design of speech-based interfaces*, DPhil Thesis, Department of Computer Science, University of York, UK.

- Pitt IJ and Edwards ADN (1996) Improving the usability of speech-based interfaces for blind users, *Proceedings of the ACM Conference on Assistive Technologies*, Vancouver, Canada, April 1996, 124–130.
- Pitt IJ and Edwards ADN (1997) An improved auditory interface for the exploration of lists, *Proceedings of the 5th ACM International Multimedia Conference*, Seattle, USA, 8–14th November 1997, 51–61.
- Pitt IJ (1998) From graphics to pure text, in *Abstraction in Computer Graphics*, T Strothotte (ed.), Springer-Verlag, Berlin, 177–195.
- Posner MI and Rossman E (1965) Effect of size and location of informational transforms upon short-term retention, *Journal of Experimental Psychology*, 70, 496–505.
- Postman L and Phillips LW (1965) Short-term temporal changes in free recall, *Quarterly Journal of Experimental Psychology*, 17, 132–138.
- Poulton AS (1983) *Microcomputer Speech Synthesis and Recognition*, Sigma Technical Press, Wilmslow, Cheshire.
- Prince EF (1981) Towards a taxonomy of given/new information, in *Radical Pragmatics*, P Cole (ed.), Academic Press, New York, 223–255.
- Redelmeier DD and Tibshirani RJ (1997) Association between cellular-telephone calls and motor vehicle collisions, *New England Journal of Medicine*, 336(7), 453–458.
- Reich S (1980) Significance of pauses for speech perception, *Journal of Psycholinguistic Research*, 9(4), 379–389.
- Ribeiro N (2002) *Enhancing information awareness through speech induced anthropomorphism*, DPhil Thesis, Department of Computer Science, University of York, UK.
- Robinson CP and Eberts RE (1987) Comparison of speech and pictorial displays in a cockpit environment, *Human Factors*, 29(1), 31–44.
- Ryan J (1969) Temporal grouping, rehearsal and short-term memory, *Quarterly Journal of Experimental Psychology*, 21, 148–155.
- Sawhney N and Schmandt C (1999) Nomadic radio: Scaleable and contextual notification for wearable audio messaging, in *The Chi is the Limit: Proceedings of Chi '99*, MG Williams, MW Altom, K Ehrlich and W Newman (eds), AC, 96–103.
- Stevens R (1996) *Principles for the design of auditory interfaces to present complex information to blind computer users*, DPhil Thesis, Department of Computer Science, University of York, UK.
- Stevens RD, Brewster SA, Wright PC and Edwards ADN (1994a) Providing an audio glance at algebra for blind readers, in *Auditory Display: Sonification, Audification and Auditory Interfaces: Proceedings of ICAD '94*, Santa Fe, G Kramer and S Smith (eds), Addison-Wesley, 21–30.

- Stevens RD, Wright PC and Edwards ADN (1994b) Prosody improves a speech based interface, in *Ancillary Proceedings of HCI '94*, Loughborough, D England (ed.), British Computer Society.
- Stevens RD, Wright PC, Edwards ADN and Brewster SA (1996a) An audio glance at syntactic structure based on spoken form, in *Interdisciplinary Aspects on Computers Helping People with Special Needs: Proceedings of the 5th International Conference, ICCHP '96*, Linz, J Klaus, E Auff, W Kremser and WL Zagler (eds), R Olenbourg, 627–635.
- Stevens RD, Harling P and Edwards ADN (1996b) Reading and writing syntax trees for phrase structured grammars with a speech-based interface, in *New Technologies in the Education of the Visually Handicapped*, Paris, D Burger (ed.), John Libbey Eurotext, 271–276.
- Stevens RD, Wright PC and Edwards ADN (1995) Strategy and prosody in listening to algebra, in *Adjunct Proceedings of HCI '95: People and Computers*, Huddersfield, G Allen, J Wilkinson and PC Wright (eds), British Computer Society, 160–166.
- Streeter L (1978) Acoustic determinants of phrase boundary perception, *Journal of the Acoustical Society of America*, 64, 1582–1592.
- ten Hoopen G (1996) Auditory attention, in *Handbook of Perception and Action*, O Neumann and A F Sanders (eds), Academic Press, London, 3, 79–112.
- 't Hart J and Cohen A (1973) Intonation by rule: A perceptual quest, *Journal of Phonetics*, 1, 309–327.
- Tognazzini B (1992) *Tog on Interface*, Addison-Wesley.
- Tulving E and Pearlstone Z (1966) Availability versus accessibility of information in memory for words, *Journal of Verbal Learning and Verbal Behaviour*, 5, 381–391.
- Turing A (1950) Computing machinery and intelligence, *Mind*, 49, 433–460.
- Vaissiere J (1983) Language-independent prosodic structures, in *Prosody: Models and Measurements*, A Cutler and DR Ladd (eds), Springer-Verlag, Berlin, 53–66.
- Walker MA, Cahn JE and Whittaker SJ (1997) Improvising linguistic style: Social and affective bases for agent personality, *First International Conference on Autonomous Agents*, Marina Del Rey, ACM Press, 96–105.
- Waterworth JA (1983) Effect of intonation form and pause durations of automatic telephone number announcements on subjective preference and memory performance, *Applied Ergonomics*, 14(1), 39–42.
- Wicklegren WA (1964) Size of rehearsal group and short-term memory, *Journal of Experimental Psychology*, 68, 413–419.

- Witten IH (1982) *Principles of Computer Speech*, Academic Press, London.
- Yankelovitch N (1994) Talking versus taking: Speech access to remote computers, *Companion to the ACM CHI '94 Conference*, Boston, USA, April 24–28 1994.
- Yankelovitch N, Levow G-A and Marx M (1995) Designing speech acts: Issues in speech user interfaces, *Proceedings of ACM CHI '95*, Denver, USA, May 7–11 1995, 369–376.
- Zajicek M, Powell C, Reeves C and Griffiths J (1998) Web browsing for the visually impaired, in *Computers and Assistive Technology, ICCHP '98: Proceedings of the XV IFIP World Computer Congress*, Vienna & Budapest, ADN Edwards, A Arato and WL Zagler (eds), Austrian Computer Society, 161–169.
- Zhang J (1996) A representational analysis of relational information displays, *International Journal of Human–Computer Studies*, 45, 59–74.

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