

Knowledge-guided hearing: The benefit of familiar voices

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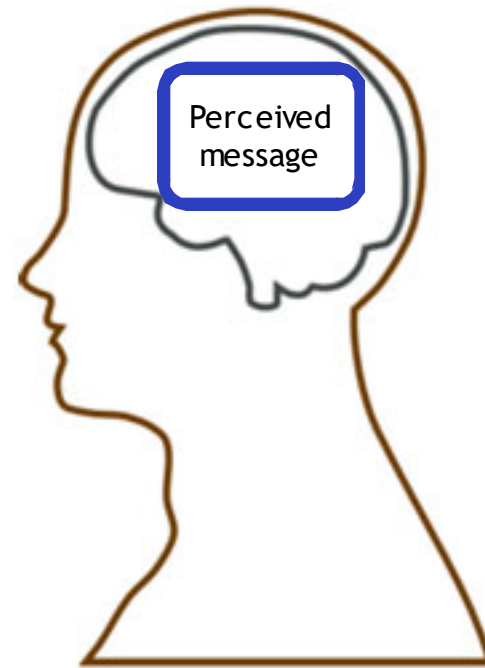
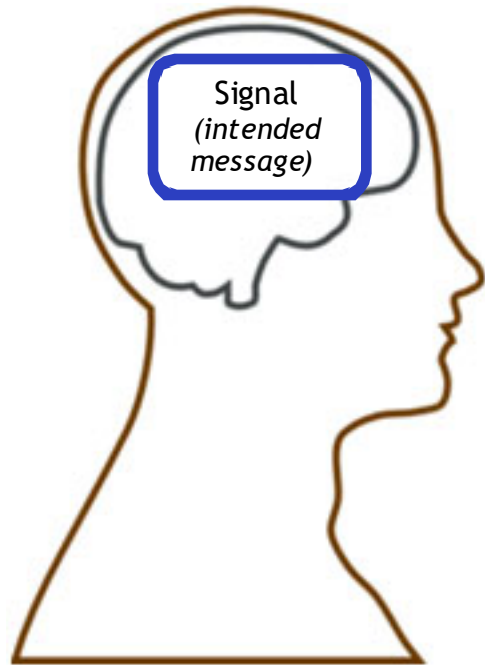
Western
The Brain and
Mind Institute



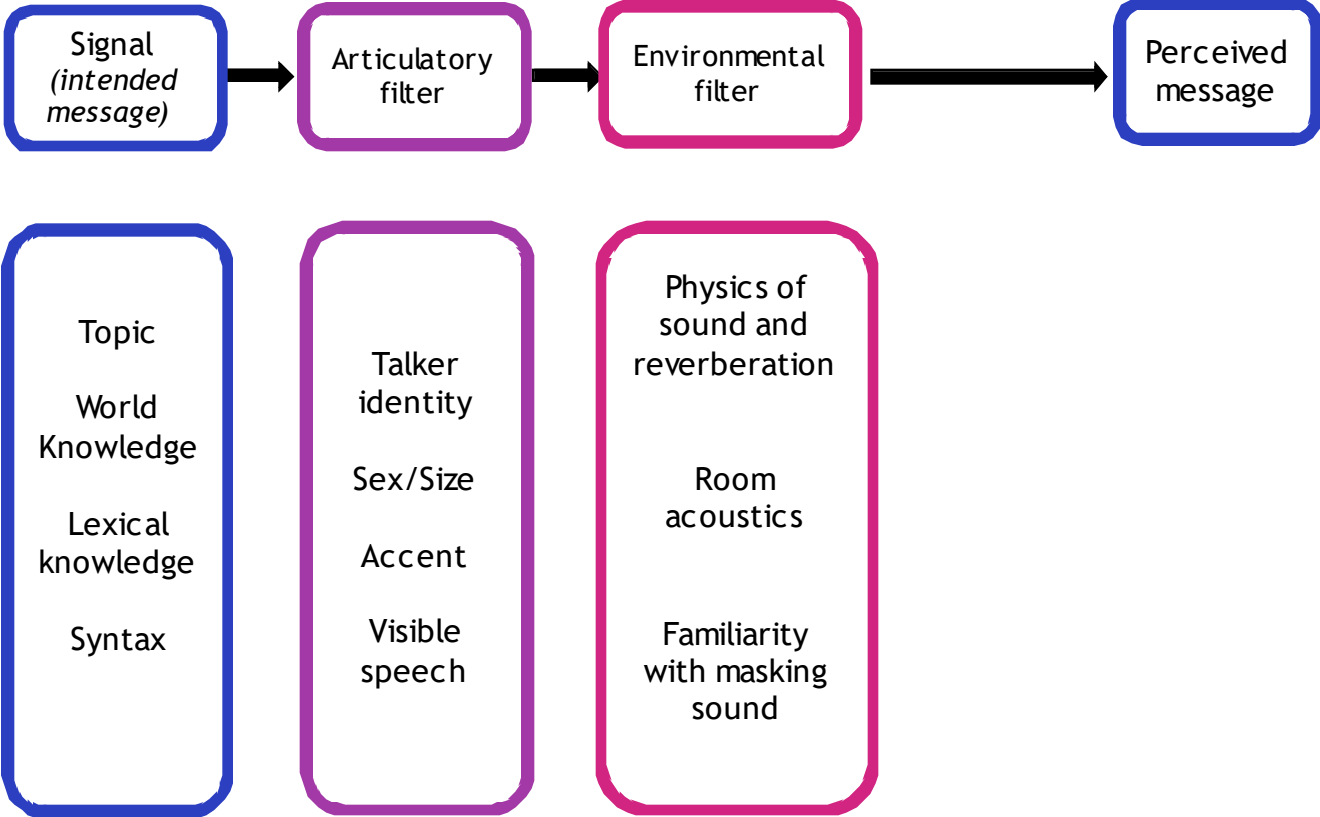
Learning Objectives

1. Describe how acoustic information and knowledge are combined in auditory perception.
2. Describe the evidence showing that familiar talkers are better understood than unfamiliar talkers when competing talkers are present.
3. Describe the evidence showing that the acoustic cues that listeners use to identify a person by voice are different from those used to realize an intelligibility benefit.
4. Describe the evidence showing that the familiar-talker benefit to intelligibility is probably due to reduced interference.
5. Predict listening situations in which listeners will be able to benefit from the presence of a familiar talker in a complex listening environment.

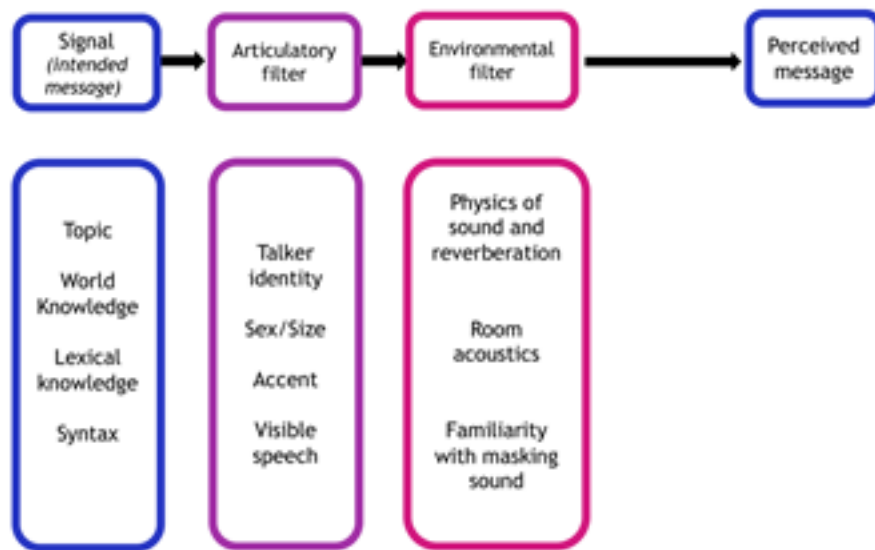
Kinds of knowledge that may facilitate speech understanding



Kinds of knowledge that may facilitate speech understanding



How might knowledge help speech perception?

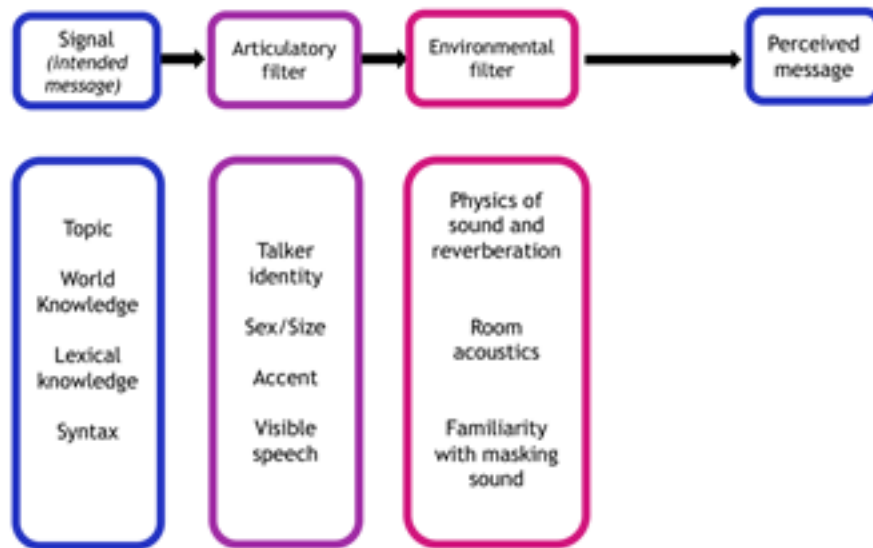


Knowledge may:

“Fill in” missing information



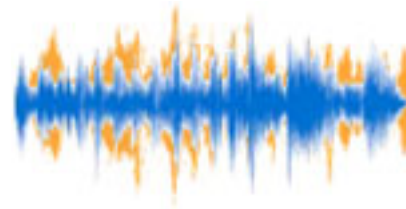
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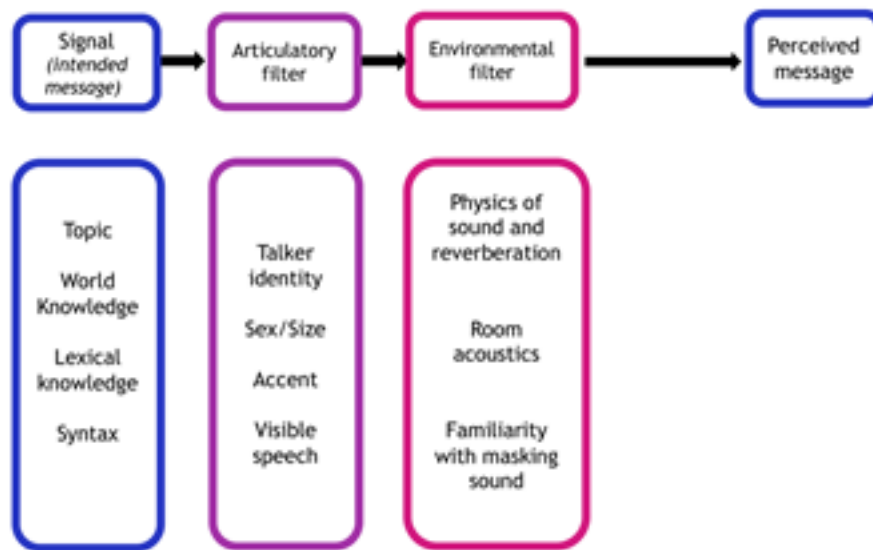
Knowledge may:

“Fill in” missing information

Allow you to “hear out” a familiar target (“template-matching” Bregman, 1990)



How might knowledge help speech perception?

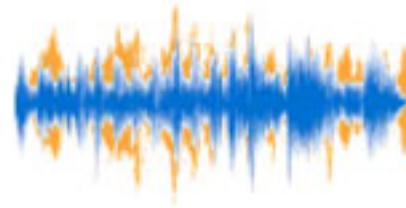


Knowledge may:

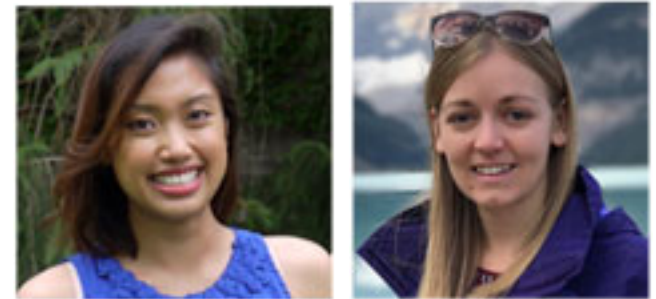
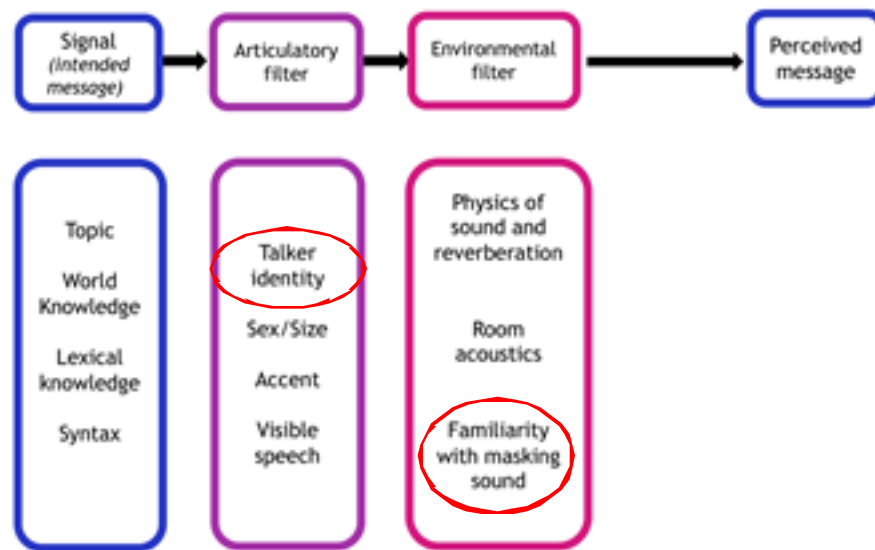
“Fill in” missing information

Allow you to “hear out” a familiar target (“template-matching” Bregman, 1990)

Enhance stream segregation



How might knowledge help speech perception?



Ysabel Domingo, MSc Emma Holmes, PhD
now at UCL

Johnsrude, Mackey, Hakyemez, Alexander, Trang & Carlyon (2013). Swinging at a cocktail party: Voice familiarity aids speech perception in the presence of a competing voice. *Psychological Science*, **24**, 1995-2004.

Holmes, Johnsrude (under review). Speech spoken by familiar people is more resistant to cognitive interference by linguistically similar speech.

Domingo, Holmes, Johnsrude (in revision). The benefit to intelligibility of hearing a familiar voice. *Journal of Experimental Psychology: Applied*

Holmes, Domingo, Johnsrude (2018) Familiar voices are more intelligible even if they are not recognized as familiar. *Psychological Science*, **29**, 1575-1583.

The benefit to speech perception of hearing a familiar talker



Familiar voices more intelligible:

Nygaard, Sommers & Pisoni (1994) Psychological Science

Nygaard & Pisoni (1998) Perception & Psychophysics

Yonan and Sommers (2000) Psychology and Aging

Newman & Evers (2007) J Phonetics

Rosenblum, Miller & Sanchez (2007) Psychological Science

Souza, Gehani, Wright, & McCloy (2013) J Am Acad Audiol

Kreitewolf, Mathias & von Kriegstein (2017) Front Psych

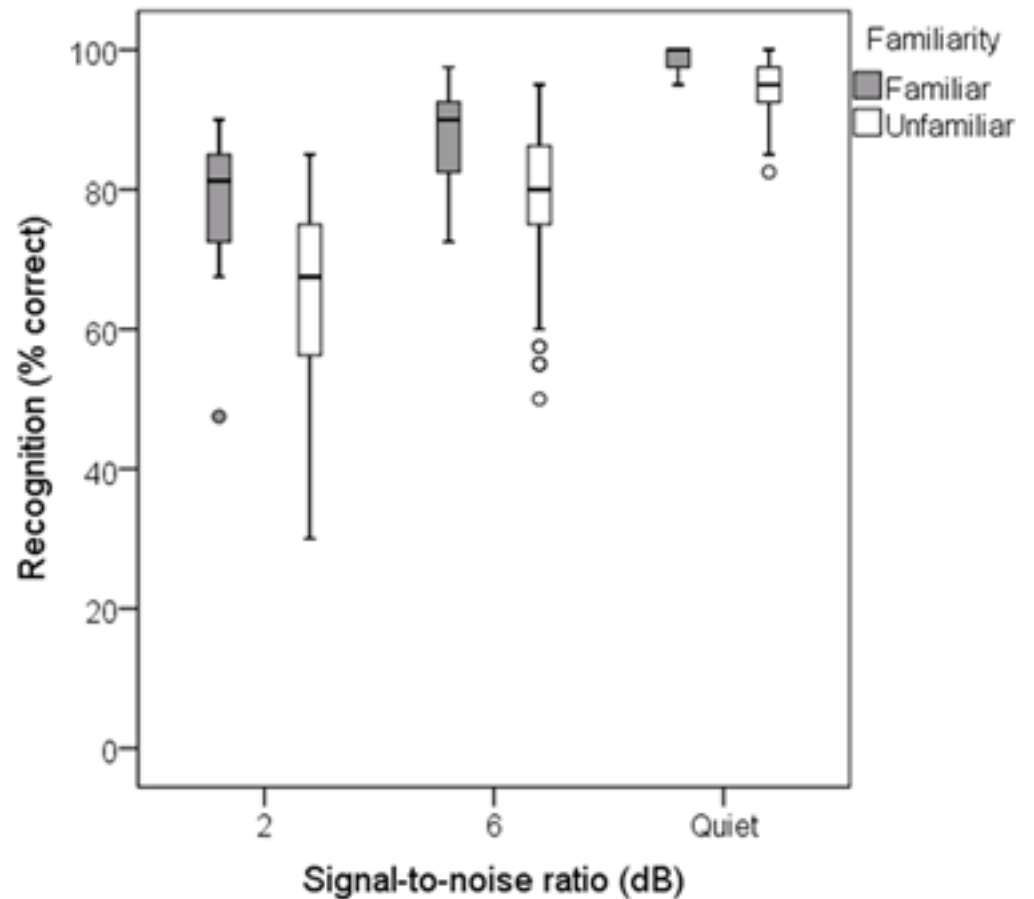
The advantage of knowing the talker.

Souza, Gehani, Wright, & McCloy (2013). J Am. Acad. Audiol. Sept, 24, 689-700

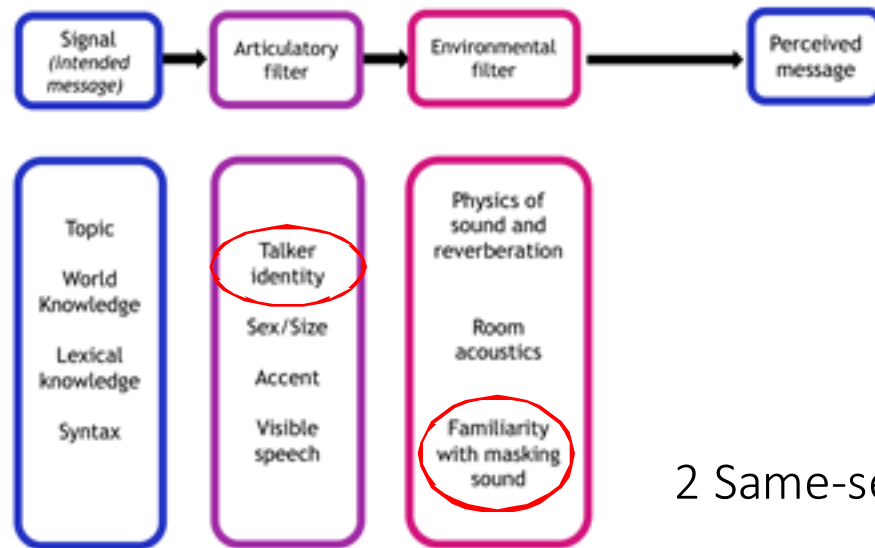
Middle aged vs older?

Bias effects?

Mechanism?

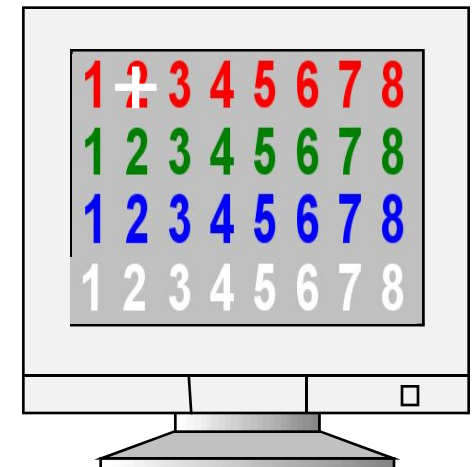


How might knowledge help speech perception?



Bob Carlyon
Cambridge University

The Coordinate Response Measure task
(Bolia et al, 2000, Brungart et al, 2001)



2 Same-sex talkers: 

Johnsrude, Mackey, Hakyemez, Alexander, Trang & Carlyon (2013). Swinging at a cocktail party: Voice familiarity aids speech perception in the presence of a competing voice. *Psychological Science*, **24**, 1995-2004.

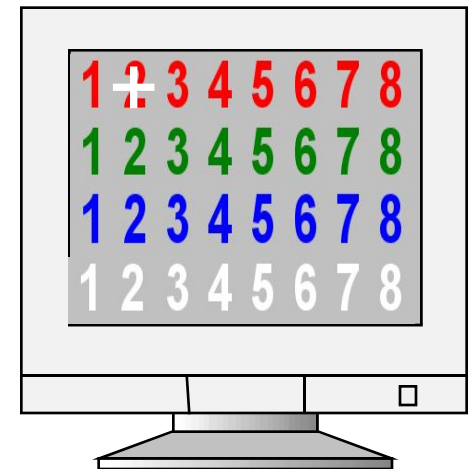
How might knowledge help speech perception?

Group	<i>n</i>	Sex		Age (years)		Years with spouse	
		Female	Male	<i>M</i>	Range	<i>M</i>	Range
< 60 years	24	14	10	54	44–59	27	18–40
≥ 60 years	22	9	13	67	60–79	35	20–49

Condition	Target voice	Masker voice
Familiar-Target	Familiar	Novel 1
	Familiar	Novel 2
Familiar-Masker	Novel 1	Familiar
	Novel 2	Familiar
Novel-Baseline	Novel 1	Novel 2
	Novel 2	Novel 1

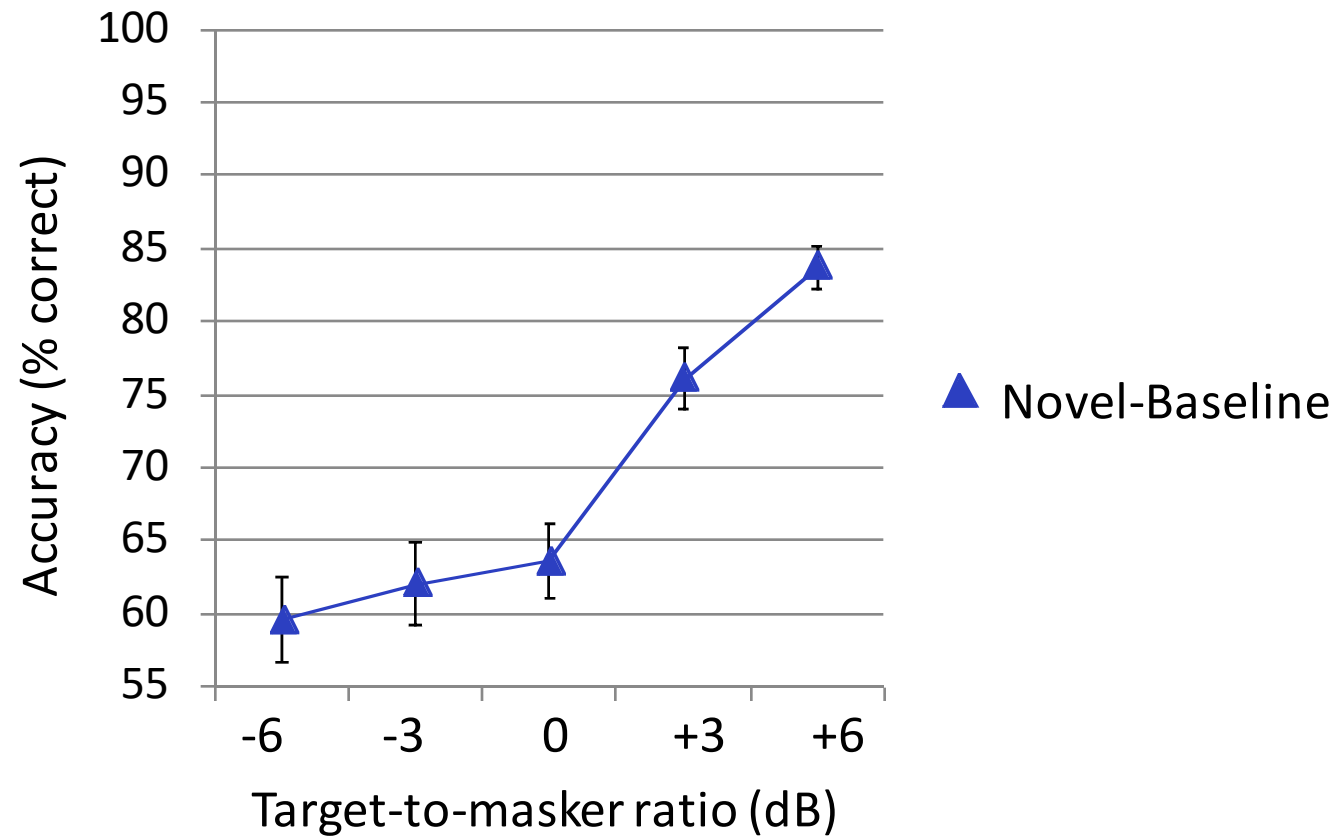
2 Same-sex talkers: 
 Target: Call Sign = “Baron”

TMR (-6, -3, 0, +3, +6 dB)
 600 trials total



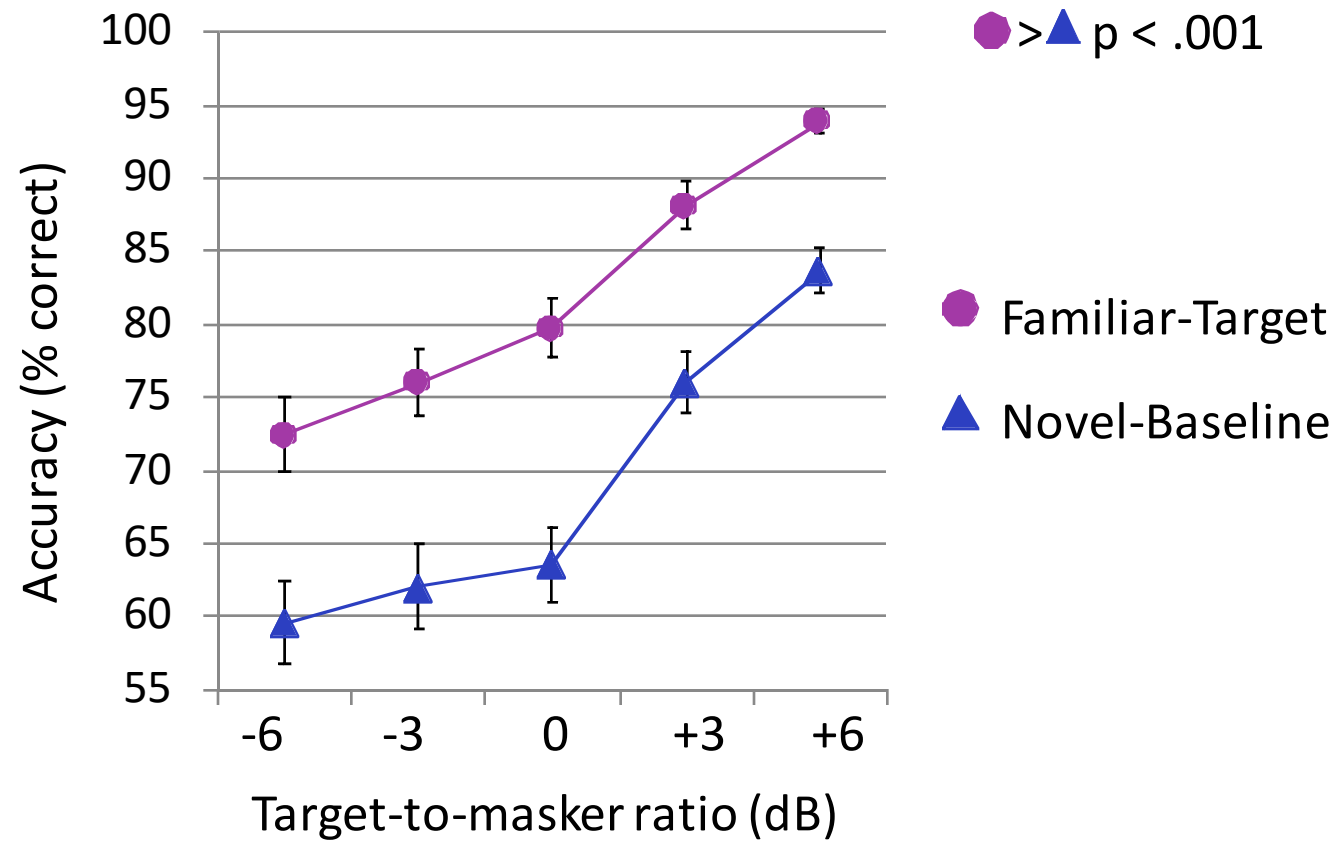
Johnsrude et al (2013) Psychological Science

Performance by condition



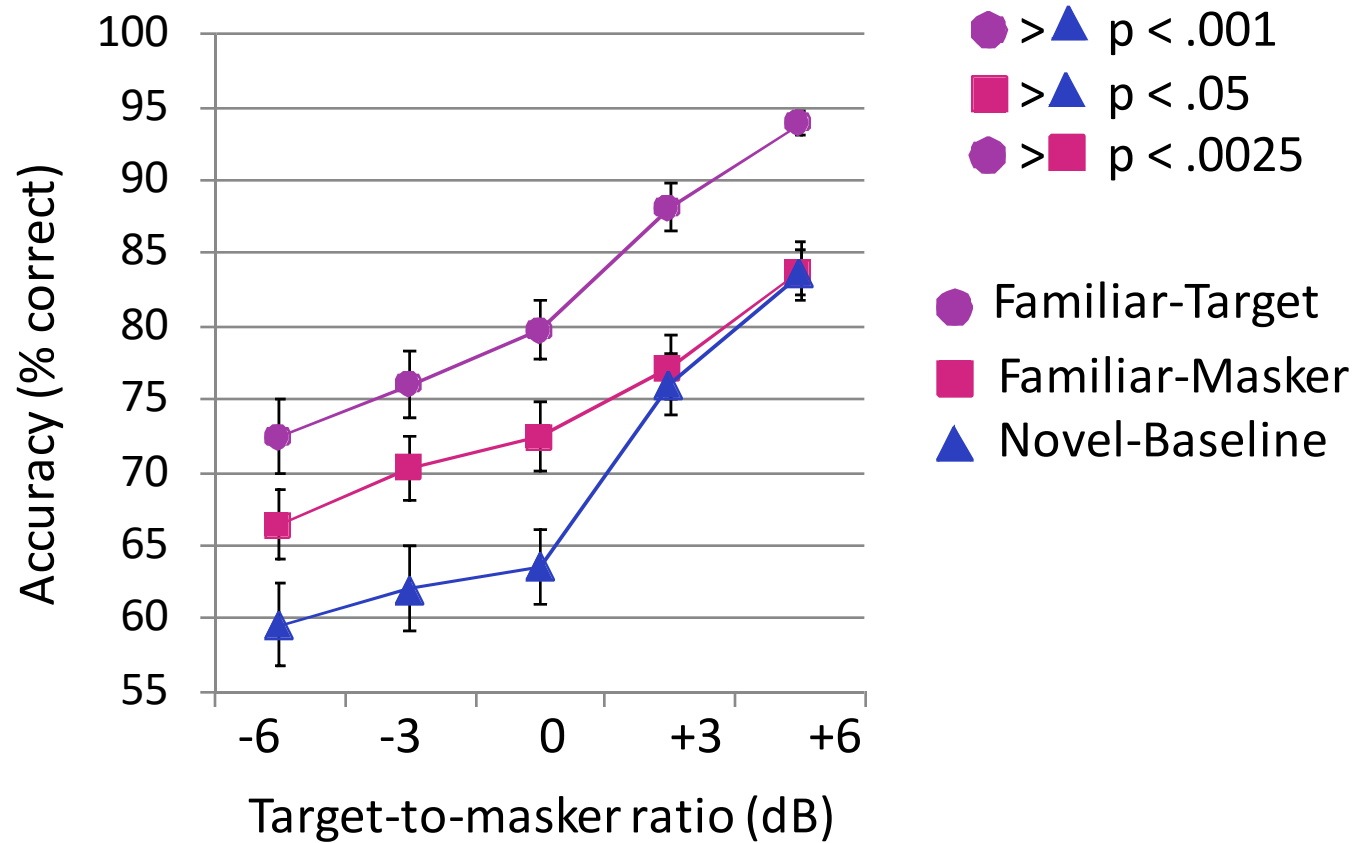
Johnsrude, Mackey, Hakyemez, Alexander, Trang & Carlyon (2013), Psych Science

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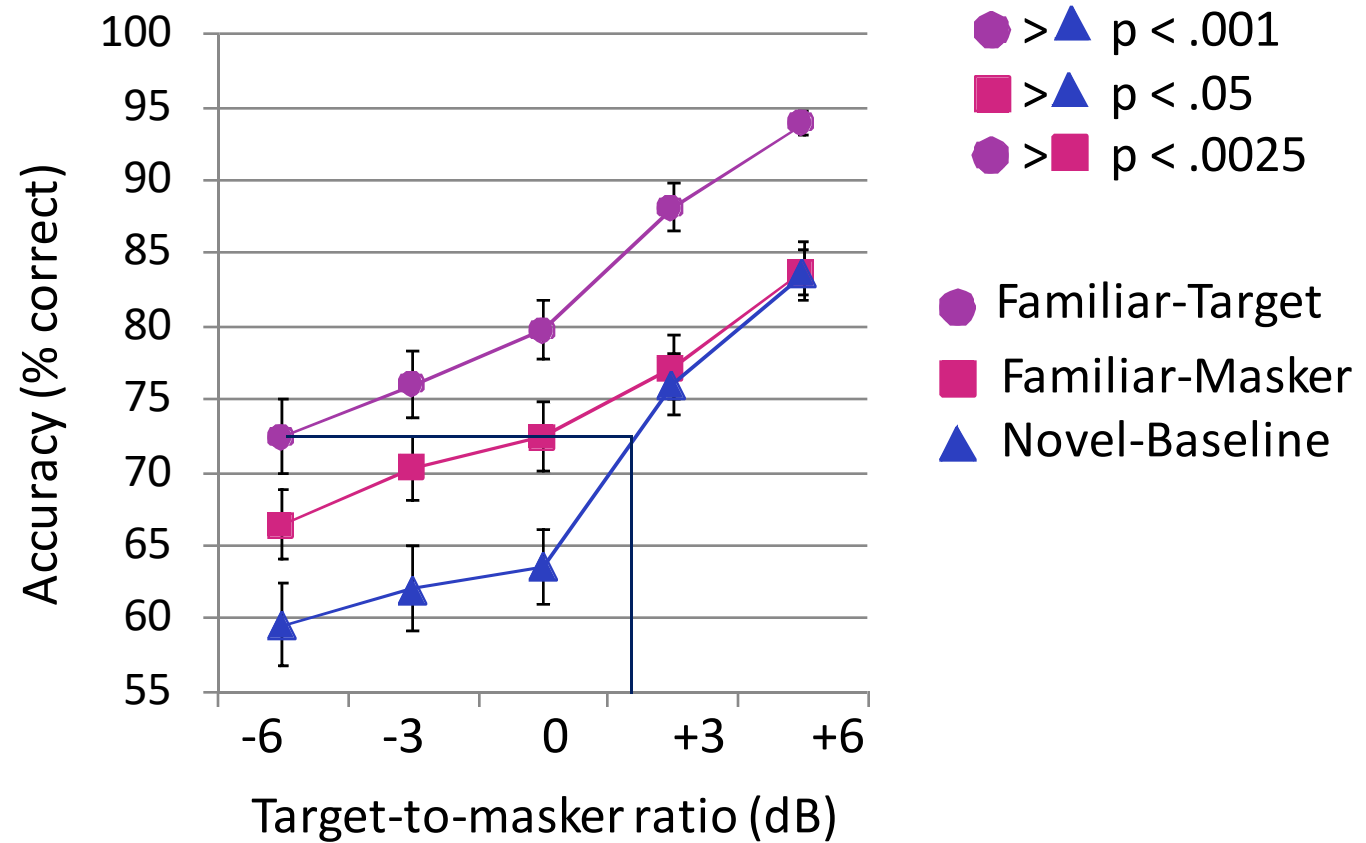
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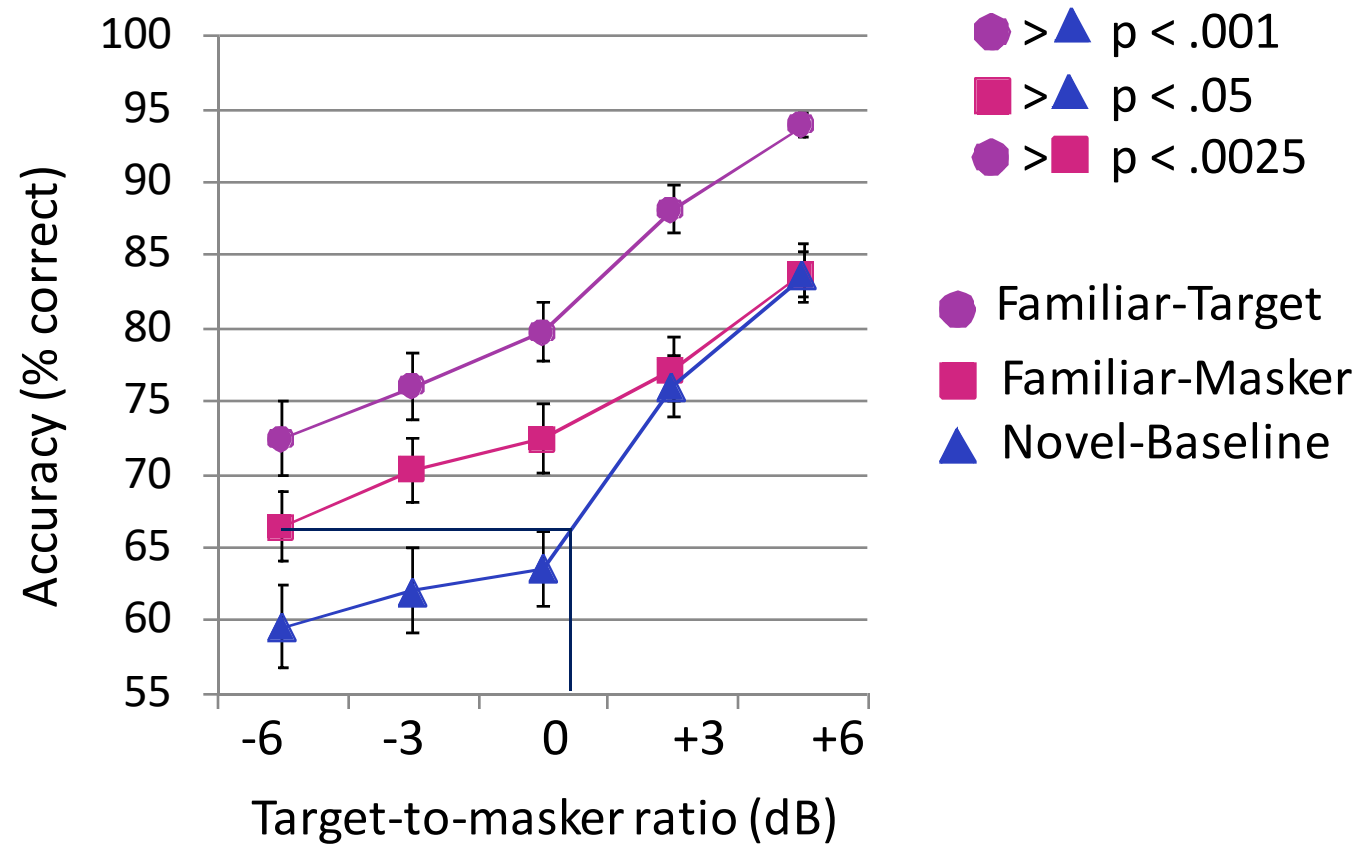
Johnsrude, Mackey, Hakyemez, Alexander, Trang & Carlyon (2013), Psych Science

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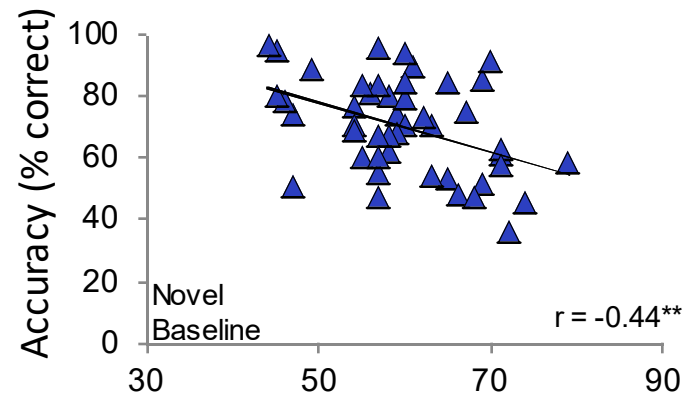
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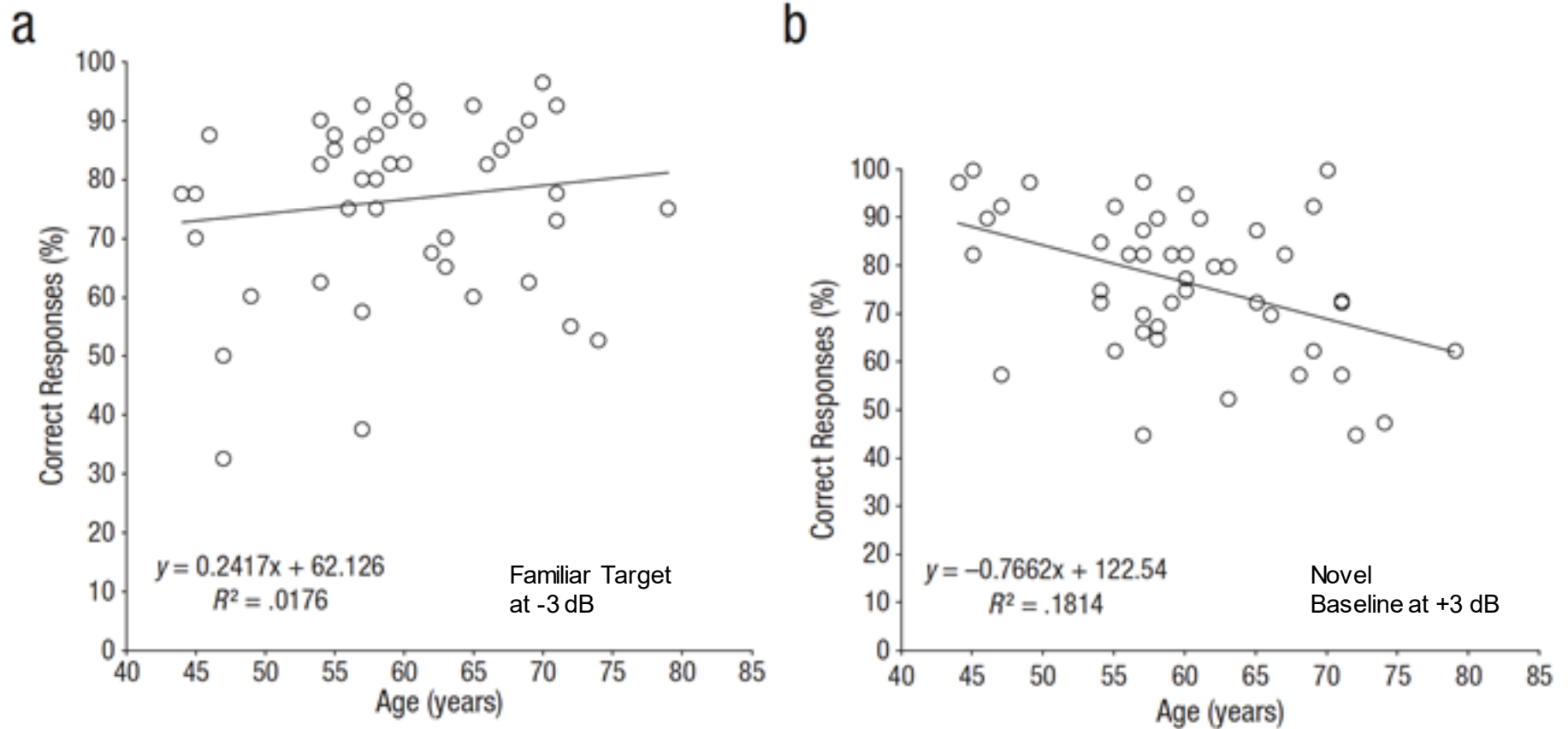
Johnsrude, Mackey, Hakyemez, Alexander, Trang & Carlyon (2013), Psych Science

Condition by age interaction



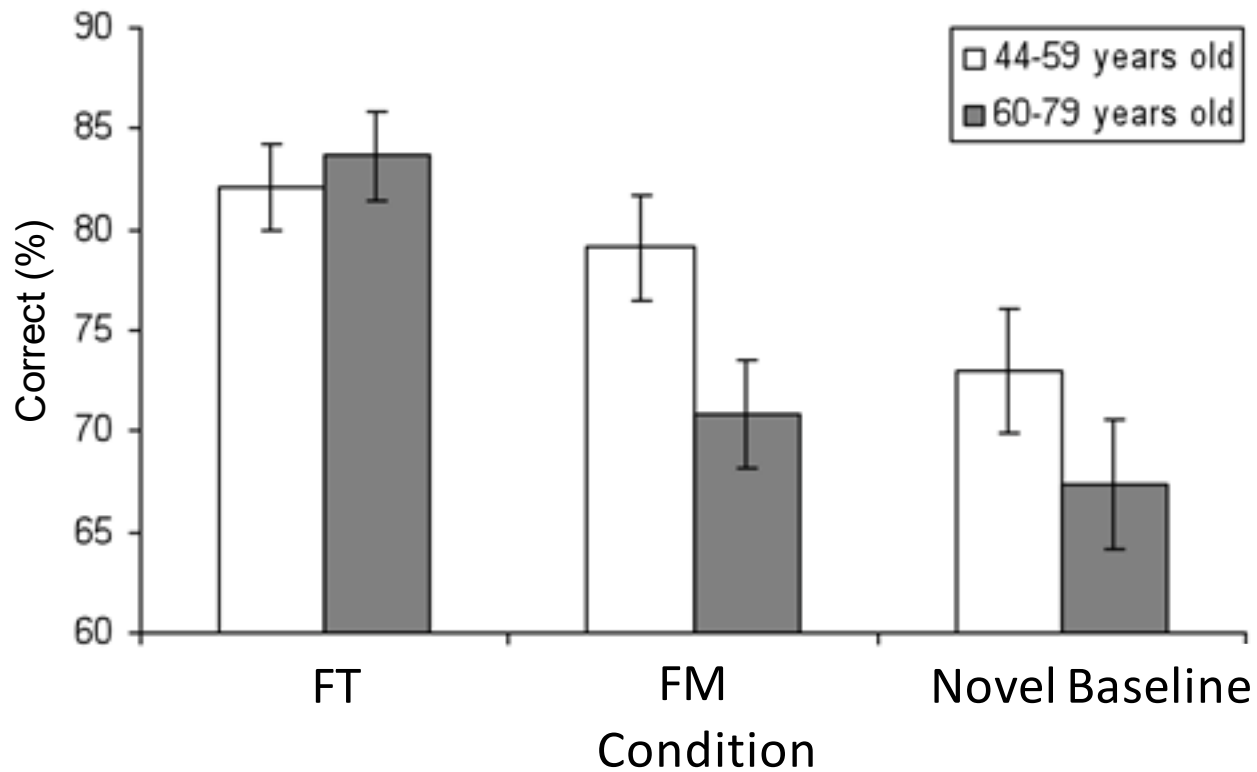
Johnsrude, Mackey, Hakyemez, Alexander, Trang & Carlyon (2013), Psych Science

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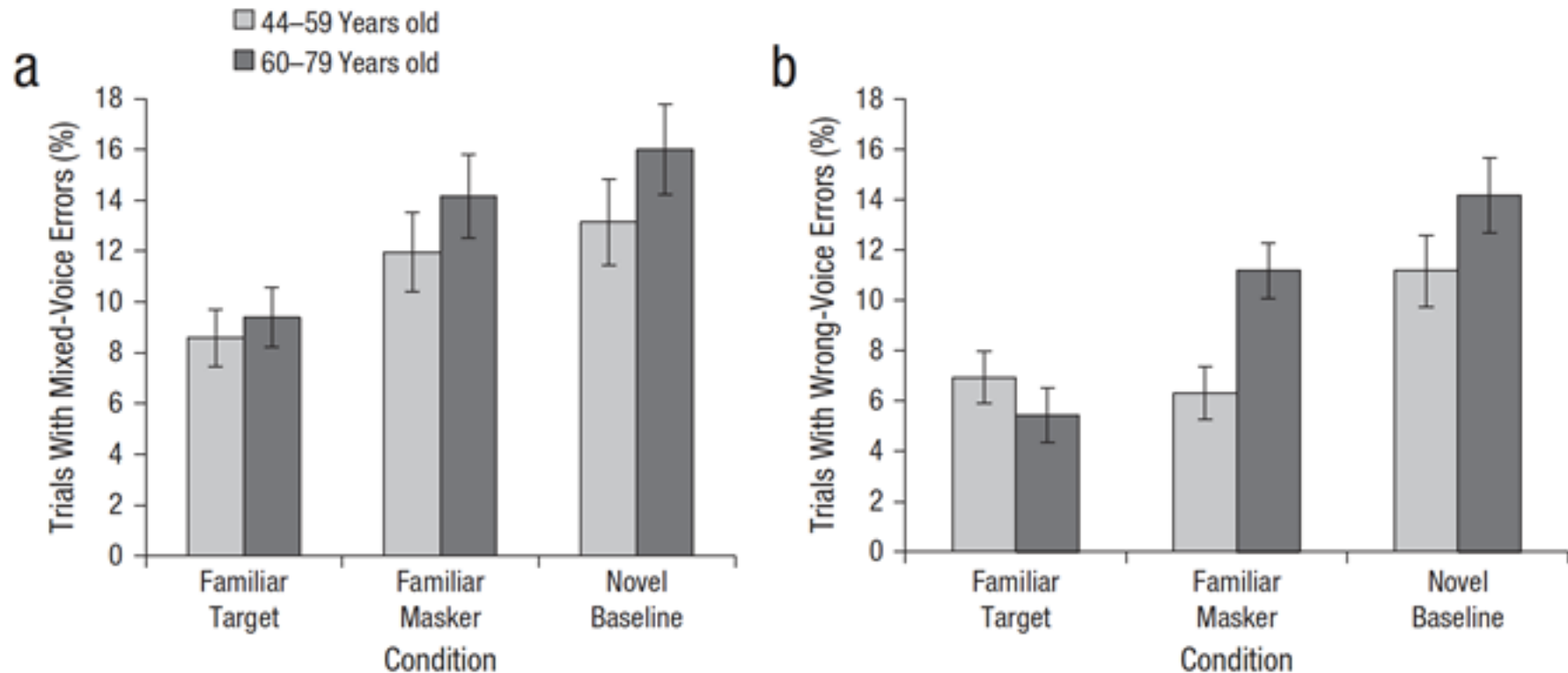
Johnsrude, Mackey, Hakyemez, Alexander, Trang & Carlyon (2013), Psych Science

Older people do not benefit from having their spouse as competing voice



Johnsrude, Mackey, Hakyemez, Alexander, Trang & Carlyon (2013), Psych Science

Types of error, by age group and condition



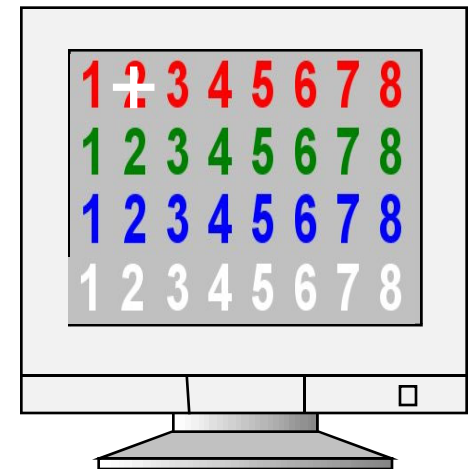
Johnsrude, Mackey, Hakyemez, Alexander, Trang & Carlyon (2013), Psych Science

Conclusions – Knowledge of a talker

- *Robust benefit when the familiar voice is the target.*
- *Is this true for less extremely familiar voices?*
- *Younger listeners, at least, benefited from having the spouse voice as masker, suggesting ability to perceptually organize voices / segregate streams) is enhanced (but... artefact of materials?)*
- *What acoustic characteristics matter for a familiar voice benefit?*
- *What about other types of maskers?*
- *Do familiar target voices help listeners compensate for age-related changes in hearing and cognition?*

The Coordinate Response Measure procedure

2 Same-sex talkers: 
Target: Call Sign = "Baron"



“Boston University Gerald” (BUG) corpus

Bob	Bought	Two	Big	Bags
Gene	Found	Three	Blue	Cards
Jane	Gave	Four	Cold	Gloves
Jill	Held	Five	Hot	Hats
Lynn	Lost	Six	New	Pens
Mike	Saw	Eight	Old	Shoes
Pat	Sold	Nine	Red	Socks
Sue	Took	Ten	Small	Toys

Replication (and extension) using the BUG corpus



Ysabel Domingo

Group	<i>n</i>	Sex		Age (years)		Years with partner	
		Female	Male	Median	Range	Median	Range
Friends	30	21	9	21	18-25	5	1-19
Spouses	30	15	15	60	28-82	27	4-52

Condition	Target voice	Masker voice
Familiar-Target	Familiar	Novel 1
	Familiar	Novel 2
Familiar-Masker	Novel 1	Familiar
	Novel 2	Familiar
Novel-Baseline	Novel 1	Novel 2
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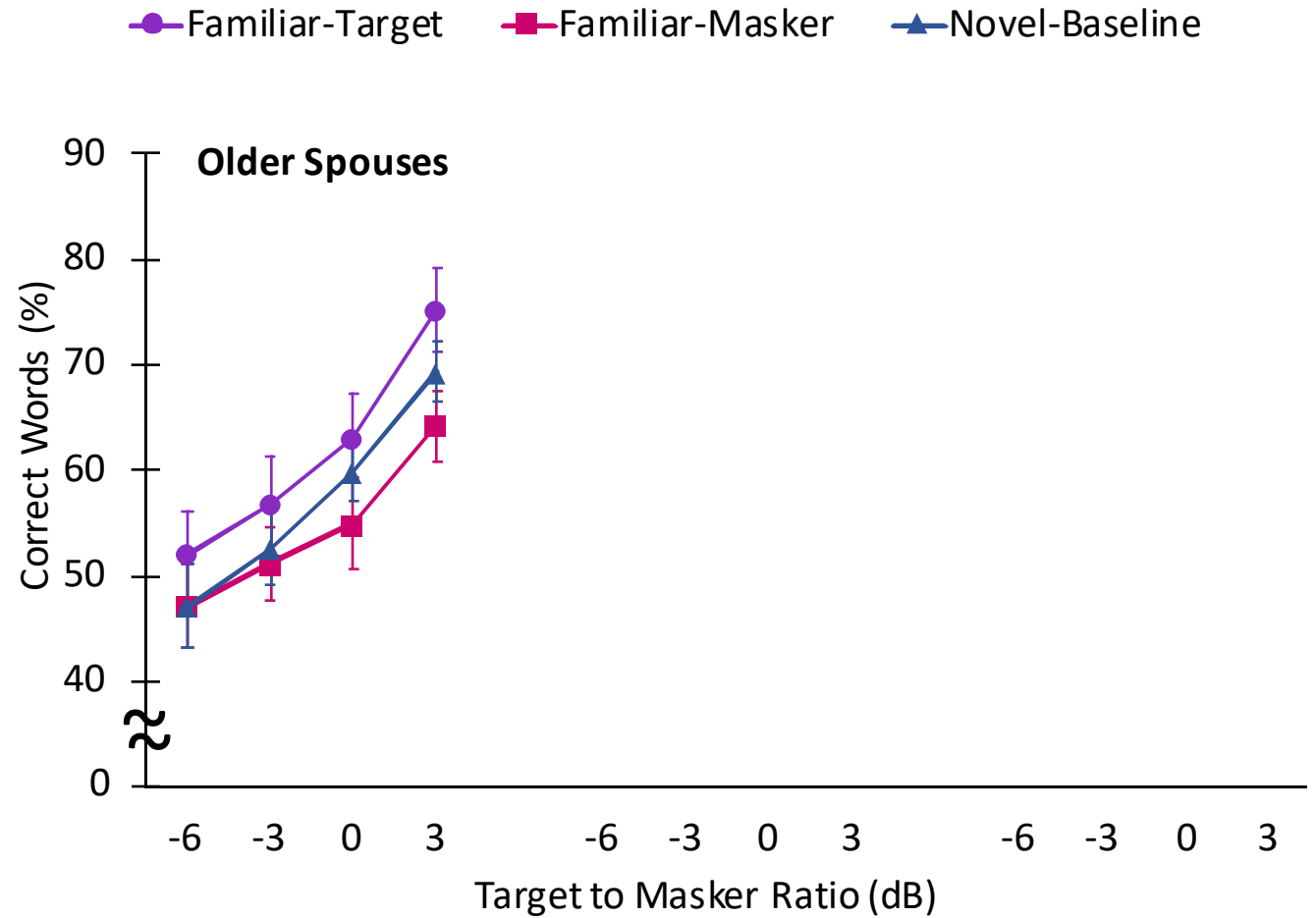


SNR (-6, -3, 0, +3 dB)
720 trials total

Bob

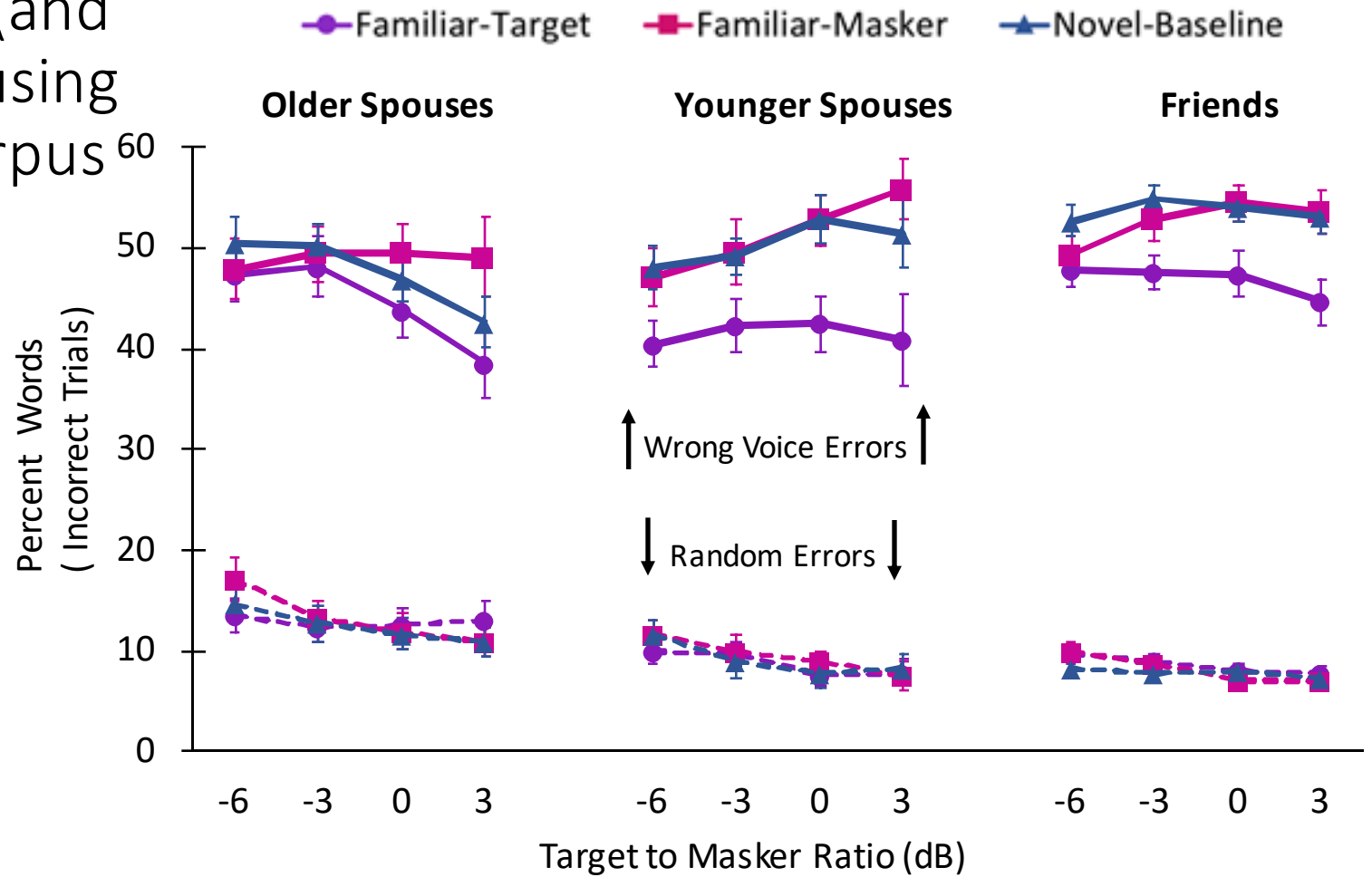
bought	eight	new	gloves
found	five	big	shoes
gave	four	red	cards
held	nine	cold	socks
lost	six	hot	hats
saw	ten	small	bags
sold	three	blue	pens
took	two	old	toys

Replication (and extension) using the BUG corpus



Domingo, Holmes, Johnsrude (in revision) *J Exp Psychol: Applied*

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Similar magnitude of benefit from a familiar talker.
- *Is this true for less extremely familiar voices?*

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Similar magnitude of benefit from a familiar talker.
- *Is this true for less extremely familiar voices?*
Yes - Similar benefit for shorter term, more casual relationships as for longterm spouses.
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May have been an artefact of the task. Results more compatible with a template matching than stream segregation mechanism.
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What acoustic features matter?

Identity recognition



Intelligibility in noisy environments



Emma Holmes

Holmes, Domingo, Johnsrude (2018) Familiar voices are more intelligible even if they are not recognized as familiar.
Psychological Science, **29**,1575-1583

What acoustic features matter?

Identity recognition

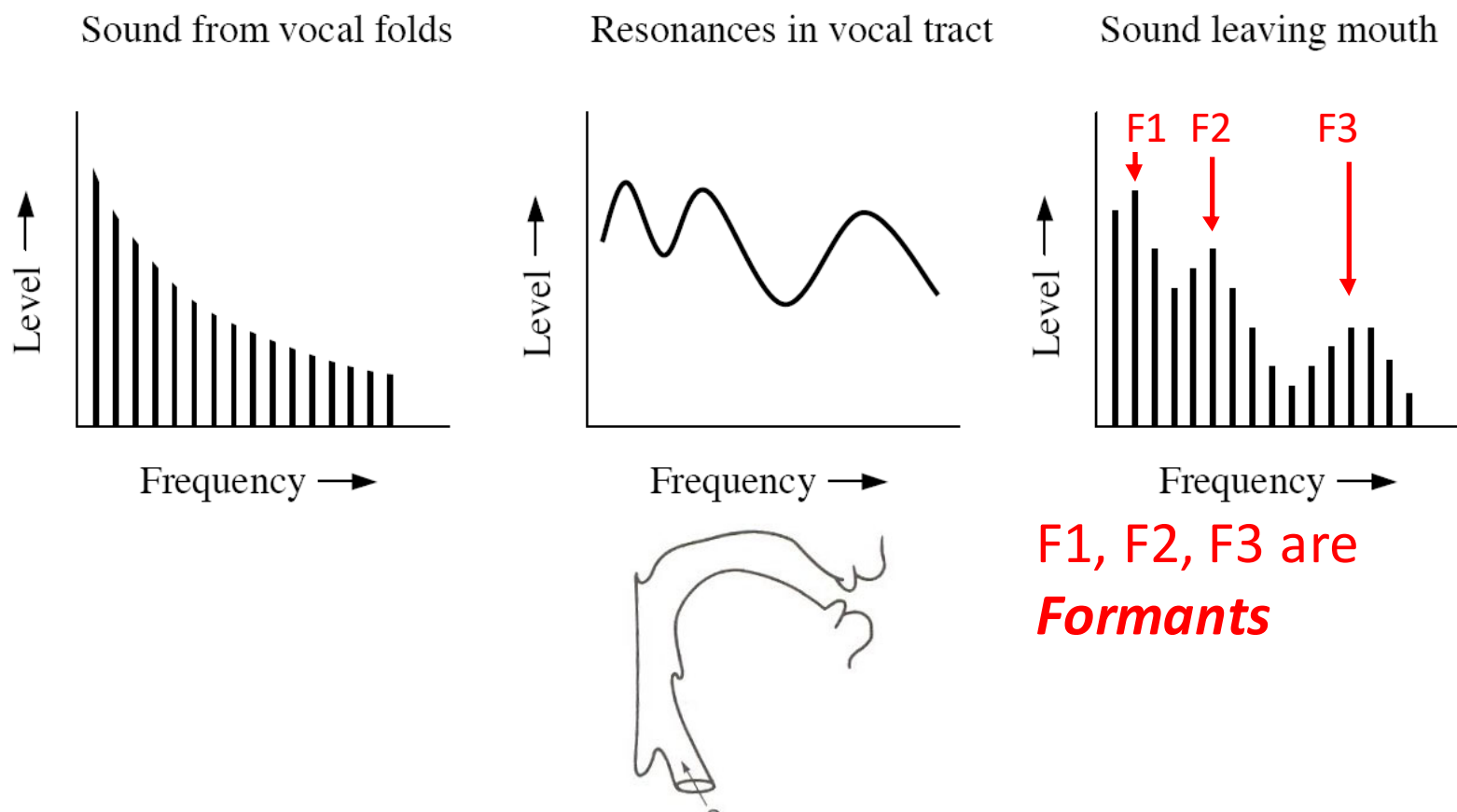
- **Fundamental frequency (f_0)**
(e.g., LaRiviere, 1975; Lavner et al., 2000, 2001; van Dommelen, 1987)
- **Vocal tract characteristics**
(e.g., Abberton & Fourcin, 1975; van Dommelen, 1990)

Intelligibility in noisy environments



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Source-filter model of speech production



What acoustic features matter?

Participants:

11 pairs: 15F, 8M

Age (years)

(median, range): 22, 19-24

Years known

(median, range): 2, 0.5-9

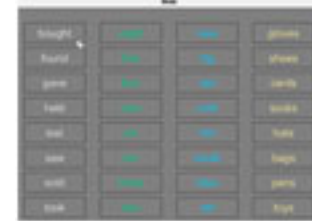
Explicit Recognition



Was this sentence spoken by your familiar voice?
Yes / No

Speech Intelligibility

Target e.g., "Bob lost two red gloves" Masker e.g., "Pat sold six small shoes"



Condition	Target voice	Masker voice
Familiar-Target	Familiar	Novel 1
	Familiar	Novel 2
Novel-Baseline	Novel 1	Novel 2
	Novel 2	Novel 1

SNR (-6, +3, dB)

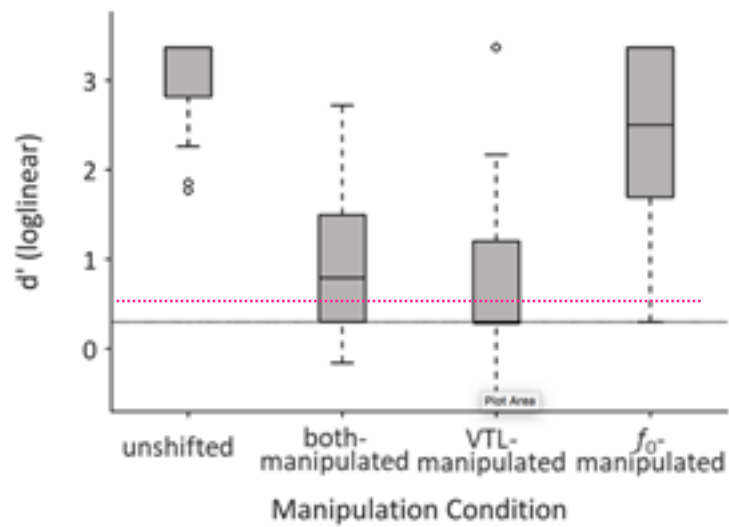
768 trials (32 per condition)

	Original f_0	Manipulated f_0
Original VTL	original f_0 original formants	$1.40 \times f_0$
Manipulated VTL	$1.27 \times$ formants	$1.40 \times f_0$ $1.27 \times$ formants

Holmes, Domingo, Johnsruide (2018) Familiar voices are more intelligible even if they are not recognized as familiar. *Psychological Science*, **29**, 1575-1583

Results

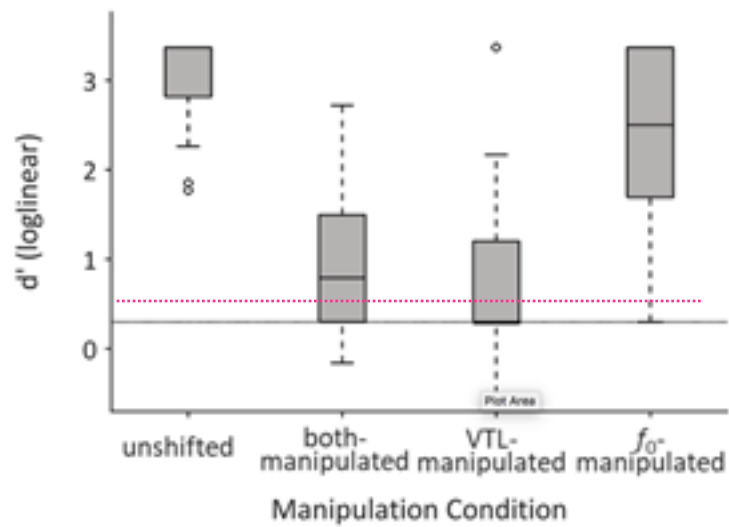
Explicit Recognition



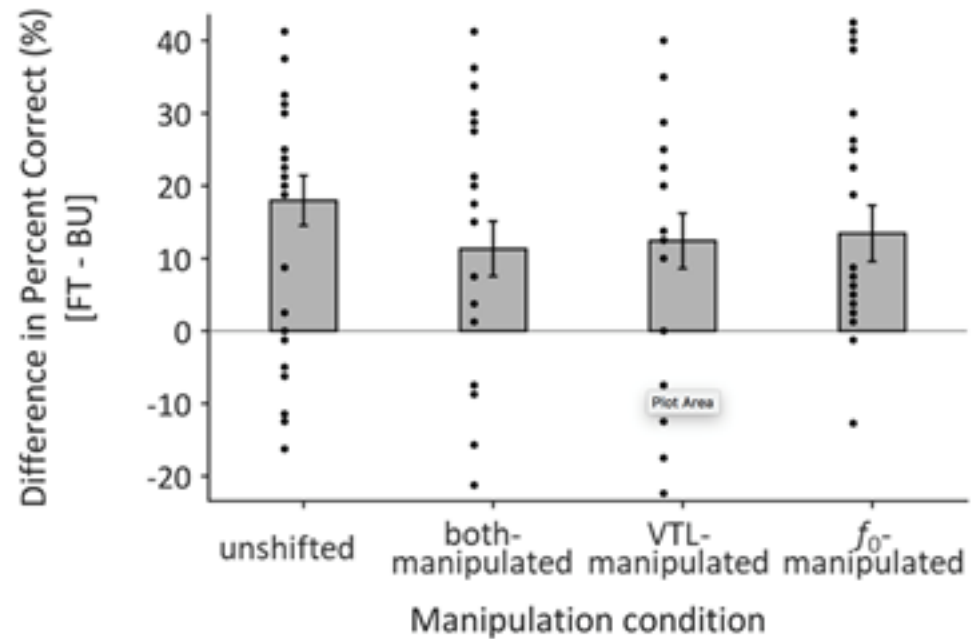
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Results

Explicit Recognition



Speech Intelligibility



Holmes, Domingo, Johnsrude (2018) Familiar voices are more intelligible even if they are not recognized as familiar. *Psychological Science*, **29**, 1575-1583

What acoustic features matter?

Recognition and intelligibility of familiar voices is robust to changes in voice fundamental frequency.

Different pattern of results for recognition and intelligibility when acoustics related to vocal tract length are manipulated.

Recognition severely affected by large VTL change; intelligibility less so, and no more than for f_0 change.

Smaller manipulation (1 JND) yielded no impairment in either recognition or intelligibility, and no difference between VTL and f_0 .

Explicit recognition and improved intelligibility of a familiar voice may rely on somewhat different acoustic information.

What about other kinds of masker?

Familiar voice benefit probably isn't due to enhanced segregation.

Benefit could be due to better perception of familiar target voice:

- template-matching

- altered auditory sensitivity

Should manifest regardless of masker type

Familiar voices are less susceptible to interference from similar maskers?

More benefit for more similar maskers

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Zokoll, Hochmuth, Warzybok, Wagener, Buschermöhle, and Kollmeier (2013) Am J Audiol.

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More benefit for more similar maskers

Target: Name= "Peter"

brought	two	cheap	chairs
gives	three	dark	desks
got	four	green	flowers
has	seven	heavy	houses
kept	eight	large	rings
ordered	nine	old	sofas
prefers	twelve	pretty	spoons
sees	fifteen	red	tables
sold	nineteen	small	toys
wants	sixty	white	windows

Zokoll, Hochmuth, Warzybok, Wagener, Buschermöhle, and Kollmeier (2013) Am J Audiol.

What about other kinds of masker?

3 Types of Masker:

- 1) English phrase
- 2) Spanish or Russian phrase
- 3) Signal Correlated Noise created from other maskers.

Adaptive procedure (50% SRT)

Target: Name= "Peter"

brought	two	cheap	chairs
gives	three	dark	desks
got	four	green	flowers
has	seven	heavy	houses
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Zokoll, Hochmuth, Warzybok, Wagener, Buschermöhle, and Kollmeier (2013) Am J Audiol.

What about other kinds of masker?

Participants:

9 pairs: 15F, 3M

Age (years):

(median, range): 22, 20-28

Years known each other:

(median, range): 2.9, 0.9-7.3

Target: Name= "Peter"



brought	two	cheap	chairs
gives	three	dark	desks
got	four	green	flowers
has	seven	heavy	houses
kept	eight	large	rings
ordered	nine	old	sofas
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Voices: 18 participants (15F, 3M),
1M, 1F Spanish/English bilingual
1M, 1F Russian/English bilingual

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Conditions:

Target	Masker (always same sex as target)
Partner 10 adaptive runs	

Holmes, Johnsrude (submitted).

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Partner 10 adaptive runs	English - 2/10 2 other participants; 1/10 Russian bilingual; 1/10 Spanish bilingual Russian/Spanish - 1/10 Russian bilingual; 1/10 Spanish bilingual SCN - 4/10 from English masker conditions.

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Unfamiliar 8 adaptive runs with each of 2 other participants	

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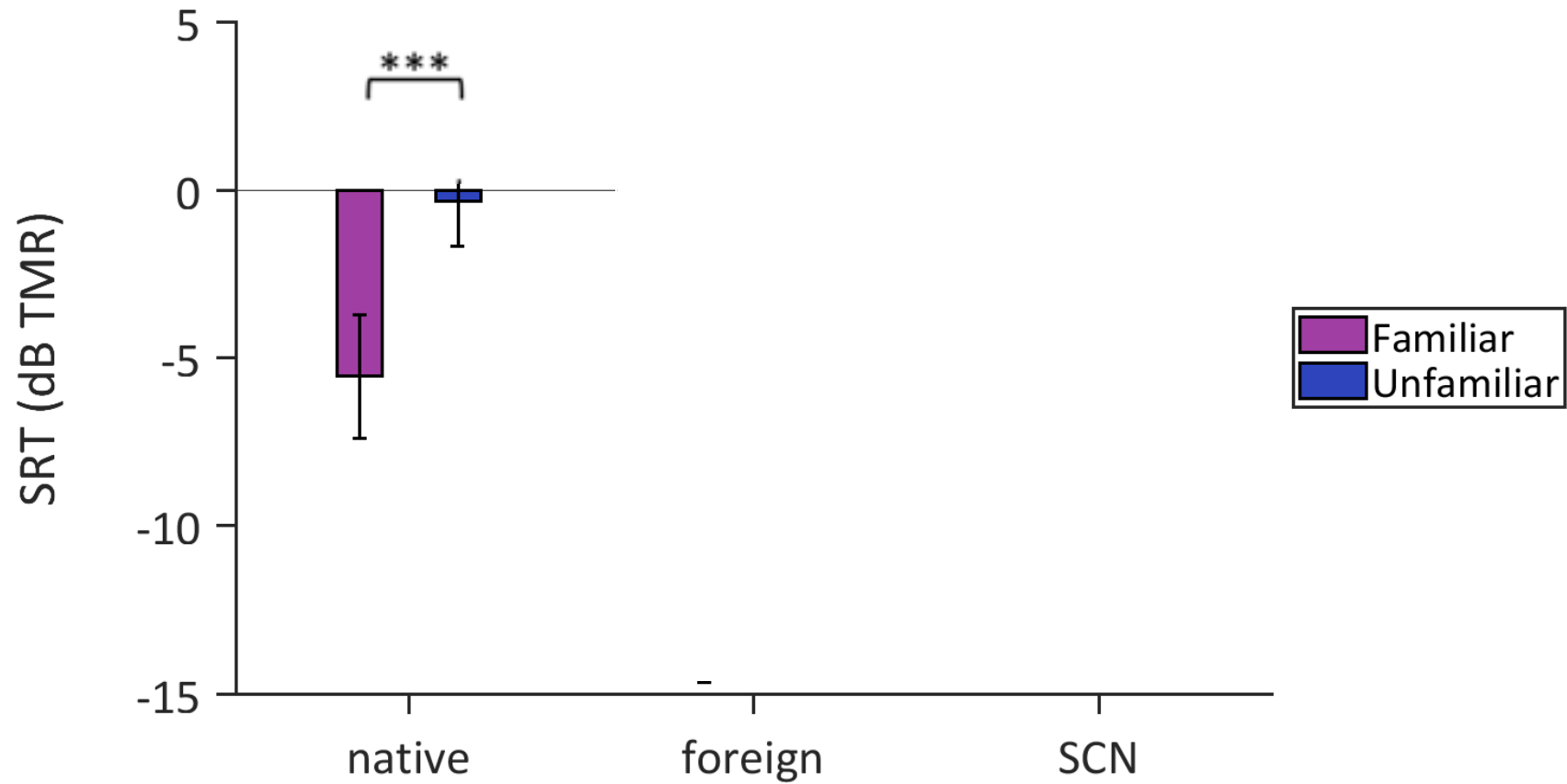
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Target	Masker (always same sex as target)
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Unfamiliar 8 adaptive runs with each of 2 other participants	English - 1/8 1 other participant; 1/8 Russian bilingual; 1/8 Spanish bilingual Russian/Spanish - 1/8 Russian bilingual; 1/8 Spanish bilingual SCN - 3/8 from English masker conditions.

Holmes, Johnsrude (submitted).

What about other kinds of masker?



Holmes, Johnsruide (submitted).

What about other kinds of masker?

Type of masker matters – most benefit when masker was most similar linguistically to familiar target.

Familiarity benefit in Souza et al (2013) when noise or babble is the masker may be due to bias, or perhaps the more naturalistic production (pacing, intonation) provided additional cues...?

*Benefit not due to better perception of familiar target voice because of, e.g.,
template-matching
altered auditory sensitivity*

Benefit is due to cognitive factors -- speech spoken by familiar and unfamiliar talkers may be perceived using cognitive mechanisms that are (at least partially) distinct.

Compatible with an episodic account of speech recognition (e.g., Goldinger, 1996; 1998), where speaker-specific information is stored and used in speech recognition; ‘talker normalization’ may not be (as) required for familiar talkers.

Conclusions

Familiar voices are easier to understand, at least when heard with competing speech

They don't seem to help when they are the competing speech.

Voices of close friends seem to be as beneficial as long term spouses.

The acoustic correlates of vocal tract length matter more for explicit recognition than does voice pitch information.

Even large manipulations of pitch and formant spacing didn't eradicate the familiarity benefit.

The familiar voice benefit is due to cognitive factors -- speech spoken by familiar and unfamiliar talkers may be perceived using cognitive mechanisms that are (at least partially) distinct.

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