WHAT CAN SYNESTHESIA TEACH US ABOUT SOUND SYMBOLISM?

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WHAT CAN SYNESTHESIA TEACH US ABOUT SOUND SYMBOLISM?
LINGUISTICS BACKGROUND
LINGUISTICS BACKGROUND

Arbitrariness

(de Saussure, 1959; Hockett, 1977; Gasser, 2004)
LINGUISTICS BACKGROUND

Arbitrariness

dog

Cane

chien

ferro

celb

(de Saussure, 1959; Hockett, 1977; Gasser, 2004)
SOUND SYMBOLISM

Crossmodal correspondences between word form and meaning
Sound Symbolism

Crossmodal correspondences between word form and meaning

(kiki)

(bouba)

(e.g., Maurer, Pathman, & Mondloch, 2006, Brown, Black, & Horowitz, 1955; DeFife, Nygaard, & Namy, 2014; Klank, Huang, & Johnson, 1971, Köhler, 1929; Kunihira, 1971)
SOUND SYMBOLISM

Crossmodal correspondences between word form and meaning

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(e.g., Maurer, Pathman, & Mondloch, 2006, Brown, Black, & Horowitz, 1955; DeFife, Nygaard, & Namy, 2014; Klank, Huang, & Johnson, 1971, Köhler, 1929; Kunihira, 1971)
**Sound Symbolism**

Crossmodal correspondences between word form and meaning

- Crossmodal correspondences are observed between the sound of a word and its meaning, often related to the natural sounds associated with the object or concept the word represents.

Examples:
- "robin" vs. bird
- "sparrow" vs. bird
- "cardinal" vs. bird
- "trout" vs. fish
- "salmon" vs. fish
- "bass" vs. fish

(Berlin, 1994)
SOUND SYMBOLISM

Crossmodal correspondences between word form and meaning

Albanian
Mandarin
Dutch
Romanian
Gujarati

Tamil
Indonesian
Yoruba
Turkish
Korean

(DeFife, Nygaard, & Namy, in prep; Kunihira, 1971; Nygaard, Cook, & Namy, 2009)
**SOUND SYMBOLISM**

Crossmodal correspondences between *word form* and *meaning*

- increases learnability for adults and *children* (e.g., Nygaard, Cook, & Namy, 2009; Imai et al., 2008)

- increases online language processing *speed* (Farmer, Christiansen, & Monaghan, 2006)
SOUND SYMBOLISM

Crossmodal correspondences between word form and meaning

• What are the cognitive mechanisms?
**Sound Symbolism**

Crossmodal correspondences between word form and meaning

- What are the cognitive mechanisms?
- Do crossmodal neural connections between sensory areas underlie sound symbolism?

(e.g., Revill, Namy, DeFife, & Nygaard, 2014; Ramachandran & Hubbard, 2001)
WHAT CAN SYNESTHESIA TEACH US ABOUT SOUND SYMBOLISM?
SYNESTHESIA

sensory or cognitive stimuli consistently cause additional sensory or cognitive experiences
SYNESTHESIA

• nonsynesthetes’ implicit associations match underlying patterns of synesthetes’ explicit associations (e.g., Simner et al., 2005; Ward et al., 2006)
SYNESTHESIA

• nonsynesthetes’ implicit associations match underlying patterns of synesthetes’ explicit associations (e.g., Simner et al., 2005; Ward et al., 2006)

• arises from additional and/or uninhibited neural connections (see Rouw, Scholte, & Colizoli, 2011 for a review)
SYNESTHESIA

• nonsynesthetes’ implicit associations match underlying patterns of synesthetes’ explicit associations (e.g., Simner et al., 2005; Ward et al., 2006)

• arises from additional and/or uninhibited neural connections (see Rouw, Scholte, & Colizoli, 2011 for a review)

Synesthesia is an exaggerated form of normal crossmodal processing? (e.g., Brang et al., 2011)
WHAT CAN SYNESTHESIA TEACH US ABOUT SOUND SYMBOLISM?
Is there a link between synesthesia and sound symbolism?

1. Are synesthetes more sensitive to sound symbolism than nonsynesthetes?

2. Is sound symbolism found within synesthetic associations?
Is there a link between synesthesia and sound symbolism?

1. Are synesthetes more sensitive to sound symbolism than nonsynesthetes?

2. Is sound symbolism found within synesthetic associations?
EXPERIMENT 1

Auditory 2AFC task with 400 foreign words
(DeFife, Nygaard, & Namy, in prep)

• 10 languages
  – Albanian, Dutch, Gujarati, Indonesian, Korean, Mandarin, Romanian, Tamil, Turkish, and Yoruba

• 4 antonym pairs
  – big/small, bright/dark, up/down, loud/quiet

19 grapheme-color synesthetes
57 controls

(Bankieris & Simner, under review)
EXPERIMENT 1

dark  bright
EXPERIMENT 1

down

up
EXPERIMENT 1

Mixed-effects logistic regression

Mean accuracy ~ group * domain

\[ \text{synesthete} \quad \text{control} \]
\[ \text{BigSmall} \quad \text{LoudQuiet} \quad \text{DownUp} \quad \text{BrightDark} \]
EXPERIMENT 1 PREDICTIONS

GLOBAL

Mean Accuracy

Control

Synesthete
EXPERIMENT 1 PREDICTIONS
EXPERIMENT 1 PREDICTIONS

GLOBAL

SPECIFIC

INTERFERENCE
Experiment 1 Results

Significant group effect $\beta = .05$, $z = 2.19$, $p < .05$
Experiment 1 Predictions

GLOBAL

Mean Accuracy

BigSmall  Loud Quiet  Bright Dark  Down Up

Control  Synesthete
EXPERIMENT 1 PREDICTIONS

GLOBAL

SPECIFIC

![Bar chart for global and specific predictions]

- **GLOBAL**
  - Mean Accuracy
  - Categories: BigSmall, LoudQuiet, BrightDark, DownUp

- **SPECIFIC**
  - Mean Accuracy
  - Categories: BigSmall, LoudQuiet, BrightDark, DownUp
EXPERIMENT 1 PREDICTIONS

GLOBAL

SPECIFIC

INTERFERENCE
EXPERIMENT 1 RESULTS
EXPERIMENT 1 RESULTS

- $p < .1$
- $p < .05$

Comparison between Control and Synesthete conditions for different stimuli (BigSmall, LoudQuiet, BrightDark, DownUp) with error bars indicating standard deviation.
EXPERIMENT 1 RESULTS

○ p < .1, * p < .05
Is there a link between synesthesia and sound symbolism?

1. Are synesthetes more sensitive to sound symbolism than nonsynesthetes? Yes!

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1. Are synesthetes more sensitive to sound symbolism than nonsynesthetes? Yes!

2. Is sound symbolism found within synesthetic associations?
EXPERIMENT 2

Case study of a lexical-gustatory synesthete
• 479 word-flavor pairs

**TRIGGER WORD**
cavalry

**FLAVOR**
dark chocolate

(Bankieris & Simner, 2013)
## Experiment 2

<table>
<thead>
<tr>
<th>TRIGGER WORD</th>
<th>FLAVOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>cavalry</td>
<td>dark chocolate</td>
</tr>
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</table>

**Coded:**

- **vowel**
  - height
  - backness
  - roundedness
- **consonant**
  - manner of articulation
  - place of articulation
  - voicing
- **consonants vs. vowels**
EXPERIMENT 2

**TRIGGER WORD**
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**FLAVOR**
dark chocolate

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# EXPERIMENT 2

**TRIGGER WORD**

`cavalry – /kæ.vəl.ri/

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**TRIGGER WORD**

*cavalry* – /kæ.vəl.ri/

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**Trigger Word**

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EXPERIMENT 2

TRIGGER WORD

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</tr>
<tr>
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\[
\frac{\text{total voiced} \times 1 + \text{total unvoiced} \times -1}{\text{total consonants}}
\]
# EXPERIMENT 2

**TRIGGER WORD**

```
cavalry – /kæ.vəl.ri/
```

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</tr>
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<td>l</td>
<td>voiced</td>
</tr>
<tr>
<td>r</td>
<td>voiced</td>
</tr>
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\[
\frac{(\text{total voiced} \times 1) + (\text{total unvoiced} \times -1)}{\text{total consonants}}
\]

\[
\frac{(3\times1) + (1\times-1)}{4} = .5
\]
Experiment 2

Trigger Word: cavalry

Flavor: dark chocolate

Coded:
- Vowel
  - Height
  - Backness
  - Roundedness
- Consonant
  - Manner of articulation
  - Place of articulation
  - Voicing
- Consonants vs. vowels
Experiment 2

TRIGGER WORD

cavalry

Coded:

- vowel
  - height
  - backness
  - roundedness
- consonant
  - manner of articulation
  - place of articulation
  - voicing
- consonants vs. vowels

20 controls rated:

- sweet
- sour
- bitter
- salty
- umami

FLAVOR

dark chocolate

1 2 3 4 5
not at all extremely
# Experiment 2

## Trigger Word

**cavalry**

## Flavor

**dark chocolate**

### Coded:

- **vowel**
  - height
  - backness
  - roundedness
- **consonant**
  - manner of articulation
  - place of articulation
  - voicing
- **consonants vs. vowels**

### 20 Controls Rated:

- sweet: .37
- sour: -.23
- bitter: 0.05
- salty: -.27
- umami: -.19

Scale:

1. not at all
2. 3. 4. 5. extremely
EXPERIMENT 2

TRIGGER WORD: cavalry

FLAVOR: dark chocolate

Coded:
- vowel
  - height
  - backness
  - roundedness
- consonant
  - manner of articulation
  - place of articulation
  - voicing
- consonants vs. vowels

20 controls rated:
- sweet
- sour
- bitter
- salty
- umami

1 2 3 4 5
not at all extremely

5 step-wise linear regression models
**Experiment 2 Results**

**Trigger Word**

- cavalry

**Flavor**

- dark chocolate

**Coded:**

- **Vowel**
  - height
  - backness
  - roundedness

- **Consonant**
  - manner of articulation
  - place of articulation
  - voicing

- **Consonants vs. Vowels**

**20 Controls Rated:**

- sweet
- sour
- bitter
- salty
- umami

- **5 step-wise linear regression models**

- high vowels p < .001
- obstruents p < .05

- 1 not at all
- 2
- 3
- 4
- 5 extremely
## Experiment 2 Results

<table>
<thead>
<tr>
<th>Phonemic trigger</th>
<th>Taste</th>
</tr>
</thead>
<tbody>
<tr>
<td>high vowels*</td>
<td>sour</td>
</tr>
<tr>
<td>obstruents</td>
<td>umami</td>
</tr>
</tbody>
</table>

* matches nonsynesthetes’ associations

(Crisinel & Spence, 2009, 2010a, 2010b; Simner et al., 2010; Whalen & Levitt, 1995)
Research Questions

Is there a link between synesthesia and sound symbolism?

1. Are synesthetes more sensitive to sound symbolism than nonsynesthetes? Yes!

2. Is sound symbolism found within synesthetic associations? Yes!
Research Questions

Is there a link between synesthesia and sound symbolism?

1. Are synesthetes more sensitive to sound symbolism than nonsynesthetes? Yes!

2. Is sound symbolism found within synesthetic associations? Yes!
Is there a link between synesthesia and sound symbolism? Yes!
Is there a link between synesthesia and sound symbolism? Yes!

Synesthesia and sound symbolism may emerge from common crossmodal mechanisms

- left superior parietal cortex

(Brang et al., 2013; Revill et al., 2014; Rouw & Scholte, 2007)
CONCLUSIONS & FUTURE DIRECTIONS

Synesthesia is a useful tool for investigating general cognition

- Statistical learning
- Ideal cue integration
THANKS!

Jools Simner

Dick Aslin

FULBRIGHT

NIH
SUPPLEMENTARY SLIDES
**EXPERIMENT 2**

**SAUSAGE**

<table>
<thead>
<tr>
<th></th>
<th>MT1</th>
<th>MT2</th>
<th>MT3</th>
</tr>
</thead>
<tbody>
<tr>
<td>bitter</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>salty</td>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>savory</td>
<td>4</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>sour</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>sweet</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

**Flavor profile**

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>bitter</td>
<td>-0.57</td>
</tr>
<tr>
<td>salty</td>
<td>0.85</td>
</tr>
<tr>
<td>savory</td>
<td>0.7</td>
</tr>
<tr>
<td>sour</td>
<td>-0.58</td>
</tr>
<tr>
<td>sweet</td>
<td>-0.04</td>
</tr>
</tbody>
</table>

Normalize by individual participants’ mean and SD

Take overall mean
## Experiment 2

**Proportions**

<table>
<thead>
<tr>
<th>Proportion</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>close</td>
<td>.5</td>
</tr>
<tr>
<td>mid</td>
<td>0</td>
</tr>
<tr>
<td>open</td>
<td>.5</td>
</tr>
<tr>
<td>back</td>
<td>0</td>
</tr>
<tr>
<td>central</td>
<td>1</td>
</tr>
<tr>
<td>front</td>
<td>1</td>
</tr>
<tr>
<td>rounded</td>
<td>0</td>
</tr>
</tbody>
</table>

**Proportions**

<table>
<thead>
<tr>
<th>Proportion</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>labial</td>
<td>0</td>
</tr>
<tr>
<td>coronal</td>
<td>1</td>
</tr>
<tr>
<td>dorsal</td>
<td>0</td>
</tr>
<tr>
<td>glottal</td>
<td>0</td>
</tr>
<tr>
<td>sonorant</td>
<td>0</td>
</tr>
<tr>
<td>voiced</td>
<td>.5</td>
</tr>
<tr>
<td>vowel</td>
<td>.5</td>
</tr>
</tbody>
</table>

**Flavor profile**

<table>
<thead>
<tr>
<th>Flavor</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>bitter</td>
<td>-0.15</td>
</tr>
<tr>
<td>salty</td>
<td>-0.38</td>
</tr>
<tr>
<td>savory</td>
<td>-0.33</td>
</tr>
<tr>
<td>sour</td>
<td>1.09</td>
</tr>
<tr>
<td>sweet</td>
<td>0.46</td>
</tr>
</tbody>
</table>

The word 'acid' is linked to 'warheads'.
CONTROL TASK
WAIS vocabulary subtest

• Define 35 words via telephone interview
• Each response scored 0-2 for correctness and completeness of definition
• Raw scores converted to scaled scores based on age (Wechsler, 1981)
RESULTS: CONTROL TASK

$W = 444.5, p = .3$