Acoustic bases of sound symbolism

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Roadmap

- Introduction: General discussion on sound symbolism
- Part I: Sound symbolism in names (Experiments I, II, III)
- Part II: A trans-modal symbolic relationship among sounds, shapes, and emotions (Experiments I, II, III)

Large Question 1

- Do sounds themselves have meanings?
- The Saussurian dictum: No, the sound-meaning connection is arbitrary.
- There is no inherent reason for why, for example, what we call [kæt] has to be called this way. In fact different languages call that animal by a different name.

Saussuare

- Saussuare raises the principle of arbitrariness as the first principle in his book.

The link between signal and signification is arbitrary. Since we are treating a sign as the combination in which a signal is associated with a signification, we can express this more simply as: *the linguistic sign is arbitrary*. (Emphasis in the original text.)

There is no internal connexion, for example, between the idea 'sister' and the French sequence of sounds *s-õ-r* which acts as its signal. The same idea might as well be represented by any other sequence of sounds. This is demonstrated by differences between languages, and even by the existence of different languages.

(taken from [41], p67-68.)

Cratylus

- However, some people have strong intuitions about meanings of certain sounds (at least since Cratylus in Plato).

Now the letter rho, as I was saying, appeared to the imposer of names an excellent instrument for the expression of motion; and he frequently uses the letter for this purpose: for example, in the actual words rein and roe he represents motion by rho; also in the words tromos (trembling), trachus (rugged); and again, in words such as krouein (strike), thrauein (crush), ereikein (bruise), thruptein (break), kermatixein (crumble), rumbein (whirl): of all these sorts of movements he generally finds an expression in the letter R, because, as I imagine, he had observed that the tongue was most agitated and least at rest in the pronunciation of this letter, which he therefore used in order to express motion.

(Taken from Wikipedia article "Sound symbolism"; see also [16])

Sapir 1929

English-speaking society does, for some reason or other, feel that of these two vowels, *a*, by and large, is possessed of a greater potential magnitude symbolism than the contrasted vowel *i*. The same feeling seems to be illustrated by the small number of Chinese cases [p. 231]

...

On the whole, it will be observed that the symbolic discriminations run encouragingly parallel to the objective ones based on phonetic considerations [p. 233]

...

It is difficult to resist the conclusion that in some way a significant proportion of normal people feel that, other things being equal, a word with the vowel *a* is likely to symbolize something larger than a similar word with the vowel *i*, or *e*, or *ε*...[40, p.235]

Jakobson 1978

[D]istinctive features, while performing a significative function, are themselves devoid of meaning. Neither a distinctive feature taken in isolation, nor a bundle of concurrent distinctive features (i.e., a phoneme) taken in isolation, means anything. Neither nasality as such nor the nasal phoneme /n/ has any meaning of its own.

...

Owing to neuropsychological laws of synaesthesia, phonetic oppositions can themselves evoke relations with musical, chromatic, olfactory, tactile, etc. sensations. For example, the opposition between acute and grave phonemes has the capacity to suggest an image of bright and dark, of pointed and rounded, of thin and thick, of light and heavy, etc. This sound symbolism, this inner value of the distinctive features, although latent, is brought to life as soon as it finds a correspondence in the meaning of a given word and in our emotional or aesthetic attitude towards this word and even more towards pairs of words with two opposite meanings. [18, p.112-113]

Large Question 2

- To the extent that sound symbolism exists, it seems that sound symbolic patterns make phonetic sense.
- "On the whole, it will be observed that the symbolic discriminations run encouragingly parallel to the objective ones based on phonetic considerations". [40, p.233]
- Example: [a] is big because the mouth is open-wide [2; 30; 37].
- or that its low frequency energy implies a large resonator [35; 36].

Jespersen 1922

The reason why the sound [i] comes to be easily associated with small, and [u, o, a] with bigger things, may be to some extent the high pitch of the vowel (in some African languages, a high tone is used for small, and a low tone for big things, Meinhof, *Die mod. Sprachforsch. in Afrika*, 81); the perception of the small lip aperture in one case and the more open mouth in the other may have also its share in the rise of the idea. [20, p.558-559]

Large Question 2

- Question: are sound symbolic relations based on articulation or (psycho)acoustics? (or both, for that matter)
- Reminiscent of the debate on “the object of speech perception”: gestural [15; 26] vs. perceptual [9; 11].
- Also a debate on the bases of distinctive features: articulatory [7; 39] vs. auditory [14; 19].

Arguments for articulatory bases

- Deaf children show sensitivity to sound symbolic patterns [13].
- The effects of sound symbolism are stronger when speakers read the stimuli out loud (i.e. when they use their actual articulators) [25].
- F1 of [a] is high; so it could imply "small", but such a pattern is not well attested in a cross-linguistic study [48] (though see [12]) or an experimental study [42].
- Particularly puzzling because F1 distributes around a range to which our auditory system is most sensitive [27].

Arguments for acoustic bases

- H-tones can mean "small" [34].
- F2 patterns predict the images about sizes very well [33; 42].
- Animals (birds, mammals, and chimpanzees) manipulate their F0 to show aggressiveness or submissiveness [1; 31].
- (However, non-speech sounds seem to have failed to evoke expected images of size: [4; 45]; though see below.)

The focus of Part I: Phonology of names

1. Male names are more likely to receive initial stress; e.g. *Dániel* vs. *Daniélle* (95% for male names and 75% for female names: [8]).
2. Male names are shorter; e.g. *Melanie, Jessica* (2.1 syllables for males v.s. 2.4 syllables for females: [51]), and less likely to be abbreviated [5].
3. Female names are more likely to contain long vowels and diphthongs; e.g. *Grace, Jane*.
4. Female names are more likely to have stressed [i]; e.g. *Nína, Tína* (ca. 15% for female names and 5% for male names: [8]).
5. Male names are less likely to end with a vowel (e.g. *Tina* vs. *Tim*).
6. Male names are more likely to contain obstruents (e.g. *Eric* vs. *Erin*).

Obstruents=male; sonorants=female

- These sound symbolic patterns in names have been studied by several researchers (perhaps more in psychology than in linguistics) [5; 6; 8; 44; 46; 49; 50; 51].

- We focus on the last sound symbolic relation: obstruents=male; sonorants=female [6; 44; 46; 50; 51].
- This correlation has been shown to hold in English (see above) and Japanese [47].
- Cross-linguistically, less sonorous consonants are more likely to appear initially for the term ‘father’ than for ‘mother’ [32].
- In addition to the descriptive correlation, women’s pictures were rated “hotter” with names with sonorants than with names with obstruents [38].

Experiment I-III: Productivity of the obstruent-male connection in English

- The first two experiments tested the correlation between obstruents and male names (and sonorants and female names).
- Experiment I: Obstruents are more likely to be associated with male names than female names by English speakers.
- Experiment II: Non speech sounds with abrupt amplitude modulation are more likely to be associated with male names.
- Overall conclusion I: Abrupt amplitude modulation implies male names.
- Overall conclusion II: Non-speech sounds can cause sound symbolic patterns (contra [4]).
- Experiment III: We will have some fun with some new Japanese data.

Stimuli

- Disyllabic words. Word-initial and word-internal consonants varied between obstruents and sonorants.
- Four conditions: OO, OS, SO, SS.
- First vowel: [a, e, ɪ, o, u]; second vowel: [ə, i] (10 combinations).
- Two items per each vowel combination.

Stimuli

	OO	OS	SO	SS
a-ə	tagə bakə	tawə tayə	labə makə	yamə ralə
e-ə	depə tekə	derə pemə	mebə yegə	weyə rewə
ɪ-ə	kɪbə tibə	kɪnə tiwə	mɪbə ligə	yɪmə wiyə
o-ə	dokə dopə	gomə dowə	wobə mogə	yorə noyə
u-ə	dukə pukə	kunə puwə	mubə nukə	munə muyə

Stimuli

	OO	OS	SO	SS
a-i	kabi	gawi	laki	mayi
	tadi	gayi	yabi	yawi
e-i	tegi	gemi	repi	reni
	tepi	geli	nebi	yewi
ı-i	tıpi	gıri	mıgi	yıni
	tıgo	bıyi	mıbi	nıwi
o-i	boki	kowi	woki	yoli
	pobi	gomi	rogi	woyi
u-i	buki	kuni	ruki	wuni
	gugi	tuwi	yugi	luri

Stimuli

- Two native English speakers repeated all the stimuli 3 times (one female, one male).
- The recorded tokens were acoustically resynthesized with a uniform falling contour (female speaker 300Hz-200Hz with linear interpolation: male speaker: 150Hz-100Hz).
- Peak amplitude were also modified to 0.7 by using Praat [3].

A sample speech stimuli

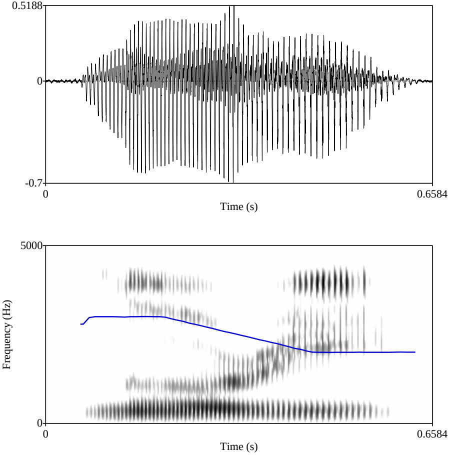


Figure: A sample speech stimuli with a uniform pitch movement and controlled amplitude.

Procedure

- 25 native speakers of English listened to each stimulus, and judged whether it sounds like a male name or a female name.
- The experiment took place in a sound-attenuated room in the Rutgers Phonetics Lab.
- All the participants were Rutgers undergraduate students, and they received extra credit.

Results

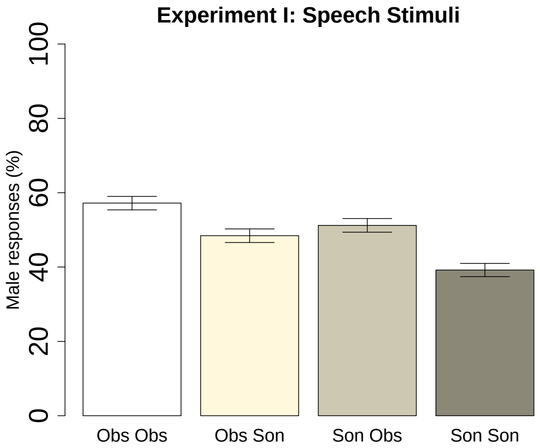


Figure: The results of Experiment I. The error bars represent 95% confidence intervals.

Results

- A logistic linear mixed model.
- Obstruents in the initial position increased male responses ($z = 4.45, p < .001$).
- So did obstruents in the second syllable ($z = 6.15, p < .001$).
- The interaction was not significant ($z = 1.88$, *n.s.*).
- The results confirm the productivity of the sound symbolic relationship between obstruents and male names.

Experiment II

- Question I: What is it that makes obstruents sound male?
- A hypothesis: Stop bursts are characterized by abrupt amplitude modulation.
- Question II: Does the sound symbolic pattern have an acoustic basis?
- An experiment with non-speech sounds (inspired by a general auditorist approach to speech perception: [10; 17; 22; 23; 29; 28]).

Stimuli

- Sine waves: periodic, gradual amplitude change.
- Square waves: periodic, abrupt amplitude change.
- White noise: aperiodic, abrupt amplitude change.
- (Aperiodic sounds inherently involve abrupt amplitude changes; therefore no aperiodic noise with gradual amplitude change).
- One potential confound: sine waves are simplex; square waves are complex.
- We also varied the frequencies of sine waves and square waves from 150Hz to 300Hz with a 50Hz increment to test the frequency code hypothesis [35; 36].

Non-speech stimuli

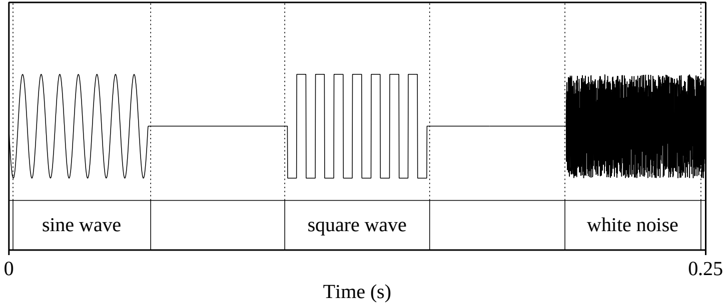


Figure: The non-speech stimuli.

Procedure

- Experiment II was run after Experiment I separated by a break.
- The participants were told that non-speech stimuli were extraterrestrial words.
- There was a familiarization phase in which listeners listened to each stimulus once (but did nothing else).
- The same task as Experiment I: they were asked to judge whether each sound is a male name or a female name.

Results

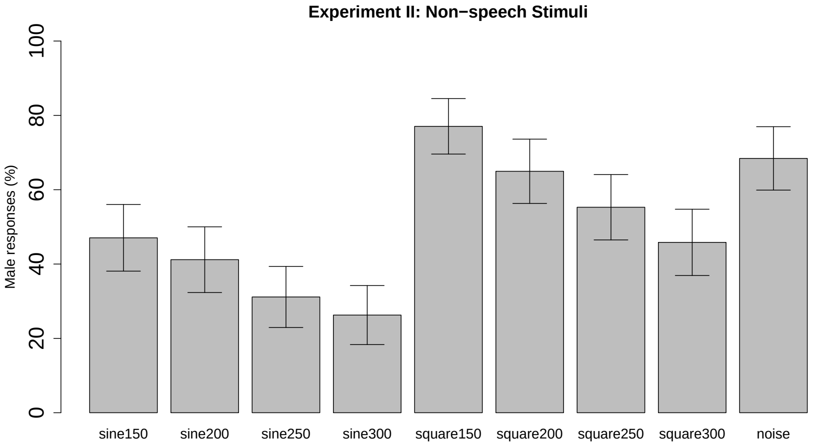


Figure: The results of Experiment III. The error bars represent 95% confidence intervals.

Results: First observations

- Sine waves are least male-like.
- Square waves and white noise are more male-like.
- Within sine waves and square waves, frequency seems to matter.

Results: Two periodic waves

- A logistic linear mixed model, comparing sine waves and square waves.
- The difference between sine waves and square waves was significant ($z = 4.09, p < .001$).
- Frequency was also significant ($z = -3.70, p < .001$).
- The interaction was not significant ($z = -1.06, n.s.$).

Results: Periodic waves vs. noise

- White noise induced more male responses than sine waves ($z = 6.61, p < .001$).
- White noise induced slightly more male responses than square waves ($z = 2.28, p < .05$).
- Abrupt amplitude changes have a larger effect than periodicity.
- Aperiodicity may also matter (although this comparison does not control for frequencies of square waves).

Summary so far

- Obstruents sound more masculine than sonorants.
- White noise and square waves sound more masculine than sine waves.
- Sounds that involve abrupt amplitude modulation (stop bursts, square waves, and white noise) sound more masculine.
- Periodic waves with higher frequencies are judged to be more female-like.
- Higher sounds imply smaller resonators [36]; females are generally smaller than male.

- A case of sound symbolism that presumably has an acoustic basis [1; 35; 36].

Further questions

- Sine waves have only one harmonic whereas square waves have multiple harmonics. Could this have been a confound?
- Phonology of names in other languages? Ideally analyses of languages in which names are not Bible-based.
- A study in Japanese has been done, but not with non-speech [47]. Other languages?
- The effect of vowels?
- The effect of voicing within obstruents?
- Distinctions within sonorants/obstruents?
- The effect on attractiveness? [38]

Experiment III: The Japanese pattern

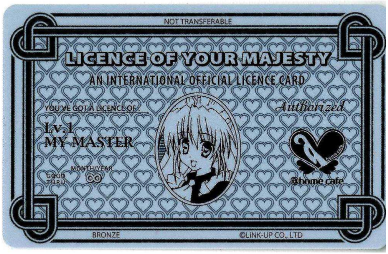
- Yasuda Seimei Top 50 popular names in 2001.
- http://www.meijiyasuda.co.jp/profile/etc/ranking/read_best50/
- (excluding moraic coda nasals; female names are more likely to contain moraic nasals.)
- $\chi^2(1) = 20.00, p < .001.$

Male			Female		
	n	%		n	%
Sonorant	37	35.6	Sonorant	72	67.3
Obstruent	67	64.4	Obstruent	35	32.7

Names of Japanese maids

- Meido kissa developed in the last ten years or so, mainly in Akihabara.
- Girls dressed up as "maids" to serve their "masters" and "ojoosama" at a cafe.
- An initial hypothesis: maids are more feminine than "normal girls", and their names may contain more sonorants.

“A corpus study”



- An analysis of maid names in a “meido kissa” (@ hoomu kafe, as of Nov 2011).
- A list of all maids; kanji-based names were removed. 133 names.
- 58% of the consonants were sonorants (171/295).
- No more sonorous than common names...($\chi^2(1) = 2.48$, *n.s.*)

Why? Fieldwork at maid kissa

- Maids often pick their maid names from anime characters (or their favorite foods or flowers).
- Some, however, come up with new names, which often conform to expected the patterns (with a bunch of sonorous consonants): *miono, rin, emyu, manyu, myumyu*.
- A further interview reveals that not all maids necessarily pursue "femaleness".

A revised hypothesis

- What was wrong may be the assumption that "maids are more female like non-maids".
- There are two types of maids: "honwaka, moe" (=cute) type and "tsun-tsun" (=sharp) type.
- The latter type may be associated with names with obstruents: e.g. *ginko*.

Experiment III

- A revised hypothesis: tsun maids= obstruents; moe maids= sonorants.
- We created ten pairs of non-existing made names, each consisting of obstruents and sonorants.
- Vowels are controlled within each pair; e.g. *sataka* vs. *wamana*

Experiment

- 2 alternative forced choice (2AFC): given *sataka* and *wamana*, which one is tsun and which was is moe?
- Distributed via surveymonkey; the order randomized per participant; the order b/w two choices also randomized.
- Participants: 10 maids working at Félicie at Akihabara.

Results

- The probabilities of the obstruent names associated with tsun.
- The chance level is 0.5.
- The actual mean p(c) is 0.74 ($p < .01$, by a Wilcoxon test).
- Every one of maid had a higher than 0.5 accuracy.

Results: SDT analysis

- Hit: Saying tsun-moe to tsun-moe
- FA: Saying tsun-moe to moe-tsun
- d-prime for 2AFC: (z(Hit)-z(FA))/Sqrt(2).
- Averaged d-prime: 1.15 ($p < .01$ by a Wilcoxon test).
- Conclusion: tsun=obstruents; moe=sonorants.

The roadmap of Part II

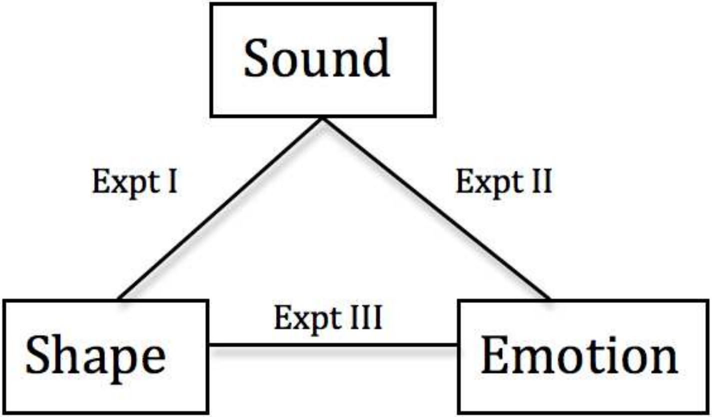


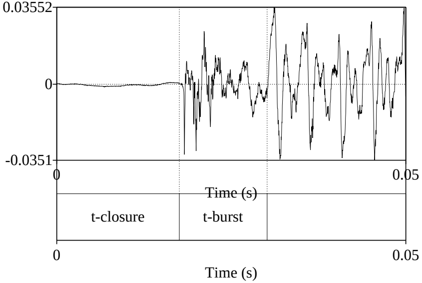
Figure: The roadmap of this project.

Meaning of stops

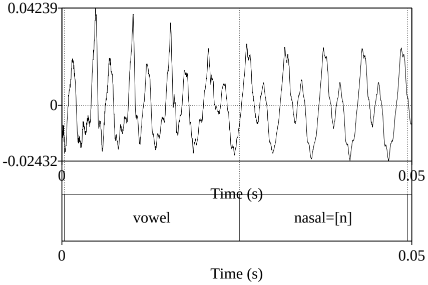
- Stops acoustically involve abrupt amplitude changes.
- Experiment I: Stops are associated with angular shapes.
- Experiment II: Stops are associated with emotions with abrupt onsets (e.g. "shocked" and "surprised").
- Experiment III: Angular shapes are associated with emotions with abrupt onsets.

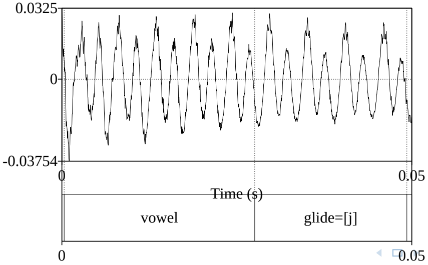
Background: Stops

- Stop bursts involve abrupt amplitude changes.
- The onset of the stop burst is abrupt with respect to the closure phase.



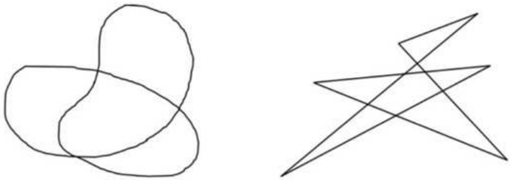
Background: sonorants





Köhler 1929/1947

- *Takete* is associated with the angular shape; *maluma* is associated with the round shape [2; 24].



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Experiment I: Introduction

- Replication of Köhler's effect.
- The experiment used purely auditory stimuli.
- The participants matched each stimulus sound with either an angular shape or a round shape.

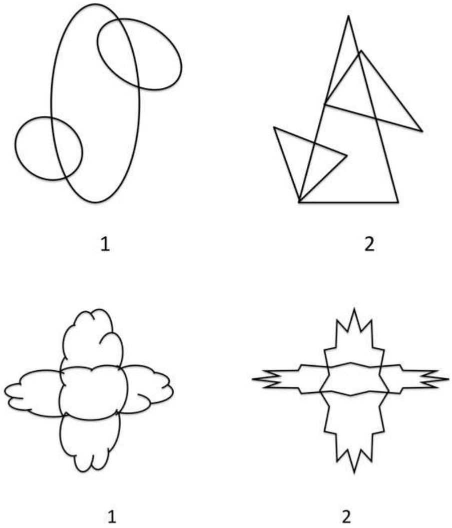
Stimuli

- The stimuli were all disyllabic CVCV nonce words (i.e. non-existing words in English; same with those in Part I).
- In one condition, both syllables contained stop onsets; in the other condition, both syllables contained sonorant onsets.
- The vowel quality was controlled between the two conditions: the first vowels were [a, e, ɪ, o, u], and the second vowels were [ə, i] (10 vowel combinations).
- Two items were included for each vowel combination.

Recording and acoustic editing

- Two native English speakers (one female, one male) pronounced all the stimuli three times in a sound-attenuated booth
- The recorded tokens were acoustically resynthesized with a uniform falling contour from the first vowel to the second vowel
- Peak amplitude of all the stimulus files was modified to 0.7 by using Praat [3].

Visual stimuli

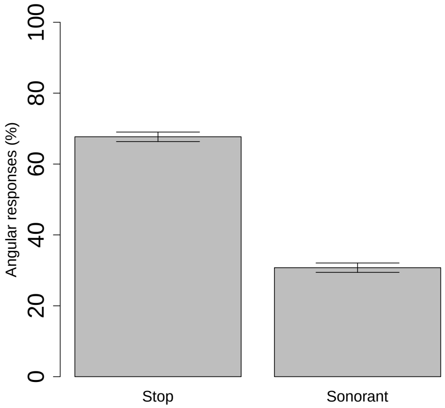


Procedure

- For each trial, the participants were presented a pair of an angular and round object, immediately followed by a stimulus sound.
- They were then asked to choose a shape that better matched each auditory stimulus.
- 80 sound stimuli $\times$ 7 visual pairs.
- 17 native speakers of English.
- Stats: a logistic linear mixed model.

Results

- Stops are more likely to be associated with angular shapes; sonorants are more likely to be associated with round shapes ($z = 35.00, p < .001$).



Experiment II: Introduction

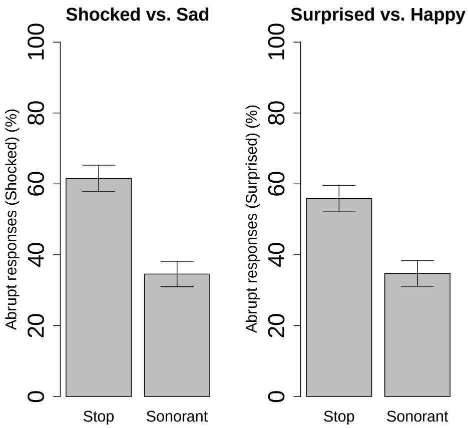
- Some emotions have abrupt onsets (e.g. "shocked" and "surprised") while others do not (e.g. "sad" and "happy").
- Japanese speakers associate stops with emotions with abrupt onsets [43].
- The questions: do English speakers show the same association? Can we replicate the results with purely auditory stimuli?
- Stimuli: a pair of negative emotions ("shocked" vs. "sad"), and a pair of non-negative emotions ("surprised" vs. "happy").
- The participants were instructed to choose the meaning that better matches the auditory stimuli.

Stimuli

- The sound stimuli are those used in Experiment I.
- The participants are also the same as those in Experiment I (conducted after Experiment I after a break)
- Stats: A logistic regression again.

Results

- Stops are more likely to be associated with emotion types with abrupt onsets ($z = -7.80$, $p < .001$).



Discussion

- The images of sounds can be projected to the domain of emotions.
- As far as we know, this is a new result.

Experiment III: Introduction

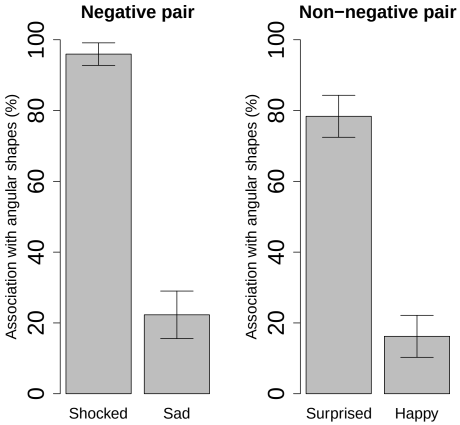
- The question: is there a direct connection between shapes and emotions with abrupt onsets?
- This study goes beyond the tradition of sound symbolism studies (it does not involve sounds).

Method

- The stimuli were 16 pairs of angular and round shapes.
- The participants were instructed to be assistants of Steven Spielberg, a film-director. They were told that in his new movie, the setting is an extraterrestrial planet where people communicate via visual symbols rather than sounds.
- A pair of negative emotions ("shocked" vs. "sad"), and a pair of non-negative emotions ("surprised" vs. "happy").
- 37 native speakers of English; responses collected online.
- Stats: A logistic regression again.

Results

- Angular shapes were associated more frequently with "shocked" and "surprised" than with "sad" and "happy", i.e. those emotions that involve abrupt onsets ($z = 9.57, p < .001$).



The conclusion

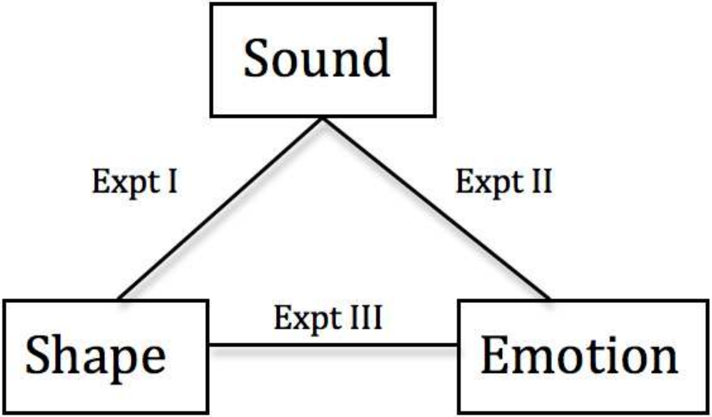


Figure: The conclusion of Part II.

Discussion

- There is a tripartite trans-modal relationship among stops (sound), angular shapes (vision), and emotion with abrupt onsets (emotion).
- There may be tighter relationships among different modalities of cognition than, for example, the Saussurian dictum predicts.

The acoustic basis (again)

- It seems plausible to assume that the image of angular shapes comes from the bursts of stops; i.e. it makes acoustic sense.
- Acoustically, the stop bursts with abrupt amplitude changes look “spiky” if we track the amplitude changes of stop bursts across time.
- By contrast, if we track amplitude changes of sonorants across time, they look “roundish”.
- The association between stops and angular shapes and the one between sonorants and round shapes can be considered as projection of the acoustic characteristics of sounds to the visual domain.

The acoustic basis (again)

- On the other hand, an articulation-based explanation of the current results seem difficult.
- There is nothing in the articulation of stops that is angular. In fact, the only superlaryngeal articulatory difference between [t] and [n] is opening of velum in [n], and it is not immediately clear why opening of velum can be associated with round shapes.

Overall conclusion

- Most generally, sound symbolic patterns exist (obstruents=sharpness, emotions with abrupt onsets, masculinity, "tsun-ness")
- The patterns found in the current experiments make more sense acoustically.

Acknowledgements

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