Neuropsychologia 76 (2015) 264–275

Contents lists available at ScienceDirect

Neuropsychologia

journal homepage: www.elsevier.com/locate/neuropsychologia

When semantics aids phonology: A processing advantage for iconic word forms in aphasia

Lotte Meteyard [a,*], Emily Stoppard [a], Dee Snudden [a], Stefano F. Cappa [b], Gabriella Vigliocco [c]

[a] Department of Clinical Language Sciences, University of Reading, UK
[b] IUSS Pavia and Division of Neuroscience, San Raffaele Scientific Institute, Milan, Italy
[c] Research Department of Experimental Psychology, University College London, UK

ARTICLE INFO

Article history:
Received 28 July 2014
Received in revised form
9 January 2015
Accepted 20 January 2015
Available online 28 January 2015

Keywords:
Semantics
Phonology
Iconicity
Sound-symbolism
Aphasia

ABSTRACT

Iconicity is the non-arbitrary relation between properties of a phonological form and semantic content (e.g. “moo”, “splash”). It is a common feature of both spoken and signed languages, and recent evidence shows that iconic forms confer an advantage during word learning. We explored whether iconic forms conferred a processing advantage for 13 individuals with aphasia following left-hemisphere stroke. Iconic and control words were compared in four different tasks: repetition, reading aloud, auditory lexical decision and visual lexical decision. An advantage for iconic words was seen for some individuals in all tasks, with consistent group effects emerging in reading aloud and auditory lexical decision. Both these tasks rely on mapping between semantics and phonology. We conclude that iconicity aids spoken word processing for individuals with aphasia. This advantage is due to a stronger connection between semantic information and phonological forms.

1. Introduction

The purpose of communication is to convey meaningful messages. Human language systems achieve this by associations between linguistic forms (spoken or signed words) and meanings (aspects of experience) (Ramscar et al., 2010). The mapping from linguistic forms to meaning during comprehension, and from intended meaning to linguistic forms in production, is carried out effortlessly and very efficiently. This is despite the presence of arbitrariness, the fact that the linguistic form does not provide *direct* cues to meaning in such a mapping.

Arbitrariness of the mapping between form and meaning has been long argued to be a foundational feature of human language systems (de Saussure, 1916; Miller and Johnson-Laird, 1976). There is nothing inherent in the sound form “cat” that cues the meaning *cat*: a fluffy, four-legged predatory household pet with whiskers, night vision and a long tail. Form-meaning mappings arise from convention and, except for historical precedent, it could just as easily have been the sound “dog” that cues the meaning *cat*. Arbitrariness in the mapping has been argued to be one key aspect of the referential problem in word learning (Ramscar et al., 2010) – how does a child learn linguistic symbols, mapping objects and events in their environment to an arbitrary word form? Neurobiological models of language uphold the separation between form and meaning, with phonological and conceptual/semantic systems supported by largely separate brain networks (Price, 2012; Binder et al., 2009). For adults, word finding difficulties are one of the most ubiquitous complaints both of ageing adults (Burke and Shafto, 2008) and those with acquired damage to language networks (Shewan and Kertesz, 1980). One reason for this may be that during production a unique phonological form has to be retrieved (e.g. Levelt, 1992); the arbitrary connection from semantics to phonology may be one reason why word retrieval is so sensitive to changes in the efficiency of language processing.

However, form-meanings mappings are not always arbitrary. Iconic relationships between form and meaning are widespread in both spoken and signed languages (Perniss et al., 2010; Schmidtke et al., 2014). Iconicity refers to there being a non-arbitrary resemblance between the signifier (the word) and what is being signified (the concept) (Fischer and Nänny, 1999). For signed languages, iconicity is ubiquitous at lexical and sentential levels (Taub, 2001). At lexical levels, it describes the presence of an imagistic relationship between some manual and non-manual properties of the form (mouth, face and signer's body) and visual and motoric characteristics of what is being signed (Perniss et al., 2010). For example, the British Sign Language (BSL) sign BELT incorporates the action of putting a belt around the waist using a “C” handshape with both hands (Thompson et al., 2010). Iconicity in lexical signs undergoes conventionalization; arbitrary signs

* Corresponding author.
E-mail address: l.meteyard@reading.ac.uk (L. Meteyard).

http://dx.doi.org/10.1016/j.neuropsychologia.2015.01.042
0028-3932/

(e.g., MOUSE, produced with a curved index finger rotating on the signer's nose) are present along with more iconic signs. Goldin-Meadow (2005) presents an analysis of homesign systems, gestural communication used by deaf children not exposed to conventional spoken or signed languages. These children produce a broad variety of iconic signs, presumably because their communication needs to be transparent to their parents (Goldin-Meadow, 2005). However, they do not use all possible manual variations (e.g. handshapes) that are available. Instead, they set up consistent form-meaning pairings – i.e. morphemes – which means the iconic signs are not always precisely mapped onto their meaning (e.g. using a fist to denote handling a balloon string and an umbrella handle, which would not be identically held in real-life; Goldin-Meadow, 2005). This illustrates a movement from iconic to arbitrary signs. Such convetionalisation in the home-sign systems of individual children may mirror processes seen in language evolution more broadly (Botha, 2007).

Among spoken languages, the degree of iconicity in the phonological form of words differs greatly. Outside the Indo-European language family, we find that iconic mappings are well represented in virtually all sub-Saharan African languages, some of the Australian Aboriginal languages, Japanese, Korean, Southeast Asian languages, indigenous languages of South America, and Balto-Finnic languages (Perniss et al., 2010). In these languages, in addition to more direct acoustic links, these iconic, sound-symbolic mappings evoke sensory, motor, or affective experiences or characterize aspects of the spatio-temporal unfolding of an event. In fact, the majority of sound-symbolic words refer to events or states in which sound is not essential. That is, properties of experiences – including visual, tactile, as well as mental and emotional experiences – may systematically correspond to properties of vowels and consonants, and their patterns of combination (e.g. reduplication) (Hamano, 1998).

Indo-European spoken languages, such as English, tend to have a lesser degree of iconicity in phonological forms. Here, iconicity tends to be for acoustic experiences (e.g. “splash”, “trill”, “croak”, “pitter-patter”, “bling”, “moo”, “whoof”; Perniss et al., 2010) although it is not limited to that domain. Iconic mappings can also arise when there are consistent *relationships* between particular forms and particular meanings; these statistical regularities then provide a consistent mapping between form and meaning (Monaghan et al., 2014). These regularities can be seen in phonoaesthemes, in which typically word initial or word final consonant clusters correlate with a certain meaning, e.g. “glitter”, “gleam” and “glow” having a “*gl*” onset that maps to the meaning ‘low intensity light’ (Firth, 1930; Perniss et al., 2010). For more abstract dimensions, mappings between vowel quality and the concept of size are present across spoken languages, for example, with high vowels (“ee”) being associated to small sizes and low vowels (“aa”) associated to large sizes (Hinton et al., 1994). It has been argued that abstract words cannot make use of sound-symbolism because they are not tied to specific aspects of experience, but other aspects of phonology may provide cues to their meaning (Reilly and Kean, 2007; Reilly et al., 2012). High and low imageability words differ on a number of phonological variables, with abstract words being longer, more derivationally complex and having fewer phonological neighbours (Reilly and Kean, 2007; Westbury and Moroschan, 2009). When asked to make a semantic judgement (concrete/abstract) about nonword stimuli, individuals consistently rate longer and inflected words as more abstract (Reilly et al., 2012). This sensitivity is preserved in semantic dementia with patients misclassifying concrete 3 syllable words (e.g. professor) more often than 1syllable words (e.g. bake) when making a forced choice concrete/abstract decision (Reilly et al., 2007). In this context, iconicity can be seen as part of the systematic way that linguistic forms cue aspects of meaning (Ramscar et al., 2010).

In English there is overall more systematicity than expected by chance. Monaghan et al. (2014) carried out a corpus analysis in English to explore how systematic the relationship is between form and meaning. They correlated measures of phonological and semantic similarity across words. As well as finding that English was more systematic than predicted by purely arbitrary mappings, words acquired earlier (earlier age of acquisition) were more systematic than words acquired later, suggesting a benefit of iconic mappings during language acquisition. A similar finding is present for BSL in parental report data (Thompson et al., 2012), with iconic signs being acquired earlier than less iconic signs by children aged 11–24 months. In an analysis of the spoken output of a child learning German, onomatopoeic words (i.e., ‘lala’ for music or ‘bow-wow’ for dog) were shown to bootstrap vocabulary growth. A sharp increase in produced onomatopoeic words between 0,8 and 0,11months preceded a more general vocabulary spurt from the age of 1 year 1 month (Laing, 2014).

Further empirical evidence for an iconic advantage for language learning comes from experiments with both children and adults. English 3 year olds are better able to learn Japanese verbs with iconic (sound-symbolism) properties (Kantartzis et al., 2011) and Japanese 3 years olds are better able to generalize the meaning of novel verbs if they have iconic properties (Imai et al., 2008). In adults, Nygaard et al. (2009) used a vocabulary task for native speakers of American English to learn Japanese words. Learners were sensitive to consistency in form-meaning mappings in a language with which they had no prior experience. When Japanese words were paired to their correct meanings in English (rather than randomly paired), they were responded to more quickly and more accurately over learning blocks. Similar benefits of iconic mappings were shown by Kovic et al. (2010) in a combined behavioural and EEG study, in which participants had to map two nonsense words to novel object pictures. They found that participants were faster to respond when the mapping was iconically congruent (e.g. ‘mot’ mapped to a curvy object, ‘riff’ matched to a pointy object). The most robust ERP response was an increased negative wave between 140 and180 ms for congruent conditions at occipital sites, interpreted as reflecting early processes of auditory-visual integration.

Regarding processing, Thompson et al. (2009, 2010) have shown that iconicity in sign forms affects sign recognition, suggesting that whenever there is iconicity in the sign, signers cannot avoid retrieving aspects of the semantics, regardless of task. In spoken English, Westbury (2005) presented CVC words and nonwords in a spiky or curvy frame for lexical decision. Words were made up of continuants (e.g. “mime”), plosives (e.g. “cope) or a mixture of the two (e.g. “food); mirroring this, nonwords were also made up of continuants (e.g. “nool”), plosives (e.g. “dibe”) or a mixture of the two (e.g. “nool”). Reaction times for lexical decision showed an interference effect for nonwords, with longer latencies when the frame was incongruent with the word structure (e.g. curvy frame with a plosive item); this effect was replicated when subjects made a decision on a single letter, rather than whole word/nonword items. Connell and Lynott (2014) explored the salience of a particular sensory modality and how that may cue meaning. They found that strongly visual words (e.g. cloudy) were responded to more quickly than weakly visual words (e.g. salty) during visual lexical decision and reading aloud, which both direct attention towards vision. Similarly, strongly auditory words (e.g. noisy) were responded to more quickly than weakly auditory words (e.g. salty) during reading aloud, as this task also directs attention towards auditory information. These effects indicate that cues to meaning are routinely processed and there may be automatic detection and *use* of form-meaning or modality-meaning consistencies whenever they are present.

The data from both spoken and signed languages indicate that iconicity confers some benefit for word learning and word