When Meaning Permeates Form:
Effects of Iconicity for Phonological Decisions in British Sign Language

Robin L. Thompson (robin.thompson@ucl.ac.uk)
David P. Vinson (d.vinson@ucl.ac.uk)
Gabriella Vigliocco (g.vigliocco@ucl.ac.uk)
Deafness, Cognition and Language Research Centre, Department of Cognitive, Perceptual and Brain Sciences
University College London, 26 Bedford Way, London, WC1H 0AP, UK

Abstract

Signed languages exploit the visual/gestural modality to create iconic expression across a wide range of basic conceptual structures in which the phonetic resources of the language are built up into an analogue of a mental image. Previously, we demonstrated a processing advantage when iconic properties of signs were made salient in a corresponding picture in a picture/sign matching task (Thompson et al., 2009). The current study investigates the extent of iconicity effects with a phonological decision task (does the sign have straight or bent fingers) in which the meaning of the sign is irrelevant. The results show that iconicity is a significant predictor of response latencies with more iconic signs leading to slower responses. We conclude that meaning is activated automatically for highly iconic properties of a sign, and this leads to interference in making form-based decisions. This is supported by the even greater inhibition observed when iconicity specific to a sign's handshape was analyzed (phonological decisions involved sign handshape). Thus the current study extends previous work by demonstrating that iconicity effects permeate the entire language system, arising automatically even when access to meaning is unnecessary.

Keywords: iconicity; sign language; lexical processing; embodiment.

Introduction

Signed languages conform to the same grammatical constraints and linguistic principles found in spoken languages, and are acquired along the same timeline (for reviews see Emmorey, 2002; Sandler & Lillo-Martin, 2006). Nonetheless, they make use of iconicity (the transparent relationship between meaning and form) to a much greater extent than spoken languages (Taub, 2001). This is likely because the phonetic resources of a visual/gestural language can be exploited to a greater degree than oral/aural languages to build up iconic expressions that are analogues of mental images. To spell this out, for an English speaker who is producing the word 'eat', there is no direct link between the phonological representation /it/ and the concept of 'eat'. However, for a signer producing the sign EAT[1] there is a more direct expression related to the action of

eating because the phonological form[2] can be manipulated to create a form that bears a strong resemblance to the meaning (in British Sign Language the hand is brought to the mouth as if eating, see Figure 1).

Figure 1: The BSL sign EAT

There are few experiments that address the role of iconicity, likely because, until recently, sign language research has sought to stress the parallels between signed and spoken languages (e.g., Bellugi & Klima, 1976; Klima & Bellugi, 1979). The few early studies there are suggest that iconicity is irrelevant in language development such that children's earliest signs are not iconic (Orlansky & Bonvillian, 1984) and iconic signs are not less prone to errors (e.g., for iconically motivated agreement signs such as GIVE which move from source to goal, Meier, 1982). More recently the findings have been mixed. In support of earlier work, a case study of anomic patient "Charles" suggested he was no better at producing iconic signs than noniconic signs (Marshall, Atkinson, Smulovitch, Thacker & Woll, 2004; However this study may have simply lacked power to detect a small effect of iconicity (13/20 performance for iconic signs, 10/20 for noniconic). Further, Meier, Mauk, Cheek & Moreland (2008), found that errors in the earliest ASL signs of four deaf infants (in which the sign form did not match the adult target form) did not tend to be more iconic than what was produced by the adult model (e.g., actually licking the hands when producing the sign ICE-CREAM, normally produced with a fist moving in front of the mouth). The authors conclude that because children's earliest sign errors do not tend to be more iconic,

---

[1] Signs are customarily represented as English glosses in capital letters.

[2] Just as in spoken languages, signed languages have a sublexical level of representation (i.e., a phonology). Signs are made up of three major parameters: handshape, place of articulation and movement (see Sandler, and Lillo-Martin, 2006, for an overview.)

they are not guided by these closer form-meaning mappings in acquisition.

Alternatively, normative data on 300 lexical signs in British Sign Language (BSL) suggests that there is at least some relationship between age of acquisition (AoA) and iconicity, with more iconic signs tending to be acquired earlier in life, while acquisition of less iconic signs is more distributed across age ranges (Vinson, Cormier, Denmark, Schembri & Vigliocco, 2008). Further, Vigliocco, Vinson, Woolfe, Dye, and Woll (2005) found that adult BSL signers and English speakers differ in their judgments when grouping signs/words referring to tools, tool-actions and body-actions according to meaning similarity. While English speakers in the study tended to group tool actions along with body actions (showing a preference for distinguishing actions from objects), BSL signers tended to group tools and tool-actions together, as predicted on the basis of shared iconic properties of the signs (i.e., signs referring to tools [e.g., KNIFE] and tool actions [e.g., CUT] share "tool-use" iconicity, making them more similar to each other than body-actions [e.g., HIT]). The authors account for the difference in terms of the mental images triggered by the iconic signs. In support of this, when English speaking non-signers were instructed to develop a mental image including typical experiences with the thing or action, they also judged tool-actions to be more similar to tools, compared to the speakers to whom no imagery instructions were given.

With growing interest in the relationship between general cognition and language, along with the ever-widening belief that the two are inseparable (e.g., theories of embodiment; e.g., Barsalou, et al., 2003; see Meteyard & Vigliocco, 2008 for a review), more transparent mappings between meaning and form seem a natural outcome even for spoken languages. While Indo-European languages have relatively small inventories of onomatopoetic words in which there is a non-arbitrary relationship between meaning and sound, some spoken languages such as Japanese and Korean have a much larger inventory covering not only onomatopoeia, but also sound-symbolism related to other sensory experiences, manner, and mental/emotional states (several thousand entries, including both common and very rare examples, are found in one Japanese dictionary of iconic expressions; Kakehi, Tamori & Schourup, 1996).

Recently, Imai, Kita, Nagumo, & Okada (2008), found that 25 month-old children are sensitive to sound-symbolic matches in the domain of action verbs and that this sound symbolism facilitates learning (both English and Japanese-speaking children were able to generalize the meaning of novel sound-symbolic verbs, and unable to generalize the meaning of non-sound-symbolic verbs). The authors conclude that iconic scaffolding through sound symbolism plays an important role in early verb learning. Interestingly, the authors additionally suggest that certain aspects of sound symbolism may be universally and biologically grounded (based on the finding that both Japanese and English speaking adults were sensitive to sound-symbolic relations

between novel words and novel actions during the norming phase of the study). While these studies are crucial to a better understanding of the role of iconicity in language they do little to address the potential role of iconicity during language processing.

For signed languages, the presence of more transparent links between meaning and form could, in principle, be beneficial to on-line language processing, both in sign production and sign comprehension. For example, a stronger link between semantic properties and iconic phonological properties in sign production could help signers avoid TOT states (or tip-of–the-fingers as it has been coined for signed languages; Thompson, Emmorey, Gollan, 2005). In sign comprehension, iconic properties of a sign could more readily activate the corresponding conceptual properties of the referent, resulting in faster on-line processing.

In support of this, Ormel (2008) found iconicity effects for deaf children using Sign Language of the Netherlands in a picture/sign matching task where responses were significantly faster for highly iconic signs than for less iconic signs (to answer "yes the picture matches the sign"). In a similar study using picture/sign matching for adult users of American Sign Language (ASL), strong relationships between iconic properties of a sign and features of a pictured object speeded sign recognition (Thompson, Vinson & Vigliocco, 2009). Specifically, participants were asked to indicate by button-press whether a picture and a sign refer to the same object. Experimental signs were all iconic. In one condition, the iconic property/feature of the sign (e.g. BIRD, produced with thumb and forefinger at the mouth, representing a bird's beak) was salient (e.g., a bird pictured from the front, beak well in view) while in the second condition the iconic property was not salient (e.g., a picture of a bird flying, extended wings well in view). As a control, English-speaking non-signers were also presented with the same pictures followed by English words. ASL signers responded faster when the iconic property of the sign was salient in the picture than when it was not, while English controls showed no such difference. In a British Sign Language (BSL) replication of the ASL study, Vinson, Thompson, Skinner & Vigliocco (2008) likewise found faster RTs for picture-sign matching when the iconic property of a sign was made salient in a picture compared to when it was not. Additionally, this study manipulated general salience of iconic properties (based on English semantic feature norms; McRae, Cree, Seidenberg & McNorgan, 2005) to rule out the possibility that iconicity effects are modulated by a property's general salience. For example, the BSL sign for ELEPHANT shows the shape of an elephant's trunk, a feature frequently listed for elephants in the McRae et al. feature norms and thus highly salient to English speakers, while the BSL sign LION shows a lion's claws, not considered a generally salient feature of lions, being only infrequently listed as a feature for lions. BSL signers responded faster when the iconic property of a sign was highlighted in a corresponding picture regardless of general

salience, thus showing that the effect was not modulated by a property's general salience.

These response time studies provide evidence that a more transparent mapping between meaning and form can aid language processing. That iconicity is used in areas such as poetry and word play suggests that signers have an awareness of the iconic properties of signs and these properties might therefore be tapped into specifically under conditions that draw signers' attention to them. Crucially, however, these studies aimed to minimize the possibility that iconicity effects could arise from meta-cognitive strategies or direct attention to iconicity, by using experimental methodologies in which participants' attention is diverted from the iconicity manipulation itself.

Despite these recent findings, however, little is currently known about the scope of iconicity effects. Given that iconicity in signed languages is represented in the phonological form of signs, there may exist stronger links between phonological and semantic levels of representation. This is suggested by the Thompson et al. study. However, one possibility is that iconicity effects are task dependent (i.e., limited to conditions where semantic representations and their iconic properties are directly relevant to the task). This, for example, could have been the case in the Thompson et al. study, which precisely manipulated the connection between a real world picture and iconic properties of a corresponding sign. Alternatively, iconicity effects may be more automatic and occur during language processing tasks, including those that do not directly tap into meaning representations. Thus, for iconic signs regular mappings between meaning and form might affect processing at all levels.

In the current study we make use of a phonological decision task to determine the extent of iconicity effects during language processing. If iconicity effects are limited to tasks that require access to meaning, then we predict the absence of an effect in a phonological decision task which does not depend upon accessing the meaning of signs. However, if iconicity effects are more general in nature, stemming from a tighter coupling between meaning and form as a result of greater predictability in these mappings, we should expect processing effects even in a phonological decision task in which the meaning of signs is irrelevant. It is only in this case, if iconicity can be shown to have an effect even when it is irrelevant to the task that we can confidently argue that it affects language processing in general.

Method

Subjects

Fourteen adult participants (five men, eight women, average age 47.5, range 25-72) were recruited from Deaf communities in London, Birmingham and Edinburgh. One participant responded at chance level and was removed from the data set, leaving 13 subjects with analyzable data. Of these 13, twelve were Deaf, while one subject was hearing from a Deaf family who learned BSL from birth. Five of the subjects were native signers from Deaf families, three early signers (exposure to BSL by age 5) and five were late signers (exposure to BSL after age 5).
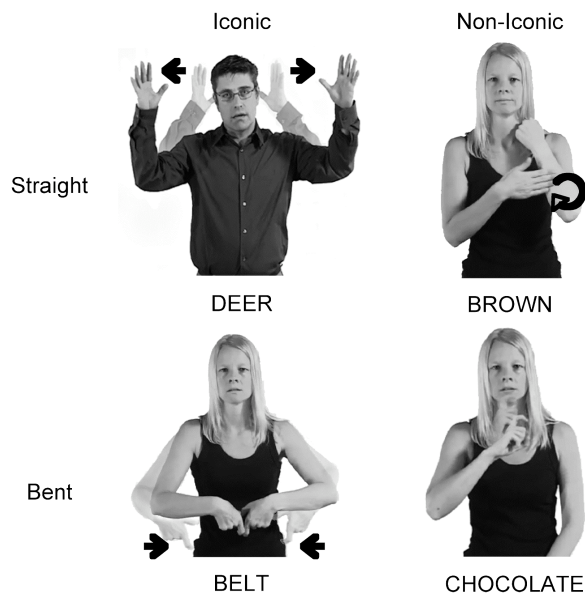

Figure 2: BSL signs with straight and bent handshapes that are either iconic or non-iconic.

Materials

Video clips of BSL lexical signs were selected from a set of 300 for which age of acquisition (AoA), iconicity and familiarity norms have been collected (Vinson et al., 2008). We aimed to use as many normed items as possible, thus including items that covered a range of AoA, iconicity and familiarity ratings (excluding those rated as the least familiar since these items might not be in the vocabulary of most participants). Here we decided upon a distinction between signs that employ "straight" and "bent" handshapes (see Figure 2). This distinction is determined based upon whether the finger(s) of any one sign are straight or bent. Ambiguous signs were excluded from the set (e.g., signs beginning with one handshape and ending with another), leaving 162 signs that met all criteria. Video stimuli for the BSL norming sample were produced by four different models. To avoid the possibility that participants might use model identity as a cue to make a particular response, we selected an additional 24 filler signs (filmed but not normed by Vinson et al., 2008) so that each model produced an equal number of straight and bent handshape signs. The final set included a total of 186 signs, plus twenty additional signs as practice items.

Procedure

After giving consent to participate, participants were presented with video-recorded instructions in BSL (presented by R.S., a native BSL signer). The instructions focused specifically on the distinction between straight and bent signs. Examples were provided of signs with handshapes that are straight or bent (as in BROWN or

BELT in Figure 2). Subjects were told that their task was to make decisions about whether a sign has a straight or bent handshape as quickly and accurately as possible by pressing keys. The experiment began with twenty practice items using a wide range of different handshapes. For these practice items only, subjects received feedback (correct or incorrect response) and after the practice, subjects were given the opportunity to ask questions and then the actual experiment began.

Stimulus presentation was carried out using DMDX v. 3.2.2.3 (Forster & Forster, 2003) on Windows computers. The order of presentation of experimental items was randomized for each participant. Each trial began with a fixation cross that was displayed for 400 milliseconds, followed by a BSL sign clip (.AVI format, 720 x 576 pixels). The participant was able to respond as soon as the clip began to play. Once a response was made, or after a 3000ms timeout, there was a 250ms delay before the fixation cross for the next trial. Participants were given frequent opportunities to take breaks if needed.

Results

We first examined accuracy by participants and items. Signs with accuracy rates below 70% (TEACH, CLOUD, SICK, KITCHEN, SWALLOW) as well as signs with handshapes that were not consistently judged as straight or bent across participants (e.g., a fist with the thumb extended), leaving 132 experimental signs in the data set (average 92.0% correct), each with responses by 13 participants. We excluded all error trials and those with RTs more than three standard deviations from a participant's average. Average trimmed correct response latencies in this task were 1345msec ($\underline{SD}$=330).

Analysis was primarily intended to test for effects of iconicity. This was accomplished by the use of sequential multiple linear regression, with correct trimmed response latencies as the dependent measure. The first step included predictors not related to lexical variables. The first variable was Straight/Bent, whether a sign had a straight or bent handshape, as assigned to different response buttons. In this step we also included predictors to distinguish between the different sign models used in the task, because there were clear differences in their speed and smoothness of production which could translate into differences in the latency of sign recognition independent of the lexical variables of interest. The residuals from this step were passed to a second step where lexical variables other than iconicity (i.e., familiarity and AoA ratings) were entered as predictors; these variables typically affect lexical decision latencies and are somewhat correlated to iconicity (Vinson et al., 2008) and so were factored in first. Finally, residuals from this step were passed to a final step in which iconicity ratings from Vinson et al. (2008) were used as a predictor.

The first step (adjusted R^2 = .022) revealed differences in the speed of responses to signs produced by different models (ranging from 1251ms for the fastest model, to 1369ms for the slowest). The Straight/Bent variable was not significant (standardized beta = .034, t=1.321, p=.187). In the second step (total adjusted R^2=.037) familiarity was a significant predictor (standardized beta = -.134, t=-5.051, p<.001, $r_{partial}$= -.127); more familiar signs were responded to more quickly. However, AoA was not a significant predictor (standardized beta = -.011, p>.6). In the last step (total adjusted R^2=.040) iconicity ratings were significant predictors (standardized beta = .065, t=2.171, p=.030, $r_{partial}$=.054): more iconic signs led to slower responses.

In order to rule out the possibility that the above effect of iconicity was related to purely visual characteristics of the sign stimuli rather than having to do with sign language processing itself, we ran the same BSL phonological decision experiment on participants with no sign language experience (n= 15). Non-signers were able to perform the task since it required no knowledge of sign meanings (average accuracy = 91%). The same analyses were conducted as for the signers. Non-signers were significantly slower for Bent than Straight signs (p=.008), and also showed differences in recognizing signs produced by the different sign models. Crucially, they showed no effects of familiarity (p=.174), AoA (p>.7), or iconicity (p>.9), suggesting that the iconicity effect reported above is indeed a product of language experience.

If slower RTs in the phonological decision task are due to sign iconicity, there might be even greater interference for iconicity that is specifically expressed in the handshape of a sign, because the task is specifically about the handshape (i.e., is it straight or bent). We therefore considered whether or not iconicity specific to the handshape of the sign could play an even greater role than iconicity related to other phonological parameters of a sign (i.e., movement and place of articulation). To clarify this point, consider two highly iconic signs in BSL: DEER and CRY (for DEER see Figure 2, CRY is produced with two alternating index fingers that move from either eye downward). While both signs are rated as highly iconic (on a 7 point scale, DEER has an iconicity rating of 6.0 and CRY, 6.75), only DEER has an iconic handshape (representing the antlers of a deer), while the handshape in CRY is not iconic (the index finger only serves to trace the path of the tears).

In order to analyze effects specific to handshape iconicity, we first needed to collect handshape iconicity norms. Because it proved difficult to distinguish handshape iconicity from overall iconicity, we used experts in sign linguistics for the norming task (n=4). These experts are all linguistically trained, work in the field of sign language research and have a clear understanding of iconicity in signed languages (1=M, 3=F, average age 38.4, range 34-43).

Overall ratings of handshape iconicity were highly correlated to overall iconicity ratings (r = .833), primarily stemming from the fact that noniconic signs receive the lowest ratings on both scales. We therefore focused only on iconic signs: those signs that were above average on general iconicity ratings (rating >4 on a scale of 1-7, n=61),

conducting multiple linear regressions. As before we first entered predictors not related to lexical variables (Sign Model and Straight/Bent handshape; adjusted R^2 = .035), and as in our previous analysis we found significant differences in the speed of responses to signs produced by different models, and no significant difference for the Straight/Bent variable for this reduced set of items (standardized beta = .015, t=.371, p=.711). In the second step, familiarity and AoA ratings were used as predictors (adjusted R^2 = .040) familiarity just missed significance (standardized beta = -.077, t=-1.890, p=.059) likely due to the reduced set of items in handshape analysis. A significant effect of AOA was found such that RTs for later-acquired iconic signs were faster (standardized beta = -.095, t=-2.331, p=.020). After factoring out these predictors, handshape iconicity was entered. RTs for iconic signs with higher handshape iconicity were significantly slower (adjusted R-square = .048, standardized beta = .119, t=2.556, p=.011). As a final step, we entered general iconicity to see if there was an effect of *overall* sign iconicity once variance specific to handshape iconicity was taken into account. In this step, general iconicity was also a significant predictor of RTs (standardized beta = -.126, t=-2.488, p=.013). Unlike handshape iconicity, other aspects of iconicity speeded phonological decision once effects of handshape iconicity were factored out.

Discussion

Overall the results demonstrate an effect of iconicity outside the realm of meaning, and thus reveal a general role for iconicity in language processing. In the phonological decision task, signers did not need to access meaning, or iconic representations. Nonetheless, and despite its lack of relevance to the task, iconicity affected language processing, clearly demonstrating that iconicity effects are automatic and not dependent on tasks requiring access to semantic representations.

An additional significant effect of familiarity on sign decisions further suggests that we are tapping into lexical processing. That there was no effect of AoA could suggest that subjects were not fully accessing sign meanings, but only retrieving partial aspects related to iconic properties of the sign. It is perhaps the case that only iconic aspects of meaning arise automatically, thus creating an inhibitory effect, but that in a task involving decisions on phonological form, other aspects of meaning are not accessed. Importantly, no effect of iconicity (or other lexical variables) was found when the same BSL experiment was run on participants with no sign language experience.

In the previous picture/sign matching study (Thompson et al., 2009), we observed faster RTs when subjects were asked to match a sign with a picture that highlighted properties of that sign. However, closer form/meaning mappings of iconic signs resulted in an inhibitory effect in the current phonological decision task. This difference is likely due to an interaction of the same closer form/meaning mapping of iconic signs with the experimental task. For the

task requiring access to meaning, a closer form/meaning mapping led to facilitation due (presumably) to iconic links aiding in meaning retrieval. In the phonological decision task, access to meaning was not required. However, some aspects of meaning appear to have been activated nonetheless because of closer form/meaning mappings existing for iconic signs. In this case irrelevant information about the meaning led to interference because automatic access to meaning could hinder phonological decisions.

Under this view, we might expect even greater inhibition when the handshape parameter is iconic because subjects made a decision involving handshape. Our analyses show that iconicity specific to the handshape of a sign leads to greater inhibition. Thus iconicity represented in the handshape appears to make handshape judgments on other (phonological) dimensions more difficult. The significant effect of handshape iconicity suggests that meaning is accessed (automatically) to a greater degree for highly iconic signs. This results in inhibition on the phonological decision task because it detracts from the purely form related task. Interestingly, once handshape iconicity was factored out, general iconicity led to faster decisions. That general iconicity is facilitating responses to some extent among iconic signs after handshape iconicity is taken into account, suggests that iconicity has an overall beneficial role in lexical access that is hindered here due to the nature of the task.

While there may be mixed results in research areas such as L1 acquisition, studies looking at on-line processing all support a role for iconicity in language processing (Grote & Linz, 2003, Ormel, 2008, Thompson, et al., 2009, Vinson, Thompson, Skinner & Vigliocco, 2008). That there is a difference between the acquisition literature and the processing literature may simply be an indicator of the sensitivity of the different measures used (i.e., analyses of child language production may miss underlying knowledge evident in more automatic RT studies), or the difference could be due to other factors that come into play during acquisition (e.g., motor control could affect ability to produce signs iconic or not, Meier et al., 2008).

According to embodied theories of language, word meanings are understood via mental simulations of past perception and action (e.g., Barsalou, et al., 2003). Under embodiment theory, therefore, there exists a more direct connection between the real world and meaning than previously assumed. The validity of this hypothesis has gained support through a growing number of behavioral studies showing that word meanings can interact with perceptual and motor processes (see Meteyard & Vigliocco, 2008 for a review). However, these studies have typically used paradigms that assess the general impact of the language system, specifically semantics, on sensory/motor tasks (and vice versa) and thus have little to say about the extent to which such effects might penetrate into the language system.

The current study is a first glimpse at a further connection linking semantics and phonology in cases where there is an

iconic mapping between the two. The findings suggest that study of signed languages, where iconic links between phonology and semantics are rampant across a wide range of basic conceptual structures, may provide a better window into the nature of embodied cognition. This is because iconic properties (and the degree of imagery) associated to any one sign could strengthen the relationship between meaningful human actions and the comprehension of words and sentences. Thus the current study crucially extends previous work in this area by demonstrating that iconicity effects permeate the entire language system and in particular can be found beyond what has traditionally been considered the realm of meaning.

Acknowledgments

References

Barsalou, L.W., Simmons, W.K., Barbey, A., & Wilson, C.D. (2003). Grounding conceptual knowledge in modality-specific systems. *Trends in Cognitive Sciences,* 7, 84-91.

Bellugi, U. & Klima, E. (1976). Two faces of sign: Iconic and abstract. In S. Harnad (ed.), *The origins and evolution of language and speech, p.* 514-538. New York: New York Academy of Sciences.

Bergen, B.K. (2004). The psychological reality of phonaesthemes. *Language*, 80(2), 290-311.

Forster, K.I & Forster, J.C. (2003). DMDX: A windows display program with millisecond accuracy. *Behavior Research Methods, Instruments, & Computers*, 35, 116-124.

Grote, K., & Linz, E. (2003). The influence of sign language iconicity on semantic conceptualization. In W. G. Muller & O. Fischer (eds.), *From sign to signing,* pp. 23–40. Amsterdam: John Benjamins.

Imai, M. Kita, S., Nagumo, M. & Okada, H. (2008). Sound symbolism facilitates early verb learning. *Cognition*, 109(1), 54-65.

Kakehi, H., Tamori, I. & Schourup, L. (1996). *Dictionary of iconic expressions in Japanese.* Berlin: Walter de Gruyter.

Klima, E. & Bellugi, U. 1979. *The signs of language.* Cambridge, MA: Harvard University Press.

Marshall J, Atkinson J, Smulovitch E, Thacker A, Woll B. (2004). Aphasia in a user of British Sign Language: Dissociation between sign and gesture. *Journal of Cognitive Neuropsychology*, 21(5), 537-554.

McRae, K., Cree, G. S., Seidenberg, M. S., & McNorgan, C. (2005). Semantic feature production norms for a large set of living and nonliving things. *Behavioral Research Methods, Instruments, and Computers,* 37, 547-559.

Meier, R.P. (1982). *Icons, analogues, and morphemes: The acquisition of verb agreement in American Sign Language.* Unpublished doctoral dissertation, University of California, San Diego.

Meier, R.P., Mauk, C.E., Cheek, A. & Moreland, C.J. (2008). The form of children's early signs: Iconic or motoric determinants? *Language Learning and Development*, 4:1, 63-98.

Meteyard, L. & Vigliocco, G. (2008). The role of sensory and motor information in semantic representation: a review. In P. Calvo & A. Gomila (eds.), *Handbook of Cognitive Science: An Embodied Approach,* Ch. 15. Academic Press, Elsevier: London.

Orlansky, M. & Bonvillian, J.D. (1984). The role of iconicity in early sign language acquisition. *Journal of Speech and Hearing Disorders*, 49, 287–292.

Ormel, E. (2008). *Visual Word Recognition in Bilingual Deaf Children.* Unpublished Doctoral Dissertation. Radbound University: Nijmegan, the Netherlands.

Sandler, W. & Lillo-Martin, D. (2006). *Sign language and linguistic universals.* Cambridge MA: Cambridge University Press.

Taub, S. (2001). *Language from the body: Iconicity and metaphor in American Sign Language*. Cambridge MA: Cambridge University Press.

Thompson, R.L., Emmorey, K., & Gollan, T. (2005). Tip-of-the-fingers experiences by ASL signers: Insights into the organization of a sign-based lexicon. *Psychological Science*, 16(11), 856-860.

Thompson, R.L., Vinson, D.P., & Vigliocco, G. (2009). The link between form and meaning in American Sign Language: Lexical processing effects. *Journal of Experimental Psychology: Language, Memory, and Cognition,* 35(2), 550-557.

Vigliocco, G., Vinson, D.P., Woolfe, T., Dye, M.W., & Woll, B. (2005). Words, signs and imagery: when the language makes the difference. *Proceedings of the Royal Society B*, 272, 1859-1863.

Vinson, D.P., Cormier, K., Denmark, T., Schembri, A. & Vigliocco, G. (2008). The British Sign Language (BSL) norms for age of acquisition, familiarity and iconicity. *Behavior Research Methods*, 40, 1079-87.

Vinson, D.P., Thompson, R.L., Skinner, R. & Vigliocco G (Sept., 2008), The link between form and meaning in British Sign Language: Role of iconic properties in lexical and conceptual processing. Talk given at the 14th Annual Architectures and Mechanisms for Language Processing (AMLaP) Conference, Cambridge, UK.