***KISSING* SLOWS *LICKING*:**
AN INVESTIGATION OF BODY PART OVERLAP IN VERB PRIMING

Introduction

There is growing psycholinguistic and neuroimaging evidence that the cortical systems for language and action interact. That is, motor representations are accessed during semantic processing of action words and even words referring to manipulable objects (Masson et al., 2008; Zwaan et al., in press). Neuroimaging studies show that processing of words that refer to actions associated with specific body parts activates corresponding regions of the motor cortex (Pulvermuller et al., 2001; Pulvermuller et al., 2005; Tettanmanti et al., 2005). For example, *lick, kick*, and *pick* activate the mouth, leg, and hand regions of the motor cortex respectively. This has been found not only in tasks that require deep semantic processing as in synonym judgments (Kemmerer et al., 2008), but also in speeded lexical decision tasks that do not place heavy demands on semantic processing (Pulvermuller et al., 2005). These findings suggest that speakers may simulate the action portrayed by a verb and that such action simulation is an inherent part of language comprehension.

The relationship between language processing and motor affordances has been described variously in terms of mirror neurons, embodied cognition, and semantic somatotopy depending on the authors' theoretical and empirical perspective. The present study was motivated by the Semantic Somatotopy Model of action word processing (henceforth SSM), which suggests that neuronal networks bind words and the actions to which these words are semantically linked (Pulvermuller, 2005). Hence slightly different neural networks (in the frontocentral cortex) are associated with semantic processing of action words depending on the body part invovled (Figure 1). Since the SSM implies that somatotopically related action words originate from highly similar neural cell assemblies, it might be anticipated that words with such a relationship (for example, two running verbs *stumble* and *sprint*) would facilitate each other's processing. Studies of language-motor affordances have primarily investigated either isolated word processing or the facilitation between manually enacted gestures and words which correspond to those gestures. To our knowledge, the potential facilitation between somatotopically matching action words has not previously been investigated.

Two questions were posed in this study: 1) Does processing of an action word facilitate processing of another somatotopically related action word? 2) Does the pattern of facilitation/inhibition differ in individuals with verb naming deficits, such as those with Broca's (agrammatic type) aphasia? The latter question is relevant because the locus of aphasic verb naming deficits is unknown. This study investigates the possibility of inadequate activation of a verb's semantic features (in this case, bodypart involved). In order to address these questions, a visual priming lexical decision task was used in which somatotopic relatedness between primes and targets was varied. It was hypothesized, based on the SSM that lexical decision times in the congruent body part condition would be significantly faster than other conditions. It was further predicted that this pattern may

not be found in individuals with deficits in verb retrieval if there is difficulty with semantic feature activation.

There were several motivations behind this investigation. First, we wanted to examine if somatotopic congruency between two action words can indeed be facilitatory. Prior research on semantic feature overlap priming (*dog>cat*) reveals a speeding up (facilitation) of responses (see Hutchison, 2003 for a review). The second purpose was to explore the nature of verb deficits in aphasia, and to specifically examine the processing of bodypart features. This would illuminate a novel aspect of the aphasic verb deficit. The third motivation was to examine the future potential for using somatotopically congruent verbs to cue action word retrieval in aphasia therapy. Finally, the results could be used to predict the possibility of facilitating generalization of treatment effects to untrained somatotopically congruent words (for example, training of *lick* and *kiss* generalizes to other mouth/face verbs such as *chew* and *whisper*).

Methods

Participants

Twenty two unimpaired right-handed native English speakers (Mean age: 19.7years; 19 female) and five aphasic individuals with a verb naming deficit (Mean age: 60.4 years, one female) participated in the study. Three more aphasic individuals have been scheduled and their testing will be completed by January 31, 2009. All aphasic participants had a single left hemisphere cerebrovascular accident, demonstrated nonfluent agrammatic speech pattern (in narratives), were classified as Broca's aphasia as per the Western Aphasia Battery (Kertesz, 1982), and demonstrated a greater deficit in verb (Mean=33.3%) compared to noun naming (33.3% verb versus 80.1% noun naming accuracy; Object and Action Naming Battery, Druks & Masterson, 2000).

Stimuli and Procedure

The stimuli were 25 verbs each with arm/hand or face/mouth involvement (total=50). Selected verbs had a higher verb than noun usage frequency (CELEX, Baayen et al., 1993). These verbs were presented in the following conditions (see Table 1):
1. Baseline (*xxxx*[prime]>>*kissing*[target]),
2. congruent body part (*licking>>kissing*, *clap>>knead*),
3. incongruent body part (*clapping>>kissing*),
4. pseudoword fillers (*crawling>>ziring*).

The progressive verb form was used in order to avoid any ambiguity with noun homophones. The stimulus onset asynchrony between the prime and target was 200 ms as this duration is claimed to be sensitive to semantic aspects of verbs (Bonnote, 2008). A speeded lexical decision task was used in which participants were asked to respond to the target while ignoring the preceding prime by pressing one of two keyboard buttons with their left hand. The experiment was run on a desktop PC using Superlab Pro 1.74 experimental software.

Prior to statistical analyses, incorrect responses and outliers (2 standard deviations above or below each individual's mean RT) were deleted. This resulted in a loss of 6.6% and 17% of the data for unimpaired and aphasic participants respectively.

Results

For reaction time (RT) data, an analysis of variance treating group as the between-participant factor and condition as the within-participant factor revealed main effects of group (F[1,18]=23.4, p<0.000) and condition (F[3,46]=13.4, p<0.000). Aphasic participants were significantly slower in their reaction times compared to unimpaired participants (Mean(SD)=1386(507) versus 813(281) milliseconds). Planned comparisons revealed significant differences in reaction times between conditions, with slower RTs for the congruent condition compared to baseline (Unimpaired t(20)=36.5, p<0.000; Aphasic t(4)= 4.7, p<0.01) and incongruent conditions (Unimpaired t(20)=20.1, p<0.00; Aphasic t(4)= 15.7, p<0.000) (see Table 1 and Figure 2). Additionally, the aphasic group was slower in the incongruent condition compared to baseline (t(4)=6.8, p<0.05). The differences in aphasic and unimpaired RT were normalized by calculating the size of the priming effect as ([Baseline RT minus condition RT]/Baseline RT). This is shown in Figure 3. While both groups showed interference for the congruent condition, this was much larger for the aphasic group. Additionally, the aphasic group was facilitated by the incongruent condition.

Aphasic participants were significantly less accurate than unimpaired participants (92.3% vs. 98.6%; *t*(20)<.05), but there was no difference in accuracy between conditions for either group.

Discussion

This study examined SSM's notion of action word-motor cortex links using a visual lexical priming paradigm. We found interference (rather than the predicted facilitation) between somatotopically congruent verbs in both unimpaired and aphasic participants, with a considerably larger interference for aphasic participants. Although the observed interference is contrary to the typically observed facilitation between verbs and manually enacted actions (e.g., Masson et al., 2008; Zwaan et al., in press) or for other verb features such as durativity (Bonnote, 2008), these findings are not inconsistent with the SSM if one assumes that activation of any neuronal assembly will interfere with the re-use of the same neural assembly for another task (Bergen, 2007; Kachack, et al., 2005). The presence of interference for aphasic participants indicates that they successfully activate bodypart features, and hence inadequate feature activation may not underlie their verb naming deficit. However, their larger magnitude of interference might suggest a slower decay of activated features. This explanation awaits further confirmation with longer temporal separation between the prime and target. Interestingly, two verb deficient aphasic participants in our research lab (data not reported here) showed facilitation in the congruent condition after a semantic feature treatment with hand/arm verbs.

REFERENCES

Baayen, R., Piepenbrock, R., & van Rijn, H. (1993). The celex lexical database (release 1) [cd-rom]. Phildelphia, Linguistic Data Consortium: University of Pennsylvania [Distributer].

Bergen, B. (2007). Experimental methods for simulation semantics. In Gonzalez-Marquez, M., Mittleberg, I., Coulson, S., & Spivey, M. (Eds.). (2007) *Methods in cognitive linguistics.* Amsterdam: John Benjamins.

Bonnote, I. (2008). The role of semantic features in verb processing. *Journal of Psycholinguistic Research, 37*, 199-217.

Druks, J., & Masterson, J. (2000). *An object and action naming battery.*Philadephia, PA: Taylor & Francis.

Hutchison, K. A. (2003). Is semantic priming due to strength or feature overlap? A microanalytic view. *Psychonomic Bulletin & Review, 10*, 785-813.

Kaschak,M. P., Madden, C. J., Therriault,D. J., Yaxley,R. H., Aveyard,M. E., Blanchard, A. A., & Zwaan, R. A. (2005). Perception of motion affects language processing. *Cognition*, *94,* B79–B89.

Kemmerer, D., Castillo, J. G., Talavage, T., Patterson, S., & Wiley, C. (2008). Neuroanatomical distribution of five semantic components of verbs: Evidence from fmri. *Brain and Language, doi:10.1016/j.bandl.2007.09.003*.

Kertesz, A. (1982). Western aphasia battery, *Grune Stratton*. New York.

Masson, M. E. J., Bub, D. N., & Newton-Taylor, M. (2008). Language-based access to gestural components of conceptual knowledge. *The Quarterly Journal of Experimental Psychology, 61*, 869-882.

Pulvermuller, F. (2005). Brain mechanisms linking language and action. *Nature, 6*, 576-582.

Pulvermüller, F., Härle, M., & Hummel, F. (2001). Walking or talking? Behavioral and neurophysiological correlates of action verb processing. *78*, 143-168.

Pulvermuller, F., Shtyrov, Y., & Ilmoniemi, R. (2005). Brain signatures of meaning access in action word recognition. *Journal of Cognitive Neuroscience, 17*, 884.

Tettamanti, M., Buccino, G., Saccuman, M. C., Gallese, V., Danna, M., Scifo, P., et al. (2005). Listening to action-related sentences activates fronto-parietal motor circuits. Journal of Cognitive Neuroscience, 17, 273–281.

Zwaan, R., Taylor, L., & Boer, M. (in press). Motor resonance as a function of narrative time: Further tests of the linguistic focus hypothesis. *Brain and Language, doi:10.1016/j.bandl.2008.11.004*.

Table 1. The priming conditions, examples, stimulus details and group reaction times (RT) in milliseconds.

	Conditions			
	Baseline	Congruent	Incongruent	Pseudoword
Examples Prime>>Target	xxxx>>chopping xxxx>>kissing	clapping>>chopping licking>>kissing	licking>>chopping clapping>>>kissing	Blending>>>tishing Cuddling>>>dopaling
Number stimuli	100	50	50	200
Unimpaired RT Mean (SD)	797.8 (280.5)	834.3 (281.4)	807.7 (282.6)	844 (281)
Aphasia RT Mean (SD)	1175.7 (88.7)	1283.1 (128.3)	1121.7 (118.4)	1160 (491)

Figure 1. Illustrating the neuronal networks for processing verbs and their corresponding cell assemblies (adapted from Figure 1 in Pulvermuller, 2005)
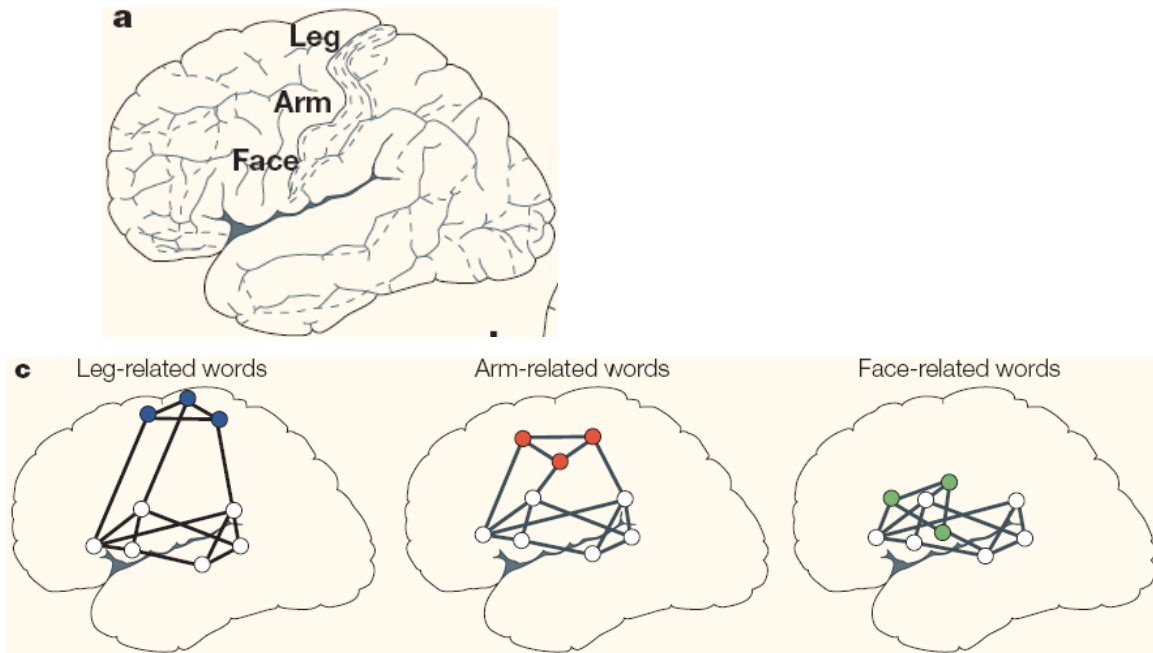
Figure 2. Mean reaction times (in milliseconds) for each condition and group.
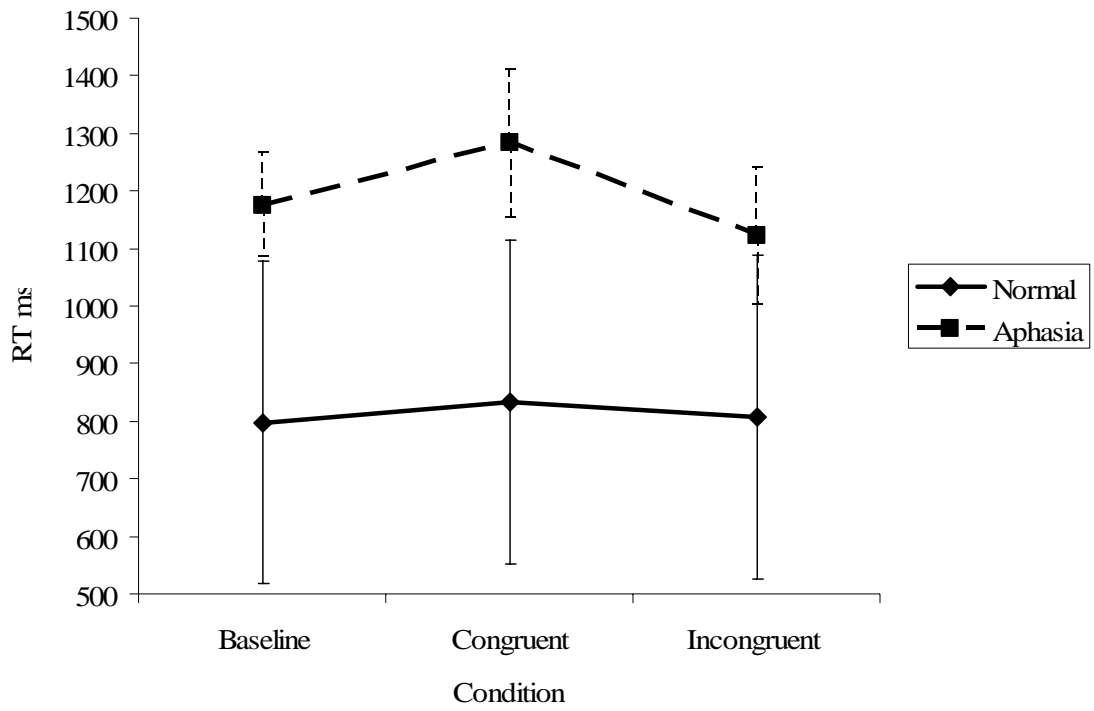
Figure 3. Priming size (corrected for baseline reaction times) for each group and
condition.