Introducing the Gesture Norming Study: A tool for understanding on-line word and picture processing

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Introduction

Motivated by recent data involving the mirror neuron system in the monkey (e.g., Rizzolatti et al., 2002, 1996), researchers have become increasingly interested in theories of embodiment (e.g., Buccino et al., 2001; MacWhinney, 1999). These theories suggest that the involvement of certain body parts in the processing of action and (action-related) object concepts should activate the corresponding sensorimotor areas in the brain, whether an action is performed by the subject, performed by someone else (and observed by the subject), or simply processed in the imagination. Therefore, the semantic and sensorimotor properties behind a given set of stimuli should play a significant role in the way knowledge is organized in the brain, and thus also in the way language may break down following brain injury.

The broad goal of the Gesture Norming Study is to access a deeper dimension of our stimuli, which can be crucial when exploring questions of embodiment in research using different testing methods with various healthy and brain-injured populations. Our item corpus consists of object and action (noun-verb) words from the CRL-IPNP (the Center for Research in Language International Picture-Naming Project, Bates et al., 2000), which has been used by our lab members and collaborators in various cross-population and cross-linguistic studies over the years. Up to date, these stimuli have been presented in three different processing tasks (including two different sensory modalities): picture-naming (PN), single-word reading and single-word repetition (often referred to as word repetition paradigm, or WRP). By having subjects produce “instinctual” gestures to the items presented in written form, our goal is to tap into the motor associations of each word’s meaning, thus allowing us to move one step further, beyond the lexical and into the conceptual/semantic component of each word. Thus, the Gesture Norming study extends the usefulness of our picture/word database to explore questions of body imagery, the organization of meaning, and linguistic and cognitive processing in general.

Background

Many theories have been offered to account for the way in which information and meaning are organized in the brain. Much of what we know comes from research with aphasic patients, whose behavior can often provide insight (albeit not always straightforward) into how language functions may have been organized before injury. Probably the best-known study case is the noun-verb dissociation. Nouns and verbs have been known to dissociate in brain-injured populations across different languages (Bates et al., 1991) as well as across different processing tasks and modalities (Caramazza & Hillis, 1991; Székely et al, 2003; for a review, see Arévalo, 2002). Classic theory contends that while Broca's aphasics tend to display difficulty with verbs while retaining their ability to process nouns, Wernicke's aphasics and Anomics display difficulty with nouns relative to verbs (Chen & Bates, 1998; Daniele et al., 1994; Zingeser & Berndt, 1990).

In addition to the noun-verb distinction, several other categorizations have also been offered as possible ways in which information is organized in the brain, e.g., living vs. non-living items (Cappa et al., 1998a; Silveri et al., 1997) or animals vs. tools (Perani et al., 1995), just to name a few. Another line of research has pointed to the importance of item features; namely, these authors have suggested that items are categorized not by word class but by their semantic and physical features and the correlations between these (Martin & Chao, 2001). One account even argues for the combination of feature types, correlated features and distinguishing features together in order to predict dissociations (Cree & McRae, 2003).

Finally, some have offered ways of reinterpreting classic lexical dissociations by categorizing items along body imagery criteria. One such example is the notion of "manipulability", or hand imagery (Kellenbach et al., 2003; Gerlach et al., 2002). Specifically, items commonly classified as nouns or verbs may also be coded as "manipulable" or "non-manipulable" (i.e., nouns representing objects which can or cannot be manipulated and verbs representing actions which do or do not involve fine hand movements). Furthermore, the way in which these items group and dissociate may be more consistent with the manipulability distinction than the lexical categories of noun vs. verb. Other body parts have also been found to be crucial in mental imagery, i.e., the mouth and the foot (Ehrsson et al., 2003). Therefore, a sensorimotor meaning theory could explain cases in which patients consistently display relative difficulty or sparing for items belonging to both categories of a predetermined set (e.g., nouns as well as verbs).

A recent fMRI study using items from the picture corpus mentioned above (Bates et al., 2000) divided the noun-verb stimuli into manipulable and non-manipulable groups using subjective categorization criteria (Saccuman et al., 2003). Interestingly, results suggested that differences in brain activation were more robust when items were compared along the manipulability distinction than along the lexical distinction of nouns vs. verbs. This finding provides support for the notion that the semantic and sensorimotor properties behind our stimuli play a significant role in the way knowledge is organized in the brain, and that this distinction is perhaps stronger than that seen for the classification based on lexical or grammatical categories.

Stimuli & Methods

As mentioned above, our lab has developed and used a large corpus of action and object (noun-verb) picture stimuli known as the CRL-IPNP (Bates et al., 2000, see Introduction). This corpus consists of 275 action and 520 object pictures, all 2-D black and white line drawings, which have thus far been tested across several different age groups, languages, and in three different modalities (for the reading and repetition tasks, the target[1] words for these items are presented in written and auditory form, respectively). This set of stimuli was originally designed along noun-verb (action-object) distinctions, yet its nature allows us to selectively alternate our focus and test many other possible categorical distinctions (e.g., manipulability).

For the Gesture Norming study, healthy subjects are presented with the written target words of the IPNP stimuli (in order to avoid confounds inherent to presenting the picture stimuli) and are asked to produce "the first position, movement or expression" that comes to mind when thinking of that item. They are told to avoid "charades", given that the goal is not to communicate the concept to someone else, but rather to "embody" their image of that item. Response times (RTs) are recorded by having subjects place both fingers on the button box while waiting for the target word to appear on the screen and to lift them only when ready to perform the gesture. An "ideal" gesture (or one that

[1] Target names were the dominant responses elicited by healthy control subjects for the same picture stimuli on previous runs of action-only and object-only PN; the reading and repetition stimuli were the written and aurally-presented target names of these pictures.

most closely follows the instructions) is on average relatively brief and would usually not convey a clear message to an observer who is not aware of the target word presented. Subjects are videotaped and their gestures are coded with a complex 4-part database we designed along neurological lines, which allows us to account for a number of different variables relevant to our questions of interest (see Appendix A), such as whether a movement is proximal or distal to the body, simple or complex (i.e., one or more related movements), fine or gross. In addition to quantity and quality of each performed gesture, our database records additional information, such as whether a subject encoded the presence of an object or produced a facial expression deemed essential to their conceptualization of that item.

One goal of this study is to provide a more objective way of determining whether certain words involve any body part imagery as part of their meaning, by having subjects externalize their internal representation of that item. Clearly, an experimental task is rarely a perfect representation of processing as it occurs naturally in everyday life, and single words devoid of a natural context are clearly not an everyday occurrence. However, we do believe that gestures produced across several subjects can yield a truly informative set of data, one that can provide us with an empirical (and arguably more objective) way of addressing our questions. One major consideration is inter-subject variability. In fact, for many of the items tested, there is considerable variability across subjects. However, it is the similarities between the gestures as well as the average output across several subjects that will provide the most interesting information.

To date, over 50 subjects have been tested and approximately 32 of these have been scored, due to the time-intensive nature of the coding. Each subject is presented either with object or action target words. Some picture items share the same target words (in our English corpus) and therefore these items are presented only once, reducing the number of object items to 508 and the action items to 238. Because there are almost twice as many object items as action items, we divided our object list in two, such that each subject would be presented with approximately the same number of items, and twice as many subjects were assigned to an object list (resulting in equal numbers of data points per item across lists).

Applicability

In a previous study using a task called the Production Mini-Battery (Arévalo et al., in preparation), the principal goal was to test action and object (noun-verb) naming in aphasic and healthy subjects across three well-studied processing tasks: picture-naming (PN), single-word reading and single-word repetition (WRP). Dissociations along the classic noun-verb distinction occurred only in the picture-naming (PN) task (with verbs being named consistently less accurately and slower than nouns) and were comparable in nature across healthy and patient groups. In other words, no contrasting ("classic") profiles were observed (i.e., double-dissociations between groups), and patients were simply overall less accurate and slower than their healthy counterparts. The lack of any noun-verb dissociations in either of the other two tasks tested (reading and WRP) limits support for a theory of noun-verb dissociations at the lexical/word-category level. In other words, if nouns and verbs always dissociate from each other, then the same set of nouns and verbs (tested on the same set of subjects) should yield similar results across the three processing tasks.

Like our colleagues (Saccuman et al., 2003, see Background above), we then became interested in the notion of embodiment and how the sensorimotor properties of our stimuli influenced processing in our particular task. However, unlike the previous study, we were interested in using a classification method which would be as objective as possible. Therefore, using the data acquired from the Gesture Norming study, we determined whether each item elicited clear, fine movements of the hands and fingers in at least 70% of our subjects and thus classified each noun or verb item as either manipulable or non-manipulable. We then re-analyzed the same data using this new item classification, which produced surprising results: whereas the noun-verb dissociation had not provided support for a double-dissociation and resulted mainly in a single dissociation in one of the tasks (PN), differences in "manipulability" resulted in a double-dissociation between patient and control groups, which for patients occurred in two of the modalities (PN and WRP). Namely, whereas controls as a group were significantly more accurate at producing the manipulable items, patients displayed the opposite pattern: they were significantly more accurate at processing the non-manipulable items (Arévalo et al., 2004).

Clearly, the Mini-Battery study was not originally created to pose questions about body imagery, and a carefully-controlled design addressing hand as well as other body part involvement is sure to target these issues directly and yield additional interesting information. However, these significant preliminary results are extremely promising and pave the way for future research investigating these various topics. They also speak to the applicability of the Gesture Norming Study and its value as a tool in all kinds of research pertaining to linguistic as well as non-linguistic processing. This study is currently a work in progress, yet once enough data is acquired and analyzed, our plan is to create a set of normed gestures which can easily be used as reference and shared with others asking similar questions.

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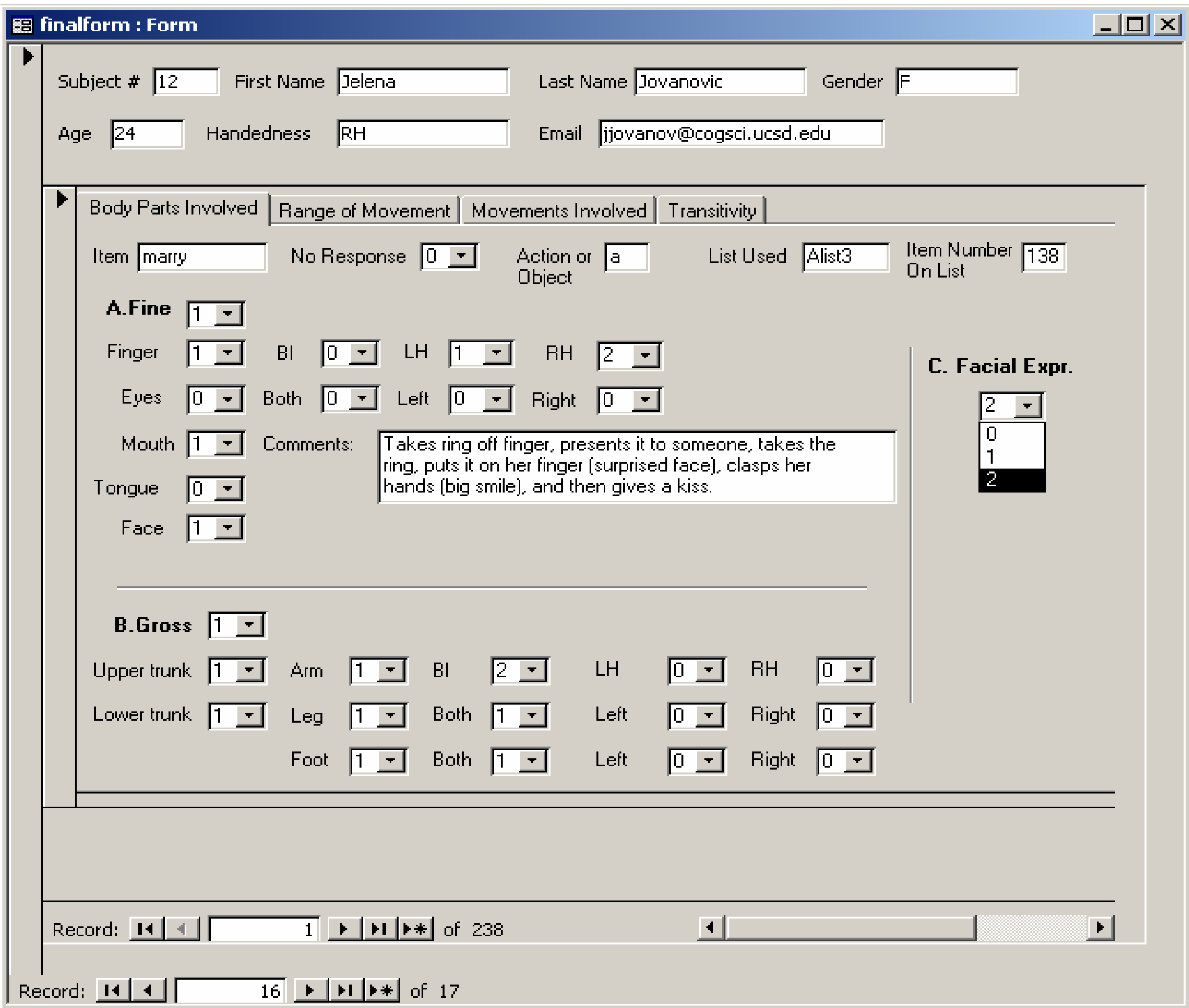
Appendix A

Fig.1: Coding Database. Page 1 of 4: “Body Parts Involved”. Each box contains a range of numbers (usually 0 to 2 or 3), intended as a scale of degree of movement of each body part. Each page also includes a comment box in which the rater can include any additional comments deemed important for the interpretation of each gesture.



finalform : Form

Subject # 12 First Name Jelena Last Name Jovanovic Gender F

Age 24 Handedness RH Email jjovanov@cogsci.ucsd.edu

Body Parts Involved | Range of Movement | Movements Involved | Transitivity

Item marry No Response 0 Action or Object a List Used Alist3 Item Number On List 138

A.Fine 1

Finger 1 BI 0 LH 1 RH 2

Eyes 0 Both 0 Left 0 Right 0

Mouth 1 Comments: Takes ring off finger, presents it to someone, takes the ring, puts it on her finger (surprised face), clasps her hands (big smile), and then gives a kiss.

Tongue 0

Face 1

C. Facial Expr. 2 (0, 1, 2)

B.Gross 1

Upper trunk 1 Arm 1 BI 2 LH 0 RH 0

Lower trunk 1 Leg 1 Both 1 Left 0 Right 0

Foot 1 Both 1 Left 0 Right 0

Record: 1 of 238

Record: 16 of 17

Table 1: List of Coded Variables

Fine Motor Movements	Gross Motor Movements
Face	Upper Trunk
Finger (Both Hands)	Arm (Both)
Finger (Left Hand)	Arm (Left)
Finger (Right Hand)	Arm (Right)
Mouth	Lower Trunk
Tongue	Leg (Both)
Eye (Both)	Leg (Left)
Eye (Left)	Leg (Right)
Eye (Right)	Foot (Both)
	Foot (Left)
Complexity of Movement	Foot (Right)
Simple	
Complex	**Presence of Object**
	No Object Implied
Space Needed for Movement	Object Implied but Not Coded
Across Space	Object Implied and Coded
In Place	Object Pantomime
Specific Facial Movement	**Misc. Use of Body**
Facial Expression	Done On Body