# An Exploration of Delsarte's Structural Acting System

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**Abstract.** The designers of virtual agents often draw on a large research literature in psychology, linguistics and human ethology to design embodied agents that can interact with people. In this paper, we consider a structural acting system developed by Francois Delsarte as a possible resource in designing the nonverbal behavior of embodied agents. Using human subjects, we evaluate one component of the system, *Delsarte's Cube*, that addresses the meaning of differing attitudes of the hand in gestures.

**Keywords:** Virtual Human, Nonverbal Behavior, Acting Technique, Delsarte.

## 1 Introduction

At a recent forum on emotion at the Swiss National Exchange, Leonard Pitt, an expert in mime and the use of masks, performed in front of an audience of assembled emotion researchers. He donned masks with fixed facial expressions and then proceeded to explore how alterations of posture and gesture could manipulate our impression of the emotional/attitudinal state of his character and override the emotion expressed by the mask. The performance served to demonstrate poignantly the panoply of behaviors that convey personality and emotion. Although it was not the performer's intent, it also demonstrated that designers of virtual humans have a long way to go in creating such expressivity in their behavioral models and animations.

Designers of virtual humans have been very effective in mining the large literature in psychology that has studied such phenomena. Of notable distinction is the work of Ekman & Friesen (1978), along with their collaborators, on the facial action coding system (FACS) that breaks down facial expression into action units. FACS has provided a systematic, exacting basis for emotion researchers to study and catalog the expressive capabilities of the face and its role in human interaction. Not surprisingly, the FACS has also helped to spur significant advances in the facial expressions of ECAs (Embodied Conversational Agent, also known as a virtual human). The systematic coding approach provided by FACS allows for the decomposition and enumeration of the space of all possible facial expressions (though all are not anatomically possible). For example, armed with such descriptions, the designer of an

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ECA can build a head that covers that space as well as explore manipulations of the compositions and dynamics of action units.

There has also been extensive work on posture (e.g., Mehrabian, 1969; Walbott, 1998), gesture (Kendon, 2004; McNeill, 1992), gaze (Argyle & Cook, 1976), etc. Unfortunately, this work has typically not matched the systematic level of analysis that the facial expression research has achieved. In particular, the psychological research in these areas has provided far less guidance in the cataloging of the space of all possible head movements or how to exploit and understand the dynamic manner of such movements.

Augmenting the psychological work, there are also a variety of other resources that virtual human researchers can draw upon from the performance arts that augment the psychological literature. Such resources include acting technique, choreography and rhetorical gesture. For example, structural acting systems propose that certain behaviors and the manner in which they are performed convey particular meanings, for example, the work of Laban (see Newlove, 1999) and Delsarte (see Zorn, 1968). This work has in fact informed virtual human research (Noma et al. 2000; Costa et al, 2000; Neff & Fiume, 2004). On the other hand, some acting theories are not directly relevant to our work. For example, Stanislavsky's acting technique (Stanislavski, 1989) informs the performer to put herself in the mental and emotional state of her role and the appropriate physical performance will then naturally follow. This clearly is less relevant to virtual human work, since our virtual humans don't come equipped with a model that maps between internal state and behavior. Indeed it is this mapping that we seek to create.

The analysis technique of Delsarte is particularly intriguing for virtual human researchers. This technique systematically and extensively describes how emotions, attitude and personality are conveyed in dynamic body postures and gestures. Delsarte's work is based on his extensive observations of human behavior across a range of ecologically varied settings. Unfortunately, the description of the technique is often couched in a language and terminology from the 1800s that strikes a 21$^{st}$ century reader as perhaps quaint and metaphysical. More importantly, Delsarte's observations have not been empirically confirmed.

It is in this context that we have been exploring Delsarte's work and asking very basic questions. Are the interpretations that people derive from Delsarte's catalog of movements consistent with Delsarte's analysis or at least reliable across observers? In this paper, we begin to address these questions with some preliminary human experiments targeting what Delsarte describes as *attitudes of the hand*. The results of this pilot study suggest that Delsarte's work deserves some closer scrutiny. For the reader who is not familiar with the Delsarte technique, we will present a brief primer on its relevant features prior to the description of our method and the presentation of results.

## 2 Acting Methods and Delsarte

Acting operates simultaneously on two levels. The opaque level pertains to the body and voice of the actor; we generally associate this level with the skills and virtuosity of the acting craft. The transparent level pertains to the stories and emotions revealed, as conveyed through the actor's body and voice. In short, the audience looks at the opaque body of the actor in order to see through that body a character.

Contemporary actors usually work from the transparent level and assume that their trained bodies and voices will automatically follow. They generally do not think about their bodies when they perform. Expressivity will come as a natural consequence of establishing the proper internal state. If actors are trained in the Stanislavsky System, they begin by asking a simple question. What would I do, if I were in the circumstances of my character? If actors are trained in the American Method, they ask themselves a slightly different question. What is it in my own life that makes that makes me feel the way my character must feel in this scene? In both cases, the contemporary actor places himself or herself imaginatively in the fictional world of the character and then behaves as that world dictates (see Carnicke, 1998, for a comparison of the two approaches).

Unfortunately, contemporary acting practice does not help much in developing a computer model for encoding emotionally realistic physical gestures in virtual characters. Virtual humans do not come equipped with internal mappings from internal cognitive and emotional states to behavior that can be expected to motivate their movements. As Hooks writes [2000], "Actors create emotion – largely internally – in the present moment, while animators describe internal emotion through the external movement of their characters." Moreover, the goals of the virtual human designer, to describe movement, to break it down into its multiple components-- spatial shapes, temporal rhythms, force and direction, and to collect data about the encoding and decoding of emotion through the body are arguably antithetical to the artistic work of the contemporary actor. The contemporary actor allows whatever happens in the moment to occur without intellectually judging it or analyzing it.

In order to address our goals we decided to go back to the past for ways to think about acting—to the time when actors worked more consciously with the opaque level of performance. We thus returned to the techniques of gestural or structural acting.

### 2.1 Introduction to Delsarte

Francois Delsarte lived from 1811 to 1871, a French singer who had lost his voice because of poor teaching practices. He began to study the relationships between physical behavior, emotion, and language in order to formulate scientific principles of expression. Over many years, he diligently observed the expressive postures and gestures of living people across all walks of life as well as corpses in the Paris morgue, developing a broad model of how emotion, body, and language interact.

Delsarte became the most significant acting teacher in Europe and one of his students, Steele MacKaye, became the leading force in American actor training. MacKaye studied with Delsarte in Paris in 1869, became his assistant in 1870, and founded the first professional acting school in the United States in 1884. Thus, Delsarte provided the predominant form of actor training in the United States until 1923 when Stanislavsky first brought the Moscow Art Theater to the United States.

Delsarte saw that movement involves a "semiotics" (Delsarte's own term)—a sign system that can be "read" by observers. Thus, the body encodes meaning which the viewer can decode. He recognized that physical "signs" come from various sources--some gestures are ours alone and express our individuality; some are social or cultural conventions, like waving "hello"; and some may be biologically connected to our emotional reactions (from Delsarte's Rhetoric, e.g. see Zorn, 1968).

The complexity of Delsarte's system is both daunting and a potential advantage. It specifies a vast range of potential gestures and postures by working through a series of principles that defines a space of variations across head orientations, stances, hand shapes, leg positions and arm orientations as well as the meanings they convey. Further, Delsarte argues how the zones of the body and space around the body tend to be associated with differing intellectual, emotional and physical interpretations.

In other words, Delsarte's system provides an enumeration of behaviors potentially both in terms of orientations and movements through space. For example, consider head movement. We know from linguistic studies (e.g., McClave, 2000) that a head shake or sweep may signify inclusivity ("everyone"), a tilt upward that averts gaze can signify an effort to think or regulate cognitive load (Argyle & Cook, 1978) and ethologists tell us that a tilt to the side can signify flirting behavior. Pieced together, these studies can greatly assist in the design of virtual humans. However, it is piecemeal. Delsarte, on the other hand, lays out all possible head tilts and what they could signify. Similarly, consider gestures. Delsarte suggests that the orientation of the gesture in space, the shape of the hand and fingers, the starting and ending location of its movement all impacts what the gesture signifies. Overall, this provides a considerable amount of raw material for designing virtual humans.

Other more recent physically based actor training systems (such as that of Laban) reduce the number of distinct movements that actors are expected to study. As Hecht observes (1971), physical training systems for the actor that come after Delsarte get progressively simpler. For the actor, they seem more manageable, hence more useful. But as a consequence are also limiting for our purpose.

The specifics of Delsarte's system are too extensive to cover in any detail. We therefore confine ourselves to a few brief comments about his work.

### 2.2 Attitudes of the Hand

In describing attitudes of the hand, Delsarte talks of an imaginary cube in front of the speaker. Consider grasping it from each possible surface—use two hands to contain the outer surfaces; push a hand outward against its inner surface; bring a hand upward to its lower surface; explore every possible way of grasping and containing this cube. Each gesture has a different connotation.

Experts on Delsarte differ in the details of what these various positions of the hand signify. There are several sources that describe the cube (e.g., Delaumosne in Zorn, 1968; Shawn, 1963). The basic intuitions of the cube seem on target to us. To address some of the discrepancies across interpretations of Delsarte's teaching, we synthesized the various approaches into the following hypotheses of how they would be interpreted: (The one marked with a plus is a hand posture suggested by the authors.)

- Palm of Hand on face of cube farthest away from body => to limit
- Palm of Hand on interior of face nearest body ⇒to possess +
- Palm of Hand on face of cube nearest body ⇒to stop
- Palm of Hand on side surface of cube ⇒to possess, include
- Palm of Hand on interior side surface of cube ⇒to reject, remove
- Palm of Hand on top surface of cube ⇒to control
- Palm of Hand on bottom surface of cube ⇒to support

### 2.3 The Three Orders of Movement

Delsarte moves beyond the static systems of gestural actor training that were used in the 17th and 18th centuries by paying close attention to the dynamics of motion. In particular, we became particularly interested in three types of motion that Delsarte identifies:

**Oppositions**
Any two parts of the body moving in opposite directions simultaneously suggest expressive force, strength, physical or emotional power. For example, a rejecting motion of arm and hand is strengthened by an opposite motion of head and torso. (This brings to mind Newton's Third Law: For every action, there is an equal and opposite reaction.)

**Parallelisms**
Any two parts of the body moving in parallel directions simultaneously suggest deliberateness, planning, intentionality. An example of this would be arms moving downward in parallel in a beat gesture.

**Successions**
"Any movement passing through the body which moves each part [of the body in turn] (in a fluid wave-like motion)" (Shawn, 1963). True successions move from the face, through the torsos and into the arms and legs and suggest sincerity and normality. Reverse successions work backwards from the limbs into the face and suggest falsity and insincerity.

## 3 Evaluation

Delsarte's system appears at times to be full of interesting insights and at other times mired in metaphysics and a performance culture that is less relevant to the scientific study of modern gesture or acting. It is in the hope to extract the insights and validate them that we have begun to experiment with Delsarte-based behaviors. As the focus of our first experiment, we selected Delsarte's idea of the imaginary cube as describing a space of hand attitudes, in part because it resonates with observations on how gestures often manipulate imaginary objects (McNeill, 1992).

**Stimuli**

The stimuli we constructed were animations of a virtual character that involved the hands moving from a rest pose (arms at the side of the body) to a position on an imaginary cube and then returning to the rest pose.

The animations were crafted with an un-textured body that moved the hand to a position on an imaginary cube. Linear interpolation was used wherever possible, relying largely on simple interpolation between a few poses as opposed to hand-crafting a rich animation. This was done deliberately to avoid inferences from the appearance or physical manner of the animations. The internal cube face animations were designed so that it appears as if the hand was moving through the cube from the opposite face. Figures 2a and 2b depict the position of the hands on the imaginary cube. As can be seen, in some of the interior face stimuli the position of hand is more consistent with having pushed the "cube" as opposed to resting the hand on the interior face. The animations used in this experiment can be found on the web: http://www.isi.edu/~marsella/experiment/. Note that subjects got no other context to guide their interpretations -- the animations are silent, there is no text, sound or dialog. We chose to use animations, instead of stills, because human gestures have motion, but one can imagine a similar experiment using stills.

**Hypothesis**

Table 1 lists the relationship between faces of the cube, animation files and predictions. Note that we explored a superset of the faces described in writings about Delsarte's cube. As noted earlier, the authors included an animation of the hand moving to the nearest internal face that we predicted would be read as a statement about possession. We also included 3 additional cases of the hand pushing through the cube: the farthest-interior face, the bottom-interior face and the top-interior face. Our predictions for these three additional animations were that they would be the same as the corresponding animation that did not push though the cube. These additional predictions are marked by a plus sign. Also, Delsarte only discusses a single hand, whereas we also explored two handed variants. A 2-handed animation was not done for the side internal face since the hands would have crossed. Our predictions for the two-handed animations are that they would coincide to the single-handed case.

**Procedure**

We presented these stimuli to subjects, broken into two groups. One group was shown animations that used only one hand and the other group was shown the gestures using both hands moving to positions on the cube. The order of presentation of animations was randomized. There were 28 subjects in the one-hand condition and 22 subjects in the two-handed condition. Subjects were recruited using Craig's List (a web-based job market).

**Table 1.** Relation between Cube Faces, Animations and Predictions

| Face in relation to body | One Hand | Two Hand | Prediction |
|---|---|---|---|
| Farthest, exterior | FarExt | 2FarExt | Limit |
| Nearest, interior | NearInt | 2NearInt | Possess + |
| Nearest, exterior | NearExt | 2NearExt | Stop |
| Farthest, interior | FarInt | 2FarInt | Stop + |
| Side, exterior | SideExt | 2SideExt | Possess |
| Side, interior | SideInt | None | Reject |
| Top, exterior | TopExt | 2TopExt | Control |
| Bottom, interior | BotInt | 2BotInt | Control + |
| Bottom, exterior | BotExt | 2BotExt | Support |
| Top, interior | TopInt | 2TopInt | Support + |

To begin the experiment, subjects sat down at a computer interface that provided the following instructions:

> **You will see videos of an animated character. Each video will show the character performing a gesture while interacting with someone off-camera.**
>
> **After each video, you will be asked to choose one phrase that best describes what the gesture conveys.**

After each animation, they were then provided a forced choice questionnaire. See Table 2. The authors broke the interpretation of “Stop” into two variants, Stop you and Stop it. Similarly, “Reject” was broken into two variants of Reject It and Reject


**Fig. 1.** Questionnaire

your Idea. This was done to explore the assumption that some motions may have different referents, either an abstract idea or the listener.

**Results**

Figures 2a and 2b show frequency distribution plots of subjects' preferred interpretations. Predicted responses are indicated with grey arrows. The white arrows are used to indicate our added predictions. In the case of Stop and Reject, where a prediction was broken into two variants, two arrows identify the predictions.

With the exception of SideExt these distributions are highly unlikely to be obtained by chance (Chi-square test for all 8 categories being equal, $p< 0.05$). This result is, however, not informative enough, since we were mainly interested in the proportions of subjects' responses on predicted categories and did not make any assumptions regarding the distributions of responses on other categories.

For this reason we have performed another series of tests to find out if the proportions of subjects' responses for individual categories were higher than the chance level. For each animation we have aggregated the data into 2 groups: predicted and un-predicted, and used Chi-square statistic to test if the proportions for predicted groups were above chance level. The predicted group contained either a single category or, in the case of Stop and Reject, two categories. We defined chance level as 0.125 (1 out of 8) for a single category, and 0.25 (2 out of 8) for the cases where 2 categories were combined together. The results are presented in Table 2 (left half).

**Table 2.** Proportions of subjects' responses for selected categories

| | **Predicted category** | **Prop.** | **Sig.** | **Most frequent category** | **Prop.** | **Sig.** |
|---|---|---|---|---|---|---|
| FarExt | Limit | *0.071* | 0.029 | Possess | **0.393** | **0.000*** |
| NearInt | Possess | **0.714** | **0.000*** | Possess | **0.714** | **0.000*** |
| NearExt | Stop (comb.) | **0.929** | **0.000*** | Stop (comb.) | **0.929** | **0.000*** |
| FarInt | Stop (comb.) | **0.929** | **0.000*** | Stop (comb.) | **0.929** | **0.000*** |
| SideExt | Possess | *0.036* | 0.009 | Limit | **0.321** | **0.002*** |
| SideInt | Reject (comb.) | **0.607** | **0.000*** | Reject (comb.) | **0.607** | **0.000*** |
| TopExt | Control | 0.179 | 0.383 | Limit | **0.500** | **0.000*** |
| BotInt | Control | *0.071* | 0.029 | Reject (comb.) | **0.464** | **0.009*** |
| BotExt | Support | **0.607** | **0.000*** | Support | **0.607** | **0.000*** |
| TopInt | Support | **0.607** | **0.000*** | Support | **0.607** | **0.000*** |
| 2FarExt | Limit | *0.000* | - | Possess | **0.714** | **0.000*** |
| 2NearInt | Possess | **0.667** | **0.000*** | Possess | **0.667** | **0.000*** |
| 2NearExt | Stop (comb.) | **0.905** | **0.000*** | Stop (comb.) | **0.905** | **0.000*** |
| 2FarInt | Stop (comb.) | **0.810** | **0.000*** | Stop (comb.) | **0.810** | **0.000*** |
| 2SideExt | Possess | *0.048* | 0.032 | Limit | **0.333** | **0.004*** |
| 2TopExt | Control | 0.238 | 0.900 | Limit | **0.476** | **0.000*** |
| 2BotInt | Control | *0.048* | 0.032 | Stop (comb.) | 0.381 | 0.166 |
| 2BotExt | Support | **0.619** | **0.000*** | Support | **0.619** | **0.000*** |
| 2TopInt | Support | **0.810** | **0.000*** | Support | **0.810** | **0.000*** |

Observed proportions that were significantly higher than the chance level ($p < 0.05$) are in bold and marked with asterisks.

As one can see from the table, 11 out of 19 predictions are supported by our data. Note, however, that in several of the other cases the proportions for predicted categories were actually lower than the chance level (shown in italic) – sometimes predicted category happened to be the least frequently selected by the subjects. In those cases, where predicted category was not the most frequent one, we have repeated the same analysis using the actual most frequent category instead of predicted. The results are presented in the right half of Table 2, and with a single exception, the subjects' preferences appear to be well above chance level.

The plots and the results of statistical analysis reveal considerable consistency in people's responses with clearly preferred responses. Moreover, the predicted response is generally the preferred category.

When the hand(s) end in a position where the palms face the virtual human (FarExt, 2FarExt, NearInt and 2NearInt), possession is the preferred interpretation. In the case of NearInt and 2NearInt, this was predicted. Given the similar movement and ending position for all 4 of these gestures, it is not surprising that the preferred response for FarExt and 2FarExt are also possession, even though it was not predicted.

When the palm faces away from the virtual human, on the face of the cube closest to it (NearExt and 2NearExt), there is a strong preference for a "stop" interpretation, as predicted. In the case of NearExt, there is a strong preference for "stop you" over other interpretations. In the case of 2NearExt, the responses are largely split between "stop you" and "stop it". (But as noted above, the Chi-square analysis aggregated these two responses).

**Table 3.** Comparison of distributions for 1 vs. 2 handed animations

| Face in relation to body | Compared animations | Chi-Square | Sig. |
|---|---|---|---|
| Farthest, exterior | FarExt – 2FarExt | 6.175 | .186 |
| Nearest, interior | NearInt – 2NearInt | 3.576 | .612 |
| Nearest, exterior | NearExt – 2NearExt | 4.578 | .469 |
| Farthest, interior | FarInt – 2FarInt | 7.389 | .193 |
| Side, exterior | SideExt – 2SideExt | 8.033 | .330 |
| Top, exterior | TopExt – 2TopExt | 4.594 | .467 |
| Bottom, interior | BotInt – 2BotInt | 3.833 | .699 |
| Bottom, exterior | BotExt – 2BotExt | 3.233 | .664 |
| Top, interior | TopInt – 2TopInt | 7.486 | .187 |

A similar "stop" response is shown when the hand moves forward through the cube - the FarInt and 2FarInt animations. Although here the responses are somewhat more spread over stop you and stop it, aggregated analysis shows a significant difference with the chance distribution.

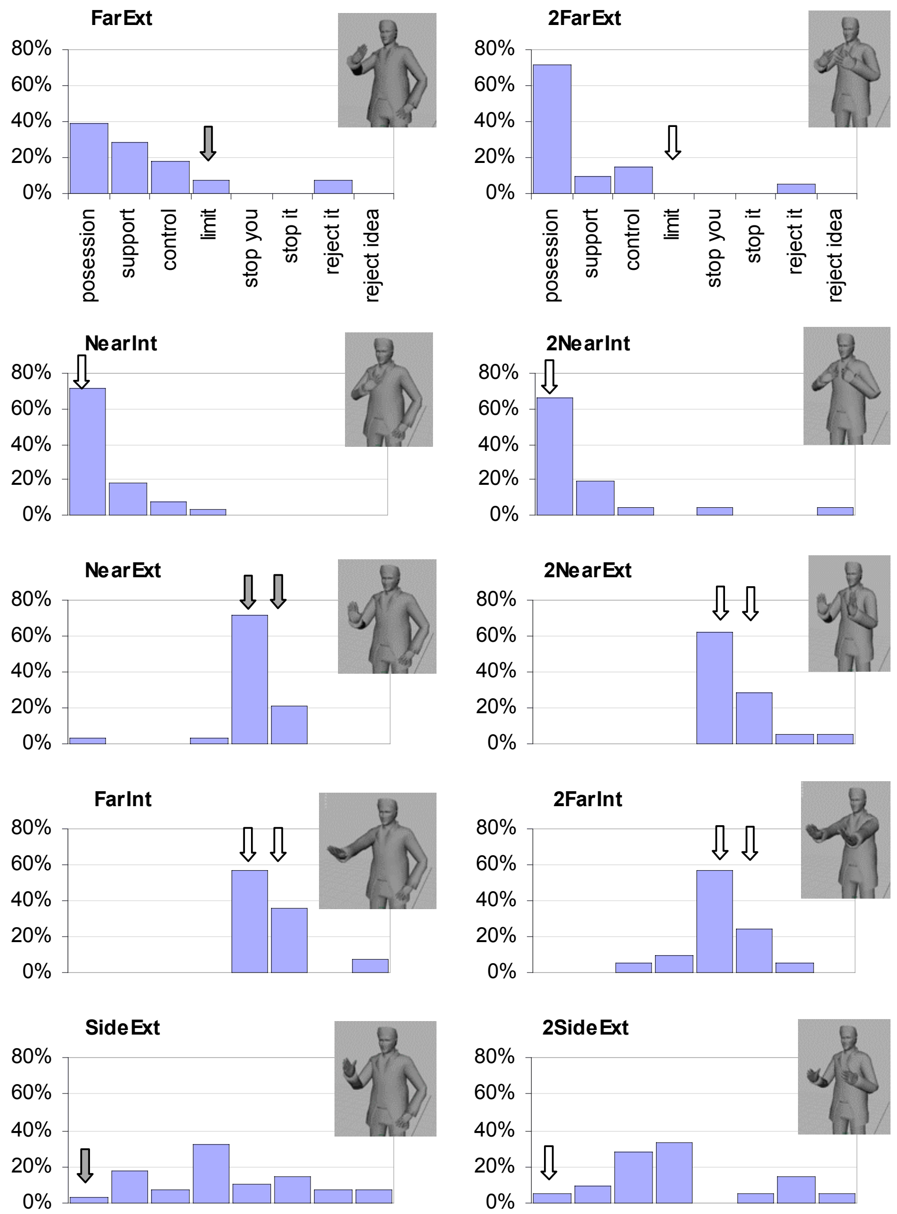


**Fig. 2a.** Frequency distributions of subjects' interpretations

When the hand is on the side of cube, there is more spread in the responses. SideExt, specifically, is the only animation where the differences between all responses are not significant. We discuss possible explanations in the discussion section. For 2SideExt, they are above chance level, but the most popular response ("limit") is not significantly different from the others.

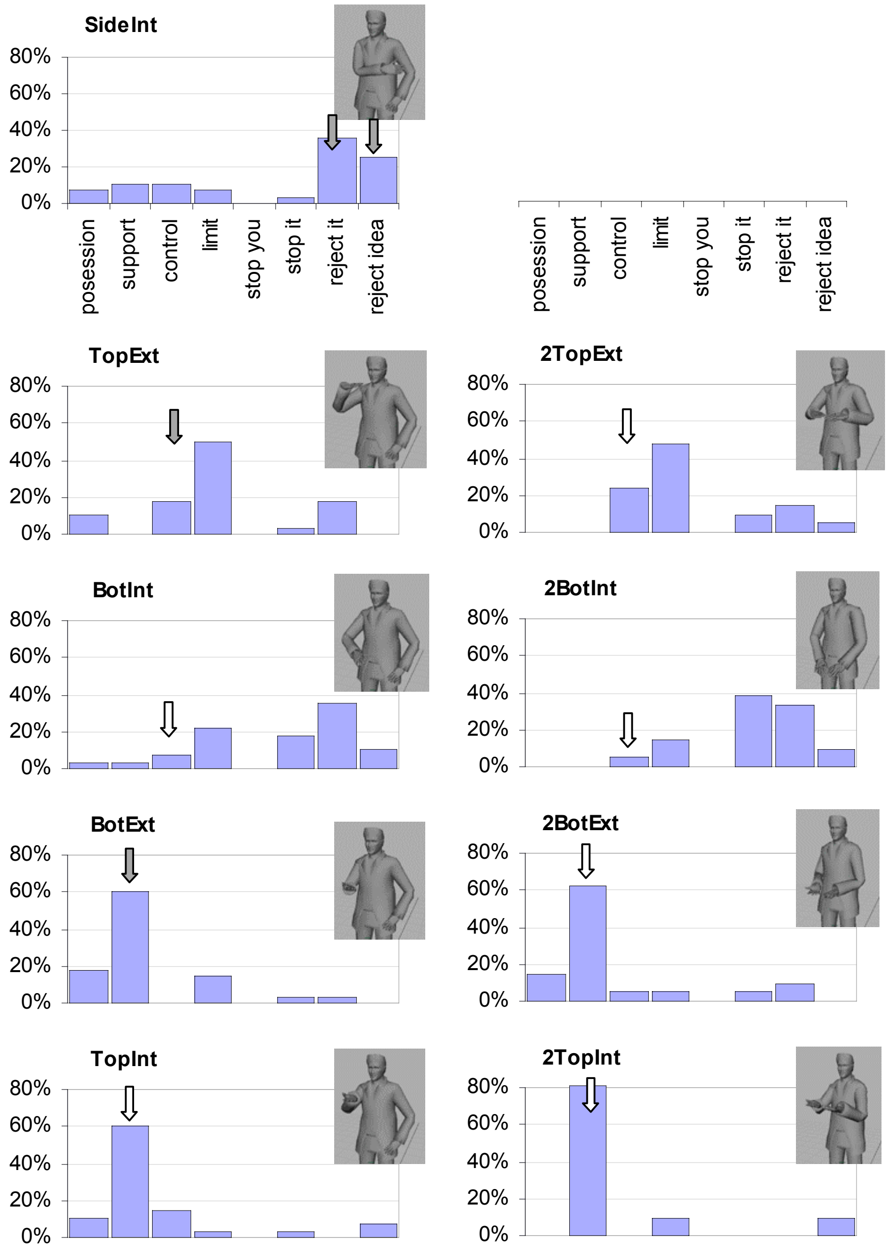


**Fig. 2b.** Frequency distributions of subjects' interpretations (*continued*)

In SideInt, the hand moving through the cube sideways, there is a strong preference for a combined "reject" interpretation (aggregating reject it and reject you), as predicted. TopExt's preferred response is limit. The predicted response, however, control, is closely related conceptually. In the case of the hands on the bottom of the cube with palms up, BotExt and 2BotExt, there is a strong preference for a support interpretation, as predicted. Finally, a similar, but even more prominent response is seen in the case where the hands move up through the cube, TopInt and 2TopInt.

Finally, comparison between 1-handed and corresponding 2-handed animations shows that their response distributions are very similar. The results of a Chi-square test are presented in Table 3: the differences within each pair of animations are non-significant (at $p < 0.05$).

**Discussion**

The results reveal considerable consistency in the subject's interpretations. Further the results are generally consistent with predictions. The results are particularly surprising given the minimal context the subjects were presented – they simply got these movements to interpret without other context or dialog. This suggests that Delsarte's cube may provide useful insight in how a virtual human's gestures can use physical space to convey meaning. And going beyond the cube, the current results suggest that perhaps the larger body of Delsarte's work is deserving of closer attention.

In the particular experiments reported here, there is room for improvement. We chose to use animations instead of static poses of the hand resting on the cube faces. Obviously, movement conveys considerable meaning that can easily override the pose. This may in fact explain some of the results that were not consistent with Delsarte's predictions. It will be informative to repeat the study with different motions to the pose. Further, animations whose responses revealed far less consistency may be due to the fact that the categories used in this experiment were synthesized by trying to find an intersection across the writings of several Delsarte experts. As a consequence, this synthesis ended up restricting the number of categories and more importantly the richness of the category descriptions. The fact that some animations did not have a strongly preferred interpretation may be an artifact of there being too few categories and limiting the possible interpretations. It may be informative and more useful to just use the categories as described by a single expert or alternatively to take a union of the interpretations across experts.

Of course, consistent interpretation, free of any specific interactional context or dialog, is a strong test for nonverbal behavior which, by itself, is often ambiguous. In fact, as long as an observer decodes the behavior appropriately in an interactional context that is well defined, the behavior has potential utility for a virtual human designer. There also is the issue of evaluating how natural the gestures appear to the subjects, an issue that is distinct from but may correlate to a degree with consistency of interpretation. Finally, the animations used a single rotation of the hand with respect to the cube face and a single hand shape, and manipulation of these factors may influence the interpretation, as Delsarte argues.

## 6 Conclusion

The design of virtual humans is an interdisciplinary task. As a community, we all draw heavily on research in artificial intelligence, psychology, human ethology and linguistics, to name a few fields. We have also drawn on insight from the arts, including narrative theory, animation, dance, theatre and film.

The preliminary work reported here attempts to go beyond just drawing insights from the arts. The knowledge and aesthetics acquired by the performance arts can provide a more systematic basis for the design of our virtual humans. We believe this to be a common goal shared by many in the virtual human community and see this work in the context of trying to help achieve that goal.

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