For the first three questions, you will be graded on the clarity of your exposition, as well as on the appropriateness, correctness and relevance of the particular examples and facts that you use to illustrate or to support your points.

1. Please read the following paragraphs carefully and answer the questions following the text.

Motor goals are extrinsic if the Central Nervous System (CNS) specifies the spatial trajectory or the target equilibrium position of the task's end-effector (i.e., tool point or terminal device for the corresponding effector system) in the outer visual space, such as a finger's end-point in a pointing task. Motor goals are intrinsic if defined in an effector-system-specific manner. Thus, intrinsic goals could be joint angles or forces generated by limb or arm muscles. Below we will criticize this conceptual distinction and try to dissolve it. The quest to identify the variables in terms of which motor goals are represented has, however, been a major theoretical theme in the field.

The extrinsic motor goals hypothesis was introduced by Bernstein (1935) who assumed that "there exist in the higher levels of the CNS projections of space and not projections of joints and muscles" (cited by Morasso, 1981, p. 224, similar views had been voiced by Hughlings-Jackson as early as 1899). In modern movement science, the debate about extrinsic vs. intrinsic motor goals began with studies which found that some key properties of the movement trajectories of the end-effector were invariant in the outer Cartesian space, across repetitions, conditions, and subjects: movement paths of the end-effector are gently curved and their tangential velocity profiles are bell-shaped with a single peak (Morasso, 1981; Abend et al., 1982). Soechting and Lacquaniti (1981) studied pointing arm movements in a vertical plane and interpreted extrinsic invariants as the consequence of the temporal coordination of the joint angles at the shoulder and the elbow (see Flanagan and Ostry (1990) for a similar conclusion for jaw movements). Uno et al. (1989) and Kawato et al. (1990) argued that optimization principles may add intrinsic to extrinsic constraints. They proposed that human movements are planned in terms of a number of via-points specified in the extrinsic Cartesian space of the end-effector. The realization of these extrinsic goals would then be achieved by optimizing intrinsic variables such as the change of the torque at each joint. Force- field studies probe this hypothesized combination of extrinsic constraints within intrinsic optimization. When Shadmehr and Mussa-Ivaldi (1994) asked participants to move the handle of a robotic manipulandum onto which an initially unknown force field was applied, participants learned to produce end-effector trajectories similar to the ones observed in the absence of a force-field. To achieve this invariant extrinsic motor goal, the participants had to generate quite different torque profiles at the intrinsic level. According to the authors, this amounted to learning an internal model of the external force field.

Because extrinsic and intrinsic variables are necessarily in a one-to-one relationship in nonredundant effector systems, those experiments—all based on such systems—are fundamentally inconclusive with respect to the relationship between these two frames of reference. Any extrinsic constraint can always be recasted as an intrinsic constraint and vice versa. Most human effector systems are redundant for most typical human motor tasks, however, both at the kinematic level and at the level of muscles (Latash et al., 2007). In a redundant effector system, multiple possible intrinsic kinematic states are possible for any given extrinsic goal. Typically, the set of such task-equivalent joint or muscle configurations forms a continuous set, sometimes called the "uncontrolled" or self-motion manifold (Schöner, 1995). Scholz and Schöner (1999) have proposed that the structure of variance in the intrinsic space can reveal motor goals in the extrinsic space. Specifically, they provided a method to decompose variance at the joint level into joint configurations that leave extrinsic variables invariant and joint configurations that induce variance of extrinsic variables. Evidence for extrinsic motor goals is obtained if variance that affects the extrinsic variables is suppressed compared with variance that does not affect the extrinsic variables. This signature was found in a great variety of tasks and effector systems that ranged from the sit-to-stand transition (Scholz & Schöner, 1999), upright stance (Hsu et al., 2007), pointing in 3D (Tseng et al., 2003) to shooting (Scholz et al., 2000). How multiple muscles generate a particular level of torque and stiffness at any individual joint can

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similarly be analyzed using the concepts of the uncontrolled manifold (Latash et al., 2007; Krishnamoorthy et al., 2005, for an early proposal see Laboissière et al., 1996). A theoretical model showed how the coupling between extrinsic motor goals and intrinsic joint-level variables may give rise to the structure of variance that the uncontrolled manifold describes while at the same time providing for classical invariance effects (Martin et al., 2009). This theory suggests that motor systems are structured by constraints at the level of extrinsic task variables, which are realized, however, in the form of coupling structures at the level of the intrinsic effector variables.

(adapted from Grimme et al. 2011, pp. 7-9)

Question: The above paragraphs defined the extrinsic and intrinsic motor goals for body motor behaviors. Based on the definitions and the discussion, what would be intrinsic motor goals for speech production? (15%) What would be extrinsic motor goals for speech production? (15%) Limit your answers to 100 words for each question.

2. Consider the following two sentences and answer the following two questions. Limit your answer to 200 words for each question asked.

(1) Time flies like an arrow.
(2) Fruit flies like a banana.

a) How do these sentences illustrate the challenges one may encounter when comprehending language? (15%)

b) Although people may stumble over the second sentence, most people can successfully and correctly interpret it within hundreds of milliseconds. This kind of comprehension accuracy, however, has been proven difficult to achieve for machines. Speculate what factors may be at play in differentiating the language processing abilities of human beings and computers. (15%)

3. In Grimme et al. (2011), the authors reveal similarities and differences between body and speech motor control and propose potential accounts for their differentiated processing mechanisms. Please read the following viewpoints proposed by the authors and answer the question below.

"... Intergestural coordination has not been studied much for object-oriented action, but is a central concern of researchers who try to understand how the elements of language are enacted during speech production. The fast, but task-dependent compensatory reactions to perturbations observed in speech production push the envelope of what is known from limb movements. Biomechanical constraints also differ in the two domains. In manipulatory movements, the effects of adaptation to external loads are a major concern. In speech production, the properties of soft tissue articulators and the sheer speed of the articulatory movements pose unique problems. A common thread of these points of divergence between the two domains may be the high rate of movement in speech production. Motor goals follow each other in a fast sequence of articulatory events. This may require more planning ahead, and more coordination among subsequent elements of the sequence allowing for fast anticipatory adjustments to predictable articulatory challenges."

(adapted from Grimme et al. 2011, p. 24)

Question: Do you agree or disagree with authors' proposal that faster sequences of articulation require more planning and coordination? In two hundred words, give your responses, reasons, and evidence, if there is any. (20%)

4. Below is an excerpt adapted from Hirschberg and Manning's review article published in Science (2015). Based on these materials, provide a title (5%) and a summary (15%).

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The development of social media has revolutionized the amount and types of information available today to natural language processing (NLP) researchers. Researchers use Web-scraping techniques to download previously unimaginable amounts and categories of data from Twitter, Facebook, YouTube, blogs, and discussion forums. Using statistical and machine learning (ML) techniques, they learn to identify demographic information (such as age and gender) from language, track trending topics and popular sentiment, identify opinions and beliefs about products and politicians, predict disease spreading from symptoms mentioned in tweets or food-related illnesses, recognize deception in fake reviews, and identify social networks of people who interact together online.

In this era of big data, the availability of social media has revolutionized the ways advertisers, journalists, businesses, politicians, and medical experts acquire their data and the ways in which those data can be put to practical use. Product reviews can be mined to predict pricing trends and assess advertising campaigns. Political forums can be searched to predict candidate appeal and performance in elections. Social networks can be examined to find indicators of power and influence among different groups. Medical forums can be studied to discover common questions and misconceptions about sufferers from particular medical conditions so that website information can be improved.

Social media also provide very large and rich sources of conversational data in Web forums that can provide "found" data for the study of language phenomena such as code-switching (mixed language in bilingual speech), hedging behavior (words and phrases indicating lack of commitment to a proposition such as "sort of"), and hate speech or bullying behavior. A particular application of data mining is the mining of data collected from Twitter or blogs to provide valuable information for disaster relief organizations, identifying the most serious problems, where they occur, and who is experiencing them.

There are also some drawbacks to social media data mining. There is an increasing concern for privacy issues, particularly for an individual's control over their own data versus researchers' desire to mine it. Sites such as Twitter severely limit a researcher's ability to download data, which impedes speedy corpus collection. There is also a major issue with discovering "ground truth" in online postings, because there is no clear way of validating an individual's demographic information; the validity of posts concerning events; and most reviews of hotels, restaurants, and products. Aggregating information from multiple sources at similar times can address some validity issues, and sites do attempt to identify spurious reviews, but this issue remains perhaps the most difficult one for those working with social media data.

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