1 Introduction: Social Signal Processing

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Introduction

Social signal processing (SSP) is the computing domain aimed at modeling, analysis, and synthesis of social signals in human–human and human–machine interactions (Pentland, 2007; Vinciarelli et al., 2008, 2012; Vinciarelli, Pantic, & Bourlard, 2009). According to different theoretic orientations, social signals can be defined in different ways, for example, "*acts or structures that influence the behavior or internal state of other individuals*" (Mehu & Scherer, 2012; italics in original), "*communicative or informative signals which . . . provide information about social facts*" (Poggi & D'Errico, 2012; italics in original), or "*actions whose function is to bring about some reaction or to engage in some process*" (Brunet & Cowie, 2012; italics in original). The definitions might appear different, but there seems to be consensus on at least three points.

- Social signals are *observable* behaviors that people display during social interactions.
- The social signals of an individual A produce changes in others (e.g., the others develop an impression or a belief about A, react to A with appropriate social signals, or coordinate their social signals with those of A).
- The changes produced by the social signals of A in others are not random, but follow *principles and laws*.

In a computing perspective, the observations above lead to the key idea that shapes the field of Social Signal Processing, namely that social signals are the *physical*, machine detectable trace of social and psychological phenomena not otherwise accessible to direct observation. In fact, SSP addresses the following three main problems.

- *Modeling*: identification of principles and laws that govern the use of social signals.
- *Analysis*: automatic detection and interpretation of social signals in terms of the principles and laws above.
- *Synthesis*: automatic generation of artificial social signals following the principles and laws above.

Correspondingly, this book is organized into four main sections of which the first three focus on the three problems outlined above while the fourth one introduces current applications of SSP technologies.

- *Part I Conceptual models of social signals*: this section covers definitions and models of social behaviour and social signals – the core concepts of SSP as researched in social psychology, cognitive sciences, evolutionary psychology, and anthropology.
- *Part II Machine analysis of social signals*: this section covers the technologies aimed at automatic detection of social signals apparent from face and facial behaviour, vocal expressions, gestures and body postures, proxemics, etc.
- *Part III Machine synthesis of social signals*: this section covers the technologies aimed at empowering artificial agents with the ability of displaying social signals, including expressive speech synthesis, facial animation, and dialogue management.
- *Part IV Applications of SSP*: this section covers the most important SSP applications domains, including socially intelligent surveillance, deception detection, healthcare, and multimedia indexing.

Every chapter is a survey aimed at beginners and experienced researchers in the field. For the former, the surveys will be a fundamental source of references and a starting point in the research on the topic. For the latter, the chapters will be a compendium of the large body of knowledge accumulated in SSP, informed by the critical views of some of the most influential researchers in the domain.

Part I Conceptual Models of Social Signals

Part I introduces social science perspectives on social signaling. Covered are theories and models related to the etiologies, form, and functions of social signals. The first chapter, "Biological and Social Signaling Systems" (Kory Floyd and Valerie Manusov), addresses the fundamental issue of nurture versus nature influences on social signals, focusing in particular on the interplay between innate biological processes and acquired components resulting from sociocultural processes. The next two chapters concern the horizontal versus vertical dimensions along which social messages are expressed and interpreted. The chapter, "Universal Dimensions of Social Signals: Warmth and Competence" (Susan Fiske and Cydney Dupree), surveys recent results on the perception of *warmth* and *competence*, the two dimensions along which people tend to assess unacquainted others in the earliest stages of an interaction. In particular, the chapter highlights that the two dimensions are *universal*, that is, they tend to appear in all situations and cultures. Judith Hall and Marianne Schmid Mast survey the use of social signals as a means to express social verticality – status and power differences between people belonging to the same social system – in the chapter entitled "The Vertical Dimension of Social Signaling."

The two chapters that follow concern the relationship between emotions and social signals. The fourth chapter, "Measuring Responses to Nonverbal Social Signals: Research on Affect Receiving Ability" (Ross Buck, Mike Miller and Stacie Renfro Powers), addresses the perception of emotions and affect that others display. In particular, the chapter focuses on pickup and processing of facial and bodily displays. It is complemented by the chapter authored by Björn Schuller, Aaron Elkins and Klaus Scherer,

"Computational Analysis of Vocal Expression of Affect Trends & Challenges," which focuses on the vocal expression of emotions. Furthermore, the chapter addresses the role that signal processing technologies can have in the investigation of social signals.

The role of social signals as a means to display identity and personality is the focus of "Self-presentation: Signaling Personal and Social Characteristics" (Mark R. Leary and Katrina P. Jongman-Sereno). In particular, this chapter analyses the considerable efforts that people make in order to lead others to treat them in desired ways. Finally, the last three chapters of Part I address phenomena that take place during the interaction between people. The chapter, "Interaction Coordination and Adaptation," by Judee Burgoon, Norah Dunbar, and Howard Giles focuses on the tendency of interacting people to mutually adapt their interaction styles or to adopt similar behavior patterns. Persuasion is at the core of the chapter authored by William Crano and Jason Siegel, "Social Signals and Persuasion," with particular attention to the effect of social signals on the credibility of a source. Finally, the last chapter of Part I, "Social Presence in CMC and VR" by Christine Rosakranse, Clifford Nass, and Soo Youn Oh, focuses on technology mediated interaction contexts and, in particular, on how to convey social presence when interaction is not face-to-face.

These Part I chapters supply essential context for conducting machine analysis of social signals. They identify the multitude of functions that given signals may perform and draw attention to the fact that many signals arise not from meanings that senders are attempting to convey but rather are a response to the displays of interlocutors and the jointly created exchange.

Part II Machine Analysis of Social Signals

The second part of the book deals with machine analysis of social signals. It represents a collection of surveys covering the state of the art in research and technology aimed at automatic detection of social signals.

The first two chapters deal with two of the most important sources of social signals, namely face and body. In "Facial Actions as Social Signals," Michel Valstar, Stefanos Zafeiriou, and Maja Pantic survey the past work in machine analysis of facial gestures (i.e., facial action units), which are the building blocks of all facial expressions, including the facial expressions typical of displays of social signals such as interest, mimicry, empathy, envy, and so on. Particular attention is paid to discussing automatic facial gesture recognition in unconstrained conditions and real-life situations. Ronald Poppe, the author of "Automatic Analysis of Bodily Social Signals," surveys the state of the art approaches and technologies for automatic recognition of social signals apparent from a human body's posture and movement. This includes interest detection in interactions with robot companions, detection of phenomena such as mimicry and turn taking, and deception detection.

The chapters following those mentioned above address the problem of using social signals as a means to infer people's characteristics. Personality traits profoundly influence one's displays of social signals and one's social interactions. For instance, it is

commonly known that extrovert people easily establish and have more pleasant social interactions than is the case with more introvert people. In "Computational Approaches for Personality Prediction," Bruno Lepri and Fabio Pianesi discuss two approaches to automatic prediction of one's personality. The first relies on automatic recognition of so-called distal cues (e.g., voice pitch) and learning which distal cues underlie which personality trait (extrovert, neurotic, agreeable, conscientious, open). The second approach to automatic personality prediction relies on one's profile and interactions in a social network such as Facebook. Attractiveness and likability affect social exchanges in very predictable ways. It is widely known, for example, that attractive people establish social interaction more easily than less attractive people. In "Automatic Analysis of Aesthetics: Human Beauty, Attractiveness, and Likability," Hatice Gunes and Björn Schuller survey the past work on automatic analysis of human attractiveness and likability based on audio and visual cues shown by the judged person.

The remaining chapters of Part II focus on phenomena that take place during social interactions. A large body of research in psychology points out that an individual's temporal coordination in social interactions has detrimental effects on the outcome of the interaction (e.g., whether one will feel liked or not, whether the outcome of negotiation will be positive or not, etc.). In "Interpersonal Synchrony: From Social Perception to Social Interaction," Mohamed Chetouani, Emilie Delaherche, Guillaume Dumas, and David Cohen focus on computational models of interpersonal synchrony and survey the automatic approaches to interpersonal synchrony assessment. Social emotions are defined as emotions that relate to interpersonal interactions, rather than to individual feelings (e.g., empathy, envy, shame, etc.). In "Automatic Analysis of Social Emotions," Hatice Gunes and Björn Schuller provide an overview of the past research on automatic recognition of social emotions from visual and audio cues. In "Social Signal Processing for Automatic Role Recognition," Alessandro Vinciarelli surveys the past work on this earliest research topic addressed by the SSP community – recognition of social roles (i.e., the position that someone holds in a given social context, such as "moderator" versus "discussion participant"). Particular attention is paid to open issues and challenges in this research field.

All previously mentioned approaches to automatic analysis of social signals build upon machine learning techniques to model latent and complex behavioral patterns, underpinning target social signals, from available data (i.e., audio, visual, multimodal observations of target social signals). In "Machine Learning Methods for Social Signal Processing," Ognjen Rudovic, Mihalis Nicolaou, and Vladimir Pavlovic focus on systematization, analysis, and discussion of recent trends in machine learning methods employed typically in SSP research.

Part III Machine Synthesis of Social Signals

Part III includes surveys on some of the most important aspects of social signals synthesis, from the generation of artificial nonverbal cues, to the use of artificial cues to convey socially relevant information, to social robots.

The first two chapters address, respectively, speech synthesis and the generation of gestures and bodily movements. Kallirroi Georgila – author of "Speech Synthesis: State-of-the-art and Challenges for the Future" – describes state-of-the-art techniques for the generation of artificial speech and emphasizes in particular the synthesis of emotional and expressive speech through the use of paralanguage and nonverbal cues. Similarly, the authors of "Body Movements Generation for Virtual Characters and Social Robots" (Aryel Beck, Zerrin Yumak, and Nadia Magnenat-Thalmann) survey not only the technologies to synthesize nonverbal cues such as body posture, gestures, and gaze, but also the use of these cues when it comes to the communication of emotion and affect.

In the two chapters that follow those mentioned above, the authors address the problem of how to artificially generate social phenomena and, in particular, how to convey emotion and prosocial behavior. Marc Cavazza (author of "Approach and Dominance as Social Signals for Affective Interfaces") surveys the adoption of affective interfaces as a principled approach toward the improvement of the interactions between users and machines. Ketaki Shriram, Soon Youn Oh, and Jeremy Bailenson (authors of "Virtual Reality and Prosocial Behavior") survey the efforts aimed at promoting positive changes in behavior (e.g., increasing environment awareness or adopting healthier lifestyles) through the adoption of virtual spaces where it is possible to interact in a controlled setting, possibly including artificial characters.

The conclusive chapter of Part III, "Social Signal Processing in Robotics" by Maha Salem and Kerstin Dautenhahn, focuses on social robots, one of the most important forms of embodiment where the synthesis of social signals can play a crucial role in ensuring smooth, enjoyable, and effective interactions between humans and machines.

Part IV Applications of Social Signal Processing

The last part of the book deals with the applications of social signal processing. While being a relatively young domain (the very expression *social signal processing* was coined less than ten years ago), the methodologies produced in the field have been shown to be promising in a wide spectrum of application areas.

The first two chapters of this part show applications where the very analysis of social signals can serve practical purposes, namely surveillance and automatic understanding of group behavior. Dong Seon Cheng and Marco Cristani ("Social Signal Processing for Surveillance") show how the automatic analysis of social signals can improve current surveillance approaches that, typically, analyze human behavior without taking into account the peculiarities of social behavior. Daniel Gatica-Perez, Oya Aran, and Dinesh Jayagopi ("Analysis of Small Groups") survey efforts aimed at inferring the social phenomena taking place in small groups, such as social verticality, personality, group cohesion, and characterization. These efforts are beneficial in particular for applications aimed at making meetings effective and productive.

Another two chapters show the use of social signal processing methodologies as a support for multimedia indexing methodologies. The chapter "Multimedia Implicit Tagging" (Mohammad Soleymani and Maja Pantic) shows that capturing the reaction of a

user (e.g., laughter or sobbing) in front of a multimedia item (e.g., a video) provides information about the content of the item itself that can then be tagged with categories such as *funny* or *sad*. In a similar vein, Alessandro Vinciarelli ("Social Signal Processing for Conflict Analysis") shows that the detection of conflict can help to extract the most important moments in large repositories of political debates.

The last two chapters of this part target the adoption of social signal processing methodologies in two major application areas, that is, healthcare and deception detection. Mohamed Chetouani, Sofiane Boucenna, Laurence Chaby, Monique Plaza, and David Cohen ("Social Signal Processing and Socially Assistive Robotics in Developmental Disorders") show in particular that the analysis of social signals can help the detection of developmental problems in children that, in many cases, cannot even speak. Judee K. Burgoon, Dimitris Metaxas, Thirimachos Bourlai and Aaron Elkins ("Social Signals of Deception and Dishonesty") survey the progress on the possibility of developing technologies capable to identify people who lie.

Conclusions

This chapter provides a description of the book's organization and content. The goal is to allow the readers to identify chapters of interest quickly and easily and, at the same time, to develop awareness of the main problems and areas covered in social signal processing. The many authors involved in the book have made major efforts to combine rigour and depth with clarity and ease of access. This will hopefully make this book a valuable instrument for a wide spectrum of readers.

- *SSP beginners*: researchers starting their investigations in SSP will benefit from surveys because these provide an overview of the state-of-the-art perspectives, identify the most important challenges in the field, include rich bibliographies, and provide the right terminology.
- *SSP experts*: researchers knowledgeable in SSP can benefit from the surveys because these condensate, in a compact and concise form, a large body of knowledge typically scattered across multiple disciplines. Critical views of the authors could provide a fertile ground for discussion and, in turn, be an effective tool in pushing the limits of innovation in the field.
- *SSP teachers*: teachers will benefit from the material because it provides an introduction to the field and can be used as didactic material for students with different backgrounds and/or at different stages of their education. Furthermore, the material is organized in parts that correspond to the most natural structure of an SSP course.
- *SSP interested*: researchers and practitioners who are not active in the field, but are interested in the domain and research in the related areas (e.g., human behavior analysis) can benefit from the book because it provides a clear account of state-of-the-art challenges and opportunities in the field and a clear positioning of the SSP research with respect to the related areas. Furthermore, the book can be an excellent entry point to the SSP domain.

- *Graduate and undergraduate students*: students at all levels will benefit from the book because the material is introductory and provides a clear explanation of what the SSP domain is about. In this respect, the book can help the students to decide whether SSP actually fits their interests or not.
- *Industry experts*: industry practitioners (or observers) can benefit from the book because they can find in it an extensive overview of the state-of-the-art applications in a wide spectrum of topics of potential interest as well as an indication on the most important actors in the domain.

Like any vibrant research field, social signal processing keeps developing in both depth and breadth. New conceptual and methodological issues emerge with continuity, often inspired by new application domains. Correspondingly, the editors hope that the chapters of this book will not be considered as a static body of knowledge, but as a starting point toward new research and application avenues. The goal of this book is not to provide the conclusive word on social signal processing, but to allow any reader to quickly engage with novelties and progress that will hopefully come in the years after the publication of the volume.

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Part I

Conceptual Models of Social Signals

2 Biological and Social Signaling Systems

Kory Floyd and Valerie Manusov

As complex beings, humans communicate in complex ways, relying on a range of faculties to encode and decode social messages. Some aptitudes are innate, based on one's biological characteristics, whereas others are acquired, varying according to one's social and cultural experiences. As we explain in this chapter, each of us uses a combination of biological and sociocultural processes to produce and interpret social signals. Our goal is to introduce some of the forms that these processes can take.

We begin this chapter with an overview of social signals and a comparison between the biological and sociocultural processes underlying their production and interpretation. Next, we explore three examples of biologically processed social signals, and then examine sociocultural processing of the same signals. We conclude the chapter by discussing some ways in which biological and sociocultural processes interact.

The Nature of Social Signals

Communicators depend on a wide variety of social signals to make sense of the world around them. Poggi and D'Errico (2011) define a *signal* as "any perceivable stimulus from which a system can draw some meaning" and a *social signal* as "a communicative or informative signal which, either directly or indirectly, provides information about 'social facts,' that is, about social interactions, social attitudes, social relations and social emotions" (Poggi & D'Errico, 2011: 189). *Social interactions* are situations in which people perform reciprocal social actions, such as a game, a surgical procedure, an orchestral performance, or a conflict. *Social attitudes* are people's tendencies to behave in a particular way toward another person or group and include elements such as beliefs, opinions, evaluations, and emotions. *Social relations* are relationships of interdependent goals between two or more people. Finally, *social emotions* include those emotions that (1) we feel toward someone else, such as admiration and envy; (2) are easily transmitted from one person to another, such as enthusiasm and panic; and/or (3) are self-conscious, such as pride and shame.

As noted, humans use both biological and sociocultural processes to produce and interpret social signals. At least four distinctions differentiate these processes from one another: (1) their connection to physical versus social traits, (2) their cultural variation,

(3) their uniqueness to the human species, and (4) the advantages or values they embody. We discuss each of these briefly to help ground our chapter.

First, a biologically processed social signal is connected to an organic anatomical trait or physiological process and derives its meaning from that trait or process. In humans, some social signals regarding age meet this criterion, insofar as height and body size, proportion of facial features, condition of skin and hair, and other visual markers of age are products of the organic aging process. In contrast, a socioculturally processed social signal is connected to traits or processes whose meaning is culturally constructed. For example, human social signals of political affiliation – such as style of dress or the variety of bumper stickers on one's car – reflect culturally constructed ideas about politics, such as the idea that conservative attire denotes conservative ideology.

Second, the meaning of biologically processed social signals is largely culturally invariant. To the extent that basic anatomy and physiology are consistent across humans around the world, the first criterion gives rise to the second criterion, that cultures should show little variation in how they interpret a biologically processed social signal. For some social signals, such as emotion displays, there is compelling evidence of cultural invariance. No such evidence exists for some other social signals, yet cultural consistency would be expected. The meaning of socioculturally processed social signals, however, often varies substantially across cultural and social groups, and there is little reason to expect otherwise. For example, a personal distance of twelve inches (30 cm) may be seen as intimate in some cultures and distant in others.

Third, biologically processed social signals are processed similarly in similar species. Many species have muscular and central and peripheral nervous systems similar to those of humans. When a social signal is rooted in an organic anatomic trait or physiological process in humans, it should be similar in species with similar anatomies or physiologies. Better evidence exists for this consistency in some signals (such as emotion displays) than in others. This consistency depends on relevant anatomical or physiological similarity, so primates with similar facial muscles would be expected to display emotions similarly to humans, but not to grow facial hair as a secondary sexual characteristic if their faces are already covered with hair. On the contrary, there is no reason to expect socioculturally processed social signals to be processed similarly – if at all – by other species. Indeed, many such signals express meanings that have no correspondence in nonhuman species, such as religious affiliation or the ability to switch between languages.

Finally, biological processes often confer advantages for survival and/or reproduction of the organism, but they are neutral with respect to their social value. Biologically driven signals of sexual attraction, such as pupil dilation and erection (discussed below), occur because sexual interaction promotes procreation but are largely indifferent to cultural practices or social mores. Learned behaviors, however, are embedded firmly within the beliefs, morals, and norms of a particular social system, such that certain ways of being become better or worse within the cultural or social frame. So, for instance, particular body sizes are thought to be beautiful in some cultures and are stigmatized in others based on the values of the particular social system.

Biological Processes Underlying Social Signals

Having shown some of the ways that biological processes differ from sociocultural processes relevant to social signals, we offer more background on each system separately before we suggest ways in which they are integrated. Humans are biological beings who use their nervous systems and sensory abilities to navigate their social world. Consequently, they biologically process a range of communicative and informative social signals. Three examples, discussed here, are secondary sexual characteristics, emotion displays, and signals of attraction and sexual receptivity. They are used to illustrate the nature and reach of biological processes. Similar examples are used when we discuss sociocultural processes.

Secondary Sexual Characteristics

Sexual ontogeny is characterized by the development of secondary sexual characteristics, those physical features that distinguish the males and females of a species but are not directly related to the functions of the reproductive system (Sherar, Baxter-Jones, & Mirwald, 2004). Androgens, estrogens, and progesterone in humans promote secondary sexual characteristics such as growth of facial and body hair, enlargement of the larynx and deepening of the voice, and increased muscle mass and strength in men, and enlargement of breasts, widening of hips, and rounding of the jawline in women. The development of secondary sexual characteristics in humans begins around age nine (Susman et al., 2010), although there is a documented trend toward earlier development among children in the United States (Herman-Giddens, 2006).

In principle, these and other phenotypic markers (the observable physical characteristics of an organism) provide sufficient information for people to differentiate between women and men in social interaction with high levels of accuracy. Indeed, research shows that observers distinguish the sexes at above-chance levels based on differences in secondary sexual characteristics such as waist-to-hip ratio (Johnson & Tassinary, 2005), jawline shape (Brown & Perrett, 1993), and vocal pitch (Bennett & Montero-Diaz, 1982). Secondary sexual characteristics therefore serve as biological social signals, insofar as they are produced biologically (hormonally, in this instance) and provide information that can shape social interactions, attitudes, relations, and/or emotions.

Emotion Displays

Emotion displays are perceivable kinesic (body) and vocalic behaviors that convey emotional states. Many emotion displays are more socially than biologically processed, as we will discuss. Nonetheless, some displays arise from organic physiological processes and are sufficiently similar across cultures and species to qualify as biological social signals.

An anger display provides an illustrative example. The experience of anger initiates sympathetic arousal, prompting a variety of physical changes that are often

perceivable by others, such as increased muscle tension in the face and body, flared nostrils, increased perspiration, and flushing in the face (Levenson, 2003; Tucker, Derryberry, & Luu, 2000). Muscle tension is observed in the furrowed brow and clenched jaw that accompany the prototypical facial display of anger, whereas flushing results from increased vascular blood flow. Flared nostrils allow for increased oxygen intake, providing extra energy to fuel a potential attack, and increased perspiration serves to prevent hyperthermia. Galati, Scherer, and Ricci-Bitti (1997) demonstrated that this configuration does not differ significantly between sighted and congenitally blind individuals, suggesting a primarily biological (rather than learned) basis.

Facial anatomy and sympathetic nervous system physiology are culturally invariant (see e.g., Gray & Goss, 1966), to the extent that anger displays are biologically processed, a high degree of correspondence would be expected across cultures in (1) the way anger is encoded and (2) the expression that is interpreted to convey anger. Matsumoto et al. (2008) reviewed evidence from multiple cross-cultural studies documenting that anger (and other basic emotions) are both encoded and decoded in highly consistent ways across cultures (although we discuss the limits to this in our next section). Similarly, to the extent that anger displays are biologically processed, the human display of anger should be similar to that of species with similar facial structure and musculature. Parr, Waller, and Fugate (2005) review evidence from nonhuman primates documenting displays of aggression analogous to human facial displays of anger, supporting their biological origins.

These observations are not unique to anger displays. As Darwin (1873) observed, humans and other animals express many emotions in ways that serve the survival functions of those emotions. For instance, the emotion of surprise aids survival by focusing attention on an unexpected and potentially threatening occurrence. The prototypical look of surprise serves that function with wide eyes (for increased visual acuity), an open mouth (for increased oxygen intake, fueling a potential response to the threat), and a hand over the mouth (for protection against unwanted ingestion). Similarly, the emotion of disgust aids survival by prompting the expulsion of a toxic substance from the body, and the expression of disgust configures the face to spew such a substance from the mouth.

Signals of Attraction and Sexual Receptivity

Some species are less than subtle when signaling their sexual interest and availability to conspecifics (others of the same species). The hindquarters of the female savannah baboon, for instance, swell and turn bright red, an unmistakable biological signal of her sexual receptivity (Altmann, Hausfater, & Altmann, 1988). Although human social signals of attraction and sexual receptivity may be more discreet, some are similarly biologically processed.

Like the baboon, male and female humans experience vasocongestion secondary to the process of sexual arousal and reproduction. Vasocongestion occurs when increased vascular blood flow and localized blood pressure cause body tissues to swell. One readily observable effect is the reddening of the skin during sexual excitement, plateau,

orgasm, and/or resolution known colloquially as "sex flush" (Mah & Binik, 2001). Vasocongestion also produces penile erection, hardening of the clitoris, and swelling of the nipples during sexual arousal (Janssen & Everaerd, 1993; Laan, Everaerd, & Evers, 1995). To those who observe them, these physical responses signal sexual attraction and receptivity among humans.

Another social signal of attraction (and perhaps also of receptivity) that is biologically processed is pupil dilation. In many species, including humans, pupils dilate automatically in response to sympathetic nervous system arousal (see Bradley et al., 2008). Having dilated pupils therefore signals arousal. Although sympathetic arousal can result from both positively and negatively valenced emotions, pupil dilation increases physical attractiveness in humans and may therefore signal romantic and/or sexual receptivity. Early research with adolescents suggested a sex difference in this effect (see Bull & Shead, 1979), but Tombs and Silverman (2004) demonstrated that both women and men are more attracted by larger pupils than by smaller pupils in opposite-sex partners.

Secondary sexual characteristics, emotion displays, and signals of attraction and receptivity are not the only social signals that humans process biologically. It is likely that signals related to age, ethnicity, sexual orientation, intelligence, dominance, empathy, and many other data also have biologically processed components. Contrariwise, many social signals are processed in fundamentally sociocultural ways, as we examine next.

Sociocultural Processing of Social Signals

In addition to being biological beings, humans are also social and cultural beings, brought up in and affected by the people around them. Following others, Philipsen (2009) refers to groups of people who share the same set of social rules and meanings as *speech communities*. As people grow up in a certain community, they learn the norms, values, beliefs, and patterns of engaging that group. These cultural ways of being shape the ways in which people come to understand many of the social signals others send to them and those they send to others. Philipsen, as do many other scholars (e.g., S. Hall, 1997; Schegloff, 1984), argues that social signals and the rules that govern them come to be understood within a particular context; only those who share a particular cultural code can fully understand the social signals and the rules that govern them. Socially determined behaviors also reflect and affect the values and ideologies of those who use the codes. To help show how these processes work, we use the same primary areas discussed in the section on biological signals, albeit in very different ways, to provide three examples of how being a cultural being can shape our signaling processes.

Being Gendered

Whereas people are born with and develop secondary sexual characteristics naturally as part of their ontological development, they also learn what it means to be male or female within a particularly society. When scholars talk about "gender" rather than "biological

sex" they reference typically how people are brought up to act, think, and feel by virtue of being male or female. In many cultures, for instance, women and girls are encouraged to be "pleasant," and they are significantly more likely to smile (and to be expected to smile) in social interactions and in photographs than are males (J. Hall, 2006). That there is no such difference when people are not in social situations suggests that the pattern is learned and not innate.

Women are also taught to be the subject of males' gaze in some cultures. Roy (2005) argued that women are often portrayed by mediated sources in India as "the province and property" of men, in that they are positioned most commonly in advertisements so as to be gazed upon by men. Men are not gazed at in the same way by women. Roy argued that the position, along with camera angle, lighting, and other elements suggested that women were there to be looked at, and in some cases "owned" by the gazing men. This suggests an array of rules presented to consumers of what it means to be a male or female in that culture.

The differences in actual behaviors (biological or learned) between males and females across cultures are quite small (J. Hall, 2006), but the perception that the two groups differ significantly is enhanced by stereotypes developed within a culture or set of cultures. In a recent study, Koppensteiner and Grammer (2011) found that their Austrian research participants made different judgments of the social characteristics of stick figures, with "male" figures seen to be more extraverted and emotionally stable and "females" described as agreeable. Whereas stereotyping is a common biological process, the concepts held within the stereotypes, and the behaviors people engage in because of their stereotypes, are learned within a cultural or social group (S. Hall, 1997).

Emotional Expression

As noted earlier, there is evidence for universal emotional expressions, such as anger. But emotional expressions and the rules for their use are also shaped by our speech communities. Ekman (1977) discussed *cultural display rules* to reveal the ways in which a particular group defines "appropriate" and normative emotional expression, including whether or not to show an experienced emotion (see also, Aune, 2005). In a project testing an inventory of display rules (the Display Rule Assessment Inventory), Matsumoto et al. (2005) found that, of the groups they studied, the Japanese were least likely to show anger and contempt, with Americans showing the most happiness. Relatedly, Matsumoto, Yoo, and Fontaine (2008) learned that, compared to individualistic cultures, collectivistic cultures enforce a display rule of less emotional expressivity overall. Within-group differences are also learned. For instance, norms of politeness proscribe displaying specific emotions in particular social contexts, such as the expression of anger toward a customer in a customer–service encounter (Goldberg & Grandey, 2007).

People learn display rules as part of their socialization or enculturation. In some cultures, the media play an important role in affective (emotional) learning, and the greater people's exposure to the media, the more they are "programmed" by what they see. Emotions displayed on television tend to be different than what occurs in real life

(Houle & Feldman, 1991) in that they appear more commonly, tend to be only of three types (happiness, sadness, anger), and are also simple rather than complex emotions. Thus, those who learn affective social signals largely from television have a different, and generally incorrect, view about the nature of such cues than do others.

Because emotional expressiveness has a learned quality, people can also become better at it over time. Variously named affective skill, emotional expressivity, and expressiveness control, among other similar terms (see Riggio & Riggio, 2005), researchers have created systems for teaching people to tend better to the socially appropriate expression of emotions within their speech community (Duke & Nowicki, 2005). Given the problems people face when they are ineffective at emotional signaling, the ability to learn how to do so more effectively is promising.

Signals of Attraction

As part of our enculturation, we come to see certain characteristics as more or less attractive, and certain ways of acting as more or less likely to attract. Within Western cultures, attractiveness has come to be defined over time as tied to youthfulness. This is a relatively recent phenomenon, and this "ageist ideology" is not one shared by all cultures (Jaworski, 2003). In order to attract others, people in many Western cultures do a great deal to suggest more youthfulness than they may have. This has been more prominent for women than for men, and for girls than for boys, but the emphasis on youthfulness as an attractor has been increasing for males as well (Coupland, 2003).

Whereas courtship and mating behaviors occur across species in order to attract another, the nature of those behaviors and the patterning of them differ significantly across cultures and are done differently by men and women. Within the United States and Canada, studies of flirting or courtship behaviors between heterosexuals in bars shows that such behaviors often follow a particular sequence linked with learned gender roles (e.g., Perper & Weis, 1987). Initial signaling tends to be done by women, for example, and includes three types of gaze, smiling, and caressing objects. Such behaviors are typically learned covertly (by watching others, with no formal discussion about how to engage in them) and, as such, can be seen as "natural" attraction cues, even though they are a part of the speech community's signaling code.

Even within the same speech community, however, different groups are socialized to see the same social attraction signals in different ways. Across several studies in the United States and England, for instance, men tend to interpret more attraction and sexual intent in cues that women see instead as "friendly" behavior (Abbey & Melby, 1986; Egland, Spitzberg, & Zormeier, 1996). Thus, there are at times competing codes, learned sometimes by part of the group in a different way than other parts.

Interactions between Biological and Sociocultural Processes

Although we have discussed them independently, biological and sociocultural processes of producing and interpreting social signals often behave interdependently. In this

section, we reference some of the means through which this occurs. To begin, some biologically processed social signals are modified by sociocultural influences. For example, individuals can intentionally manipulate many secondary sexual characteristics to alter the signal being sent (i.e., the data regarding their biological sex). Even without intervening hormonally (e.g., by taking androgen therapy), for instance, transgender individuals can modify their vocal qualities to sound more like their desired than their biological sex (Hancock & Garabedian, 2013). Men with gender dysphoria can undergo breast augmentation and facial feminizing surgery (Monstrey et al., 2014), and male cross-dressers often use electrolysis to remove facial hair (Ekins, 1997). By altering the look or sound of secondary sexual characteristics, these strategies modify their meaning and significance as social signals. They may, for example, change the information conveyed about (1) which biological sex an individual was born with and/or (2) which biological sex, if any, the individual identifies with, either of which can alter social interactions, attitudes, relations, or emotions (see e.g., Pusch, 2005).

Such characteristics are augmented in other ways. Goffman (1976) referred to the ways that people exaggerate their biological sex traits through *gender advertisements*. In his review of print advertisements, Goffman revealed a tendency for women to be shown largely as shy, dreamy, gentle, helpless, and likely to be manipulated, whereas males were "advertised" as powerful, controlling, and dominant. Although advertising, or displaying with some purpose, that we are a male or a female is only one way in which we use inherited cues in a social way, and it is a very powerful one.

In gender advertisements, biology is exaggerated by cultural demands, but social rules may also affect the ways in which we respond physiologically to another. Buck (1989), for instance, described a social biofeedback process that occurs in relationships. Partners in relationships develop rules over time for how to approach emotion and its expression between them. As the relationship continues, the rules the couple share, and the constraints that the rules provide, affect the ways in which the couples experience those emotions subsequently. When, for instance, couples come to enjoy arguing, the emotion they experience automatically when conflict arises will be positive, compared to the fear, sadness, or anger that others might feel. Thus, the existence of the social or cultural patterns of the relationship change how the couple experience some of the emotion-invoking events that occur between them.

Similarly, the social environment sometimes plays a role in activating biological processing. Some biological means of processing social signals are inert, in other words, without the influence of specific inputs from the social or cultural environment. For instance, Panksepp, Knutson, and Pruitt (1998) first described the *epigenesis* of emotional behavior, the process by which particular environmental influences are necessary to activate genetic predispositions for emotional experience (and, thus, for expression). In an example of empirical work aimed at identifying specific social/genetic interactions that influence emotion, Sugden et al. (2010) found that a variant on the serotonin transporter (5-HTT) gene predisposes children to a broad spectrum of emotional problems but that such problems emerge only among children living in threatening social environments.

These are just a few of the many ways in which biological and sociocultural processes interact as we use social signals to engage with others. They begin, however, to speak to the complexity of determining in any given social encounter which cues are purely biological, determined by the social or cultural surround, or are a unique combination of biological and sociocultural processing. Our hope is that this chapter provides an opportunity to begin to appreciate the intricate ways in which our innate and learned capabilities allow us to interact and relate with one another.

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