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Rags to Riches: Our Increasing Appreciation of Cognitive and Communicative Abilities of the Human Right Cerebral Hemisphere

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Studies of right hemisphere abilities have grown from focusing on visuospatial and facial recognition in the 1950s to covering a broad spectrum of human behavior. The emergence of better understanding of auditory specializations, affective/emotional functions, personal relevance, idiosyncratic lexical organization, and the various aspects of language use—communicative pragmatics—is briefly reviewed. © 1997 Academic Press

Hemispheric dominance, itself a surprisingly radical idea, first sprang into view in the 1860s (Broca, 1865). Up to the 1940s, the notion emphasized a left hemisphere specialization for language (for review see Cutting, 1990, p. 23). Observations and conclusions by Jackson (1874, 1876) and others regarding right hemisphere communicative and other functions did not survive the turn of the century (for review see Harrington, 1987). However, during the 1950s, numerous reports of right hemisphere disorders affecting a category loosely viewed as ''visuospatial perception'' had sufficiently accumulated to generate the idea that the ''minor'' cerebral hemisphere, as it was called, subserves a function orthogonal to that of the ''language'' hemisphere (e.g., Zangwill, 1960). Increasing evidence for right hemisphere specialization rapidly emerged in the 1960s (Milner, 1971), receiving notable impetus from patients with callosal section (Sperry, 1974).

Now there was general acceptance of the notion that both cerebral hemispheres perform specialized functions. However, as complementary hemispheric specialization (see Milner, 1980) gained increasing acceptance, the countervailing notion also gained voice—that the right hemisphere, being nonverbal, would therefore be mentally primitive. Controversy over the cog-

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nitive abilities of the disconnected right hemisphere, bereft of any linguistic support, is discussed by Bogen (1997). Much of this debate turns on the definition of ''language.'' While the right hemisphere appears resolutely unburdened by phonological or syntactic structure, it does contain rich lexical networks differing in structural organization from the left hemisphere lexicon (e.g., Drews, 1987; Richards & Chiarello, 1997; Zaidel, 1977). Whether the intact right hemisphere ever ''speaks'' remains a question as unsettled as it is important (see Code, 1997). Meanwhile, study of right hemisphere abilities continues to expand using various methodologies, including patients with lateralized lesions (see Brownell, Pincus, Blum, Rehak, & Winner; Pell & Baum, 1997), lateralized presentation (see Corballis, 1997; Richards & Chiarello, 1997), and lateralized read-out (see Simos, Molfese, & Brendon, 1997).

Facial perception has been extensively studied from many points of view, using all the methods mentioned above. Hundreds of studies continue to explore this basic and ubiquitous behavior. Perception of faces, with its qualities of pattern recognition, remoteness from verbal function, and its familiarity dimension became a popular topic, engendering vigorous debate about to what extent, in what ways, and how exclusively the right hemisphere—indeed, the right human hemisphere—as animal studies were also pertinent—plays a specialized role (Assal, 1969; Benton & Van Allen, 1968; Damasio, Damasio, & Van Hoesen, 1982; DeRenzi, 1986; Ellis, 1983; Hécaen & Angelergues, 1962; Malone, Morris, Kay & Levin, 1982; Regard & Landis, 1988; Whiteley & Warrington, 1977). The fecundity of studies on face perception is noteworthy not only for putting a bright light on right hemisphere function, but also for engendering theoretical discussions about its intrinsic processes. Visuospatial processing remains a main line of right hemisphere studies. From facial perception and other earlier studies, visuospatial processing as a specialty of the right hemisphere has developed to include personal topography (Landis, Cummings, Benson, & Palmer, 1986), visual organization (''closure''), scanning (see Beaumont & Davidoff, 1992), visuoconstruction, and mental rotation (see Corballis, 1997).

The search for explanatory terms to account for early dissociable findings in memory and other neuropsychological specializations led first to a simple verbal (left hemisphere)–nonverbal (right hemisphere) dichotomy (see Cutting, 1990). This notion gave way by the 1970s, influenced by claims of sequential (Bever, 1975), local or detailed (Martin, 1979), rhythmic (Robinson & Solomon, 1974), and temporal (Carmon, 1981) functions of the left hemisphere, to a process model, with its concept of disparate hemispheric ''modes.'' Described by a rapidly proliferating set of dichotomous terms (e.g., analytic/synthetic, sequential/holistic, temporal/spatial, high frequency/low frequency, propositional/appositional), the functional model of hemispheric specialization took hold. According to this model, it is not

the nature of stimulus material, but rather how it is processed, that better accounts for predictions about lateralized cerebral preference (e.g., Bogen, 1969; Bradshaw & Nettleton, 1983; Bryden, 1982; Hécaen & Albert, 1978). Right up to the present time, this model has proven fruitful for generating experiments and interpreting results, and it has found its way into popular commentary of all kinds.

For a long time, whatever abilities were increasingly attributed to the right hemisphere, the left hemisphere was still seen as ''leading''—the more ''active'' of the two. In this view, the left hemisphere produces verbal and motor output, subserving, as it does, speech and praxis (Heilman, 1979), whereas the ''minor'' hemisphere's work was often thought to be relatively passive (excepting a notion of ''manipulo-spatial'' abilities—see Bogen & Gazzaniga, 1965; LeDoux, Wilson, & Gazzaniga, 1977). Even that difference is blurring. More recent observations in prosodic behavior (Pell & Baum, 1997), communicative pragmatics (Brownell, Pincus, Blum, Rehak & Winner, 1997), action patterns (see Richards & Chiarello, 1997), and speech (Code, 1997) clearly attribute to the right hemisphere a more active role.

Although many more visual than auditory studies are done in neurobehavioral research, investigators began to point to a specialized role in auditory functions for the right hemisphere, utilizing dichotic listening in normal subjects as well as studies of persons who have suffered brain damage. Relatively better processed by the right hemisphere are complex pitch or timbre (Sidtis, 1980, 1984; Zatorre, 1988), chords (Gordon, 1970), familiar songs (Gordon & Bogen, 1981), and personal voice information (Van Lancker & Canter, 1982). These signals have in common (1) being complex auditory ''patterns,'' in that they are not readily decomposable into elemental units, and (2) containing complex pitch information as salient perceptual cue (see Van Lancker & Sidtis, 1992, for review).

In audition research, prosody is the laterality topic of the moment. Claims for affective–prosodic information—intonation in speech signaling emotional states—have been amply staked out in right hemisphere domains (Heilman, Scholes & Watson, 1975; Ross, 1980; Van Lancker, 1980). Observations on retained prosodic function in persons with aphasia have led to several studies of intonational abilities of the right hemisphere (Behrens, 1988, 1989; Kent & Rosenbek, 1982; Shapiro & Danly, 1985) as well as speech therapy utilizing preserved intonational output (Helm-Estabrooks, 1983). Later, reports of prosodic deficits associated with damage to subcortical areas demanded a new dimension of inquiry (Blonder, Gur, & Gur, 1989; Cancelliere & Kertesz, 1990; Cohen, Riccio, & Flannery, 1994; Speedie, Brake, Folstein, Bowers, & Heilman, 1990; Van Lancker & Pachana, 1995). Further, given a new focus on the right hemisphere as processor of emotions, it became apparent that normal prosodic performance probably has various

psychological explanations—in that prosodic cues involve pitch, auditory patterns, and emotional meanings (Scherer, 1986), as well as multiple cerebral sources.

As mentioned above, by the 1980s, there was considerable evidence that emotional experiencing might have greater representation in the right hemisphere, manifest in several modalities, including lexical, prosodic, facial, and gestural processing (Bear, 1983; Borod, 1992, 1993; Bowers, Bauer, & Heilman, 1993; Bryden & Ley, 1983; Cicone, Wapner, & Gardner, 1980; TenHouten, Hoppe, Bogen, & Walter, 1986; Wechsler, 1973), with as yet unsettled questions about lateralization corresponding with negative and positive emotion (Davidson & Tomarken, 1989; Gainotti, 1972; Sackeim, Greenberg, Weiman, Gur, Hungerbuhler, & Geschwind, 1982). Possibly related are lateralized affective disorders (Bruder, Quitkin, Stewart, Martin, Voglmaier, & Harrison, 1989; Cummings, 1997; Cummings, 1985; Galin, 1974; Heilman, Watson, & Bowers, 1983; Robinson, Kubos, Starr, Rao, & Price, 1984). In the affective realm, there are reported preference and aesthetic judgments between the hemispheres (Regard & Landis, 1986, 1989).

Another recent observation is the involvement of familiarity processing, or personal relevance (Sperry, Zaidel, & Zaidel, 1979; Van Lancker, 1991; Wallace & Canter, 1985) in behavioral deficits associated with right hemisphere dysfunction. Such problems are seldom seen in left hemisphere damage. Examples are prosopagnosia (Damasio, 1985), phonagnosia (Van Lancker & Canter, 1982; Van Lancker & Kreiman, 1987), the set of misidentification delusions including Capgras syndrome (Staton, Brumback & Wilson, 1982; Ellis, 1984), and topographical agnosia (Landis et al., 1986). A complementary finding is preserved familiar person and name recognition in extensive left hemisphere damage (Van Lancker & Klein, 1990; Van Lancker & Nicklay, 1992). Efforts to identify pathways for the familiarity judgment have been made (Bauer & Verfaellie, 1988; Ellis, 1994), but the breadth of familiarity deficits suggests that the affective response underlying personal relevance may be diffusely represented in the right hemisphere.

Currently, perhaps the most richly mined cache of right hemisphere function is the use of language in communicative contexts—the field of pragmatics. Here we refer not to phonemes or grammar, but to the subtler, crucial interstitial knowledge used to connect sentences, infer meanings, follow conversation, appreciate irony, recognize metaphor, and comprehend discourse. Deficits following right hemisphere damage have involved nonliteral language (Van Lancker & Kempler, 1987; Van Lancker, 1988, 1990; Winner & Gardner, 1977), theme and topic maintenance, humor, context relevance, and inference (see Brownell, Pincus, Blum, Rehak, & Winner, 1997; Brownell, Potter, Bihrle, & Gardner, 1986; Gardner, Brownell, Wapner, & Michelow, 1983; Molloy, Brownell, & Gardner, 1990). With this approach, studies of right hemisphere function merge with sociolinguistic (e.g., Freedle, 1977;

Rommetveit, 1974), psychological (Keenan, MacWinney, & Mayhew, 1977), and philosophical (Grice, 1975) material (see Brownell and Martino, in press). Lexical studies support this emerging view of situational context, personal reference, and real-world semantics as the right hemisphere's unique ''take'' (e.g., Sidtis, Volpe, Holtzman, Wilson, & Gazzaniga, 1981). As an additional component, clinical relevance emerges powerfully from this field of inquiry, as patients with right hemisphere damage now have diagnosable communicative deficits, which can be addressed directly in a rehabilitation program. This is a much needed endeavor, because the right hemisphere damaged patient may have troublesome communicative deficits despite fully intact ''language'' (phonology, syntax, and lexical semantics) function. Besides aiding the patient, identifying these deficits helps family members cope with what otherwise may seem to be uncooperativeness or willfully aversive behavior. Numerous such treatment programs, including an array of computer software, are available for the right hemisphere damaged patient with communicative deficits (e.g., Burns, Halper, & Mogil, 1985; Tompkins, 1996).

This special issue of *Brain and Language*, presenting only a small sampling of possible topics, along with the proliferation of books (e.g., Ardila & Ostrosky-Solis, 1984; Chiarello, 1988; Code, 1987; Cutting, 1990; Joanette & Brownell, 1990; Joanette, Goulet, & Hannequin, 1990; Brownell & Joanette, 1993; Perecman, 1983; Young, 1983), test protocols (e.g., Pimental & Kingsbury, 1989; Rosenthal, Hall, DiMatteo, Rogers, & Archer, 1979), and rapidly proliferating treatment materials, all provide testimony to the burgeoning interest in right hemisphere function.

Queries yet to be explored include how the right hemisphere might interact with basal ganglia and limbic structures and with ''frontosubcortical circuits'' in the processing of prosodic and emotional behaviors (Bhatia & Marsden, 1994; Cummings, 1993; Gainotti, Caltagirone, & Zoccolotti, 1993; Mayeax, 1983; Mendez, Adams, & Lewandowski, 1980; Poncet & Habib, 1994), better understanding of musical function (e.g., Tramo & Bharucha, 1991), the relevance of animal studies (e.g., Denenberg, 1983; Hamilton & Vermeire, 1988), the relationship of innate laterality mechanisms to developmental schedules for laterality of left and right hemisphere language and cognition (see Simos, Molfese & Brendon, 1997), maturational and aging differences between the hemispheres in the young and older adult, cross-cultural effects (e.g., Thompson, Bogen & Marsh, 1979), cerebral plasticity in right hemisphere early ''take over'' of linguistic functions (Dennis and Whitaker, 1976), what the right hemisphere does for the postpuberty second language learner, and the role of the right hemisphere in processes of alerting and attention (Posner & Petersen, 1990). Studies of the brain biochemistry (see Cummings, 1997) and the influence of hormones (e.g., Bibawi, Cherry, & Hellige, 1995), physiological–morphological differences (Geschwind, 1974), and brain scanning technologies are providing new frontiers of

investigation. The story of the visuospatial, affective/emotional, personal, and communicative competencies of the right hemisphere continues to unfold.

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