

1

2

Comparative perspectives on the missing link: communicative pragmatics

3

Julie Gros-Louis, Meredith J. West, Andrew P. King

4

5

Department of Psychological and Brain Sciences, Indiana University, 1101 E. 10th St.,
Bloomington IN 47405

6

7

8

9

10

11

12

13

14

15

16

17

Address Correspondence to:

18

19

Julie Gros-Louis

20

Department of Psychological and Brain Sciences, Indiana University

21

1101 E.10th St.

22

Bloomington IN

23

47405 USA

24

email: jgroslou@indiana.edu

25

Phone (812) 855-1297

26

Fax (812) 855-4691

27

Overview

28

The basic plan for a journalist writing a newspaper article is to assemble facts, beginning

29

with “who,” followed by “what,” “when,” and “where,” progressing to “why” and

30

ending with “how.” Here, we introduce the journalistic plan to define the major variable in

31

this chapter, communicative pragmatics. The idea is simple—we are asking how an

32

individual correctly identifies to whom to convey information in a timely fashion and in a

33

correct context. Further, we ask what biological or psychological means facilitate the act of

34

communicating. An effective communicative act, one that answers the questions cited above,

35

can be compared to an effective newspaper article. We argue that many of the parameters of

36

successful pragmatic performance are still unknown in even seemingly well-studied species.

37

The consequence of the missing answers is that stories are formed that may sound good but

38

are inaccurate, leaving the usually more complex account untold.

39 We have chosen two organisms, brown-headed cowbirds and humans, because much is
40 known about their communication system, i.e., the structuring and meaning of information.
41 The use of the information, the pragmatics, is less well studied than ordering or meaning
42 because it is more difficult to measure and frequently taken for granted. The mode of
43 communication is generally vocal, although we will see that dividing communication by
44 reference to single senses does not always work. The time period of most interest is early in
45 postnatal development, although one cannot ignore the lifespan. The function of the
46 vocalizations (“why”) also are considered but not stressed as we have written about this
47 topic often (King & West, 2002; West & King, 2001). And, we do not focus on the
48 “how” in detail because the biology of the communicative system is being explained by
49 others (see chapter xxx).

50 Our research perspective originated in reaction to traditional views that development is
51 guided by automated maturational programs. Studies of development during the 1960’s and
52 1970’s were guided by the simplified dichotomous view of nature (genes) dictating the end
53 product with nurture (environment/experience) passively triggering the developmental
54 process toward that predetermined endpoint. In this view, the developing organism and the
55 environmental experience are separable entities. Traditional studies of vocal development in
56 songbirds, for example, removed individuals from the natural developmental context and
57 examined what experience was necessary to trigger the innate developmental program.
58 Young males were housed in isolation to control their exposure to auditory stimulation and
59 experimenters selected what the males heard and how much they heard to determine the
60 influence of auditory experience on development. Or, alternatively, deprivation experiments
61 were conducted to see what developed in the absence of any stimulation, thus revealing what
62 was thought to be the innate blueprint for song (e.g., Marler et al., 1972). Although the
63 research approach was well-intentioned--individuals were removed from their social
64 environment to control external variables--it actually created a novel developmental
65 environment because the absence of companionship introduced its own effects on

66 development (Kuo, 1967). Comparable naturalistic studies of human vocal development at
67 the time were those that examined infants with sensory impairments. Early babbling, when
68 examined for phonetic properties of speech, seemed to be similar in deaf and hearing
69 infants, thus suggesting that early experience had no influence on prelinguistic vocal
70 development (Lenneberg, 1967).

71 A fundamental flaw of the false dichotomy of nature and nurture as separable entities is
72 the implicit assumption that contributions of environment to development can be controlled
73 like measurable quantities in a recipe. Adding or excluding certain experiences was thought
74 to have predictable outcomes because the fluidity of the interaction of genes and
75 environment was construed to be minimal at best: an environmental trigger of a
76 predetermined genetic program (e.g., ‘reaction range’ proposed by Gottesman, 1963; Scarr-
77 Salapatek, 1976). Thus, environment was seen as a static influence rather than dynamically
78 shaping the organisms’ development. However, rather than development being a passive
79 unfolding of preprogrammed pathways through exposure to the environment, interactions
80 with the environment, particularly the social environment, are key to directing behavioral
81 development (Gottlieb, 1976; Lickliter & Gottlieb, 1985; Moore, 1984). Individuals’ early
82 experiences have a cascading effect in structuring the pattern of further development, with a
83 fluid interaction of what was traditionally viewed as ‘nature’ and ‘nurture.’ Therefore, there
84 is no explanatory value in distinguishing the contribution of ‘nature’ and ‘nurture’ in
85 development, as there is no boundary between the two—they are interdependent and
86 inseparable. Furthermore, with the recognition of the inheritance of environments, the
87 ontogenetic niche, one could no longer distinguish genes and environment on the basis of
88 what is pre-existing before development occurs (Oyama, 2000; West & King, 1987, 1988).
89 The social surroundings and interactions of a young organism are part of its heritage just as
90 are genes and proteins in the body.

91 In this chapter, our goals stem from this theoretical framework underscored at all times
92 by the idea that communicative development is an interactive process involving social

93 partners. Mere exposure to environmental or social variables is not sufficient; individuals
94 must be active participants in their environment to learn. Organisms acting and behaving
95 elicit social responses that shape an organism's perception, affecting what there is to be
96 learned ('performatory feedback': Gibson, 1966). To exemplify this idea, we present
97 evidence for a social gateway, which is the role of ecology in making stimulation available in
98 the environment. Proximity to and interactions with social partners offer different
99 opportunities for interactions, thus mediating the communicative behaviors that individuals
100 produce and feedback they receive (West et al., 2003; White et al., 2002a). For example, for
101 young individuals the degree of access to adults-a social gateway- predicts cultural guidance
102 and thus what is available to be learned. Therefore, instead of considering exposure to all
103 potential stimulation in the environment as relevant for development, we focus on the
104 bioavailability of social stimulation: that portion that is accessible via the social gateway.

105

106 **Traditional studies of communicative development**

107 Studies of early vocal development do not often focus on the development of
108 pragmatics, that is, putting correct acoustic form into effective use; rather, most studies focus
109 on the development of mature acoustic forms of vocalizations or speech sounds, with the
110 assumption that there is a predetermined linkage between producing the appropriate vocal
111 forms and knowing how to use them. This assumption is a historic result of the widely held
112 viewpoint that vocal development in humans and songbirds can be explained through the
113 action of innate modules (Bloom, 1993; Chomsky, 1965; Konishi, 1965; Lenneberg, 1967;
114 Marler, 1967; Marler & Nelson, 1992). Additionally, original comparisons made between
115 birdsong and speech development focused on acoustic form rather than pragmatic use
116 (Marler, 1970), as both were thought to be based on similar innate mechanisms. Included in
117 such predeterminism is the pragmatic component of communication, which is simply
118 assumed to follow the development of functional vocalizations: once a bird sings, or a
119 human produces their first proto-word, correct usage comes in tow. A result of a reliance on

120 innate explanations is that development becomes oversimplified because environmental
121 influences are overlooked and underestimated.

122 However, closer examination of studies of communicative development (Payne &
123 Payne, 1993), and many studies that have been performed in our lab, suggest that such
124 simplistic views of development of acoustic form and usage cannot be supported. Studies of
125 cowbirds have revealed that the development of song structure and communicative
126 competence is dependent upon the nature of interactions between young males and their
127 social partners. Females provide nonvocal social feedback that shapes fine acoustic structure
128 of male song and that influences the rate of vocal development (King & West, 1988; King
129 et al., 2005; Smith et al., 2000; West & King, 1988). Adult males provide the interactions
130 through which males develop effective use of song (White et al., 2002b). Similarly, we have
131 evidence in humans that differential responses to vocalizations may influence vocal
132 development and usage similar to what we have seen in cowbirds (Goldstein et al., 2003;
133 Goldstein & Schwade, under review; Gros-Louis, 2006; Gros-Louis et al., 2006a; Gros-
134 Louis et al., in prep.-b). Thus, in contrast to the view that early ‘babbling’ in both songbirds
135 and infants is merely motor practice (Bloom, 1993; Oller, 2000), contingent stimulation by
136 social partners in response to early vocalizations actually drives development. The
137 demonstration that social stimulation shapes developmental change makes it necessary to
138 view the ontogeny of communication as part of a broader developmental ecology. The task
139 that we face as researchers is to figure out the aspects of the social environment and social
140 contingencies within that environment that operate to influence different components of
141 communicative behavior.

142

143 **Pragmatics defined**

144 To clarify the way in which we use the terms ‘pragmatics’ and what we mean by ‘vocal
145 usage’ in this chapter, we provide a brief overview of three different analytic levels of
146 communication that stem from early semiotic and linguistic theory (Chomsky, 1965;

147 Morris, 1946) and its extension to ethology (Sebeok, 1962, 1965). The first two levels,
148 syntactic and semantic, examine what message potentially could be contained in a signal or
149 display rather than its use in the context of an interaction. Syntactic analysis abstracts
150 signals from their communicative context to investigate their potential for communicating
151 meaning alone and in combination with other signals, asking such questions as what
152 constitutes a signal and how the potential meaning of a signal changes in combination with
153 other signals (Chomsky, 1965; Smith, 1977). Semantics, on the other hand, investigates
154 what kind of information is contained in a signal, asking whether a signal carries meaning
155 through association with particular objects or behaviors; however, although semantics
156 examine the predictable association of a signal and potential referents, this association is
157 divorced from social context to strip away any potential contextual ‘cues’ for meaning.

158 The pragmatic level of analysis considers use of signals in social interactions. Therefore,
159 it is both the signal and the contextual production of it that results in a signal’s function.
160 For this reason, the same signals in different contexts may have different meanings or
161 functional outcomes (Smith, 1977). And, this leads us to an important point of comparison
162 of pragmatics to syntax or semantics. Syntax involves specific structures, semantics involves
163 specific meanings, but because of variation across contexts, pragmatics is not predictable
164 and pre-defined in the same way as syntax or semantics. To illustrate this point, Dore states
165 “The function of interrogative structures, for example, is to ask questions. But this tells us
166 little about the experienced regularities of what, where, when, why, how, and with whom
167 questions are used” (Dore, 1986, p. 6). The analogy in the present chapter is that although
168 the function of birdsong or prelinguistic behaviors may be recognized, the development of
169 the content of a signal is not predictive of the development of its pragmatic usage.
170 Furthermore, pragmatic usage is essential for the functional effectiveness of signals.

171 Although the early semiotic distinction of the three components of the communicative
172 process included syntax, semantics and pragmatics, an examination of definitions of
173 communication from different theoretical perspectives indicates that definitions do not

174 explicitly include pragmatics (Hauser, 1996; Table I). Such an omission reiterates the fact
 175 that pragmatics are often inherently taken for granted, assumed to follow from the
 176 production of vocalizations (but see Dore, 1979 who argues that function precedes form
 177 and can derive from separate sources ontogenetically). Thus, the differential focus across
 178 academic disciplines is the structure or content of the signal but not the delivery of the
 179 signal. Ethology and sociobiology view signals as inherent in the behaviors of individuals
 180 (e.g., Smith, 1977; Wilson, 1975), whereas cognitive psychology views signals with discrete
 181 meaning and an underlying mental representation (Johnson-Laird, 1990).

182 Table I. Excerpts of definitions of communication from a variety of theoretical perspectives
 183 of different academic disciplines (adapted from Hauser, 1996).

Academic discipline	Definition
Behavioral ecology	“... signals or displays to modify the behaviour of reactors...” (Krebs & Davies, 1993, p. 349)
Cognitive psychology	‘...internal representation and symbolic behaviour that conveys that representation...the interpretation of the symbolic behaviour.’ (Johnson-Laird, 1990, pp. 2-4)
Ethology	“...the transfer of information via signals...between sender and receiver” (Hailman, 1977, p. 52)
Linguistics	‘...vocal and nonvocal gestures as we interact...’ (Lindblom, 1990, p. 220)
Neuropsychology	‘...behaviors of one member of a species conveys information to another member of the species...’ (Kimura, 1993, p. 3)
Sensory ecology	‘...behavior generates a signal that mediates interaction...’ (Dusenbery, 1992, p. 37)
Sociobiology	‘...action or cue given by one organism to another...’ (Wilson, 1975, p. 111)

184
 185 In addition, in our view, definitions of communication provide the description for the
 186 endpoint, a successful communicative act, rather than the necessary precursors of
 187 communicative behavior or the process that results in a communicative act. For example, the
 188 ‘prerequisites’ for describing vocal interactions in songbirds are indicated to be the ‘who,’
 189 ‘what,’ and ‘why,’ leaving out the ‘when’ (Dabelsteen & McGregor, 1996).

190 Nonetheless, pragmatics are implied in the definitions of communication in that they
 191 either explicitly include a signaler and a recipient of a signal, or the premise that information
 192 is transmitted between two individuals. Definitions that focus on behavioral interaction as
 193 communication, rather than those that focus specifically on the *content* of signals, are most

194 useful in comparative studies of communication across species. In particular, when
195 comparing prelinguistic communication in humans to communication in other animals, an
196 ethological perspective is a valuable approach, as both communication systems share more
197 similarities with one another than human language: “information is a feature of an
198 interaction between sender and perceiver” (Hauser, 1996) or communication is a “process
199 of signaling and eliciting responses” (Smith, 1977).

200 It is probably no accident that definitions of communication and studies of
201 communicative development lack explicit focus on the correct delivery or usage of signals.
202 Popular experimental designs employed in studies of nonhuman vocal development involve
203 solitary individuals. In such a design, pragmatics are inherently absent, as pragmatics
204 involve social partners. Furthermore, there is no need to explain origins of behavior when
205 relying on a nativist explanation: ghosts in the machine provide the blueprint for
206 development and connect form with function. Thus, endpoints serve as a starting point from
207 which researchers work backward to explain development rather than prospective studies
208 considering the process to get to the endpoint. The danger in a retrospective approach is that
209 it fails to capture the origins of behavior, as researchers have certain preconceptions of early
210 behaviors and their potential plasticity (cf. Reddy, 1999). The use and significance of
211 sounds, or their directedness to a social partner (defined by visual gaze), are overlooked
212 because they will be supplanted by mature song or words. We provide examples from
213 studies of both cowbirds and infants that demonstrate that understanding the origins of
214 behavior is necessary to understanding its function and that communicative development
215 needs to be studied in a prospective manner in order to appreciate the role of socially gated
216 stimulation to construct behavior.

217

218 **The absence of pragmatics in developmental studies**

219 *Birdsong development*

220 Researchers have noted recently that although the historical emphasis has been on
221 strictly auditory influences on song learning, the next few decades will be devoted to
222 analyses of social factors (Beecher & Brenowitz, 2005; Beecher & Burt, 2004). An early
223 consideration of social influences was rooted in the finding in the mid-1980's that live
224 tutors could facilitate imitation beyond that seen with a tape tutor (Baptista & Petrinovich,
225 1984). At the same time, studies by King and West revealed that nonvocal social stimulation
226 of females influenced vocal development in male cowbirds (King & West, 1983, 1988;
227 West & King, 1988). The newly recognized role of social interactions in development
228 ultimately led to a greater focus on the behavior of singers and recipients in the form of
229 "action-based" learning (Marler & Peters, 1982). However, because of the strong hold of
230 innate underpinnings in developmental theory, social influences were viewed as experiential
231 contributions to divergent pathways of predetermined vocal endpoints. Song variants were
232 winnowed during development via feedback between senders and receivers, rather than
233 feedback contributing to song origins (Marler & Nelson, 1993; Nelson & Marler, 1994).
234 Furthermore, social feedback was generally considered to be of an acoustic nature, such as
235 song matching to a tutor or through interactions between neighboring males (Beecher et al.,
236 2000). This is not to say that pragmatics is not part of birdsong, as birds must decide
237 whether and when to match songs or repertoires with neighbors (Beecher et al., in press)
238 and from who to learn song (Kroodsma, 2004). However, an important point is that this
239 research considers the role of pragmatics in *vocal* development rather than pragmatic
240 development itself.

241 The focus on acoustic variables may account for the fragmented state of the field as a
242 whole. Kroodsma (1996), in calling for more serious attention to the ecology of song, has
243 characterized the field of song learning as composed of "myriad facts...largely
244 unconnected, bits of a grand evolutionary picture," (p. 3). The fragmentation of the field of
245 birdsong may be tolerable for those interested in only part of the communication process,
246 e.g., the mechanisms of motor or hormonal control underlying song production and

247 seasonal neuronal plasticity (Brenowitz, 2004). But for those seeking to understand the
248 development and evolution of communication, knowledge about the dynamical nature of
249 interactions between communicators is essential (McGregor & Peake, 2000; Nowicki et al.,
250 2001; Payne & Payne, 1993). Acoustic variables are insufficient because they neglect the
251 actual social interactions in which song use is embedded. Thus, research over the past
252 decades on the development of acoustic structure of song in birds have made significant
253 discoveries into the potential mechanisms of vocal development, ranging from
254 neurobiological to external social influences, but the research has overlooked the fact that
255 effective song may not bring with it effective use in social interactions.

256 The oversight of pragmatics in vocal studies has several root causes. First and foremost,
257 investigators have simply assumed that evidence of the presence of a communicative signal
258 is also evidence that its use will be appropriate. Second, the contexts studied, often isolates
259 or small groups of songbirds, may not reveal the absence of pragmatic skills. Third,
260 investigators may unwittingly substitute their own actions for the behaviors that animals
261 must perform in nature. For example, in playback work, experimenters expose male-
262 deprived females to recorded songs and measure whether she adopts a copulatory posture to
263 the songs. The focus is on discovering song function and it has been used in diverse
264 songbird species (Searcy, 1992). The appeal of this unambiguous response is its objectivity
265 and quantifiability, but its simplicity can be deceiving because it completely obscures the
266 realm of pragmatics. It is the investigator, not the singing bird, who determines what, where,
267 when, and to whom recorded vocalizations are directed. In reality, however, males must not
268 only know what to sing, but they must also know where, when and to whom to sing.

269 Such an omission is critical when we consider the instrumental importance of
270 pragmatics of singing behavior in natural contexts. By removing the playback context
271 previously engineered by humans, a series of experiments revealed that the development of
272 biologically effective song does not automatically result in the reproductive success that is
273 suggested by song efficacy in playback experiments. Young male cowbirds were housed

274 first with adult female cowbirds or canaries and then were exposed to a new set of female
275 cowbirds or canaries to provide a more ‘freestyle’ social context of courting and mating
276 behavior (Freeberg et al., 1995; West et al., 1996). The “where” component of
277 communicating was varied by first having males meet their new companions in a flight cage
278 and then in a large aviary populated by female cowbirds from three populations, canaries of
279 different color morphs, and starlings, a novel species. In the flight cage setting, the male
280 cowbirds, who had been housed with female cowbirds, looked normal: they sang to female
281 cowbirds and ignored the canaries. But in the aviaries, the female-housed cowbirds sang
282 primarily to themselves or one another, ignoring the often-solicitous female cowbirds. Even
283 after observing the mating behavior of adult male models in the aviaries, the male cowbirds
284 still ignored females of their own species. The data from the canary housed males was more
285 dramatic. In both contexts the canary housed males courted new canaries and ignored
286 female cowbirds.

287 Returning to the journalistic framework, males in these studies collectively showed
288 deviations in “who,” “what,” “where,” and “when.” Males who developed effective
289 songs, but not appropriate ‘pragmatic’ skills, did not achieve copulations. These results
290 provided experimental evidence for the idea that form and usage do not automatically
291 develop concurrently. More importantly, it pointed to the need for researchers to consider
292 the inherited environment of development and emphasized the need for multiple contexts for
293 assessment of the endpoint of functional behaviors such as singing. Had the experiments
294 stopped with playback experiments or with the flight cage test, male’s development would
295 have appeared normal. And, in fact, these would have been potential stopping points for
296 many researchers without access to the complex social context of a flock, the context where
297 song is actually used.

298

299 *Infant development*

300 Most studies of early infant vocal development, like those of songbirds, historically have
301 focused on auditory influences on vocal learning, such as the influence of exposure to
302 speech sounds of the primary language on structural variation in phonemes during the first
303 year (e.g. de Boysson-Bardies & Vihman, 1991; Vihman et al., 1986). Thus, vocal behavior
304 is examined to document and explain stage-like changes at the phonemic level rather than
305 communicative use of vocalizations (Locke, 1983; Oller, 2000; Stoel-Gammon & Otomo,
306 1986). However, just as in songbirds, vocal development is not only about producing more
307 phonologically advanced sounds, but is also about learning the pragmatics of
308 communication: how to use vocalizations for effective social and communicative interactions
309 (Dore, 1974). The social-pragmatic approach to language development recognizes the
310 importance of pragmatic *comprehension* scaffolding language development toward the end
311 of the first year (Akhtar & Tomasello, 2000; Baldwin & Tomasello, 1998; Tomasello,
312 1997). However, few studies examine the development of pragmatics of *productive*
313 communicative behavior (Carpenter et al., 1983; but see Dore, 1983; Smith, 1998). Studies
314 more often provide descriptions of predetermined pragmatic abilities, which are labeled
315 ‘intentional communication’ or ‘communicative intentions’ rather than examining their
316 developmental origins (e.g., Carpenter et al., 1983; e.g., Wetherby et al., 1988). By
317 examining an expected endpoint, as suggested by the term ‘communicative intentions,’
318 researchers fail to notice the potential communicative function of combined vocal, attentional
319 and gestural behaviors. Not all infants will develop similar pragmatic behaviors, as some
320 infants will use more gesture, tone or proto-words (Dore, 1974) and thus it is important to
321 study their convergent development.

322 One reason that few studies have explored prelinguistic communicative development
323 may be that there is often a conflation of language and communication (Golinkoff &
324 Gordon, 1983). The designation of the term “pre” linguistic indicates that language is the
325 endpoint rather than broader communicative competence. Thus, language researchers have
326 often approached the study of the prelinguistic period in a retrospective manner, focusing on

327 month-by-month or stage-by-stage changes to bridge the gap between babbling and first
328 words by identifying precursors to formal language (e.g., Kent & Miolo, 1995 and
329 references therein). Studies that do consider social influences on language development
330 attempt to predict behavioral changes over many months, e.g., from 8 to 14 months. Often,
331 infants' abilities or behaviors at time y (14 months) are then retrospectively related to their
332 abilities at time x (8 months) to determine the relative influence of particular communicative
333 measures on developmental linguistic milestones (Bornstein et al., 1992; Tamis-LeMonda et
334 al., 2001). The result is that the development of pragmatics is taken for granted just as in
335 songbirds, in that development of a communicative signal (language) brings with it the
336 development of its appropriate use. This may be a result of early views of not only innate
337 behaviors, but also a 'hereditary teaching mechanism' responsible for connecting behaviors
338 to function (Lorenz, 1965). The machine supplies the pragmatic connection in an automatic
339 fashion not requiring learning. Pragmatics is simply doing what comes naturally or
340 nativistically. Development is of the "plug and play" variety.

341 Prelinguistic behaviors originally were identified relative to their mode of production,
342 and thus viewed as distinct channels of communication (Stern, 1974): affective (vocal and
343 facial expression), attentional (eye gaze, gestures), and vocal (babbling) (see also Barratt et
344 al., 1992; Stern, 1974). A number of studies have explored the temporal relationship among
345 communicative behaviors, such as visual gaze, vocalizing and/or smiling (D'Odorico &
346 Cassibba, 1995; Keller & Scholmerich, 1987; Schaffer et al., 1977; Striano & Rochat,
347 1999), although the perspective has been to study their co-occurrence or sequential nature.
348 Thus the structural timing, rather than communicative significance, has been the focus of
349 many studies. What is needed is a study that documents when and how phonologically
350 different vocal behaviors converge with other modes of communication and how that results
351 in broader communicative competency.

352 We propose that combining studies of vocal behavior with those of socio-cognitive
353 behavior is the starting point for understanding the development of communication because

354 socio-cognitive abilities contribute to the attentional components of prelinguistic
355 communication. It is the integration of directed attentional focus (toward objects or social
356 partners), vocal behaviors, and nonverbal gestures (though not considered in detail in this
357 chapter) that gives rise to the pragmatic function of early communicative behaviors (cf Bates,
358 1976; Ninio & Bruner, 1978). Bringing attentional and vocal behaviors together is a key, as
359 suggested for later language and apt for our journalist metaphor: integrating gaze and
360 linguistic channels tells a recipient the when, where and what use to give the gazing activity
361 in relation to language (Kasher & Meilijson, 1996; Schieffelin, 1983). Compounded
362 behaviors are especially apparent in the second six months of life when infants bring
363 together new skills: babbling, socially directed behaviors such as social referencing,
364 establishing joint attention episodes, and attentional sharing behaviors such as
365 protodeclarative pointing. A quote from Bates (1976) exemplifies the communicative
366 capacity of combined prelinguistic behaviors at the end of the first year: "...combinations of
367 apparent imperative intention: stretching forth the arms with an open-and-shut gesture of the
368 hand, pointing, reiterated and insistent vocalizations, and intermittent eye contact with the
369 adult" (Bates, 1976, pp. 55-56; Bruner, 1975; see also Ninio & Bruner, 1978). Also, a point
370 alone may orient caregivers' attention, but if the point is accompanied by a vocalization,
371 there is more indication of the infants' goal (Jones & Zimmerman, 2003). In particular, it is
372 the coordination of behavioral and attentional focus on objects and people in interactions,
373 i.e. joint attention or secondary intersubjectivity (Bakeman & Adamson, 1984; Trevarthen &
374 Hubley, 1979), that is thought to form the basis of preverbal communication because it
375 "encodes" infants' intentions (Sugarman, 1984, p. 60).

376 Though the parallel development of vocal and socio-cognitive behaviors are the basis of
377 more complex communication, at present there is a disconnect between studies of early
378 vocal development and social and cognitive development. In contrast to a handful of studies
379 in the 1970's and 1980's that examined the potential communicative function of combined
380 behaviors (e.g., Dore, 1974; Sugarman, 1984), current studies of socio-cognitive abilities

381 focus on the ages at which these abilities emerge, rather than consider these abilities in
382 combination with emerging vocal skills. This is tantamount to the documentation of
383 phonological achievements in studies of early speech development, and how they may
384 contribute to language learning (Baldwin & Tomasello, 1998; Pruden et al., 2006). Often
385 times, it is not until after a child has referential language that vocal behavior and skills such
386 as joint attention are considered together for their communicative potential (termed
387 “verbalizations”-Carpenter et al., 2002; but see Wetherby et al., 1988). Clearly socio-
388 cognitive skills play a role in language development, but we stress the need to consider the
389 convergence of prelinguistic vocalizations and emerging socio-cognitive skills during
390 development as the beginning of communicative pragmatics. As infants begin to produce
391 directed vocalizations in the context of social referencing, for example, caregiver
392 responsiveness is likely to be influenced by both the phonological quality of the infants’
393 vocalization in addition to their attentional focus or activity (Rochat & Striano, 1999). A
394 fruitful line of research would be to explore the significance and effectiveness of “re-
395 engagement vocalizations” and “re-engagement activities” that have been observed in
396 dyadic interactions in which adults adopt a still-face (Striano & Rochat, 1999). And, further,
397 researchers should explore how caregiver responsiveness to such vocalizations shape
398 pragmatic development.

399 The main studies that examine pragmatic development concurrently with vocal
400 development are those of children with socio-communicative disorders. In these cases,
401 dissociations in the form and function of communicative behavior make the significance of
402 pragmatics apparent. For example, most relevant to our comparative work with songbirds,
403 children with autism spectrum disorder, in particular Asperger’s syndrome, may show
404 deficits in the pragmatics of language although they show few deficits in vocabulary or
405 grammar (e.g, Surian et al., 1996; Tanguay et al., 1998). In fact, high-functioning autistic
406 children develop referential language, i.e. words, before they begin producing
407 protodeclarative gestures, such as pointing or showing to share or direct attention (although

408 they do produce protoimperative gestures: Baron-Cohen, 1989); thus, they can produce
409 words before becoming communicatively competent, which is the opposite of typically
410 developing children (Carpenter et al., 2002). Also, although apparent later in development,
411 children with ADHD and Williams syndrome show deficits in pragmatic aspects of
412 language rather than in other areas (Purvis & Tannock, 1997), such as inappropriate
413 initiation of conversation and conversational rapport (Laws & Bishop, 2004). In cases
414 where grammatical or semantic deficits are present, these are likely linked to pragmatic
415 deficits that negatively impact learning (Camarata & Gibson, 1999).

416 In sum, the ‘why,’ ‘when,’ and ‘who’ of communicative interactions are most impaired
417 in children with social communicative disorders, while the ‘what’ is less impaired. Although
418 there are obviously other significant differences, through a comparative lens we see a
419 parallel with male cowbirds that lack the ability to sustain attention in social interactions,
420 thus developing potent song but never engaging in successful pragmatics of song
421 production (White et al., 2002b). Therefore, there is compelling evidence in both songbirds
422 and human infants that the linkage between structure and function is not inherent in the
423 system and that pragmatic development needs to be integrated with vocal development.

424

425 **Mechanisms of communicative development**

426 *Contingent stimulation and the development of attention*

427 Our research has shown that from the
428 beginning of vocal production, young
429 songbirds produce variable vocalizations, akin
430 to infant ‘babbling,’ and non-vocal, social
431 feedback is bounced back to them, a process
432 termed ‘behavioral sonar’ (King & West,
433 1988; Skoyles, 1998; West et al., 1990). This
434 process is an extension of ‘performatory’

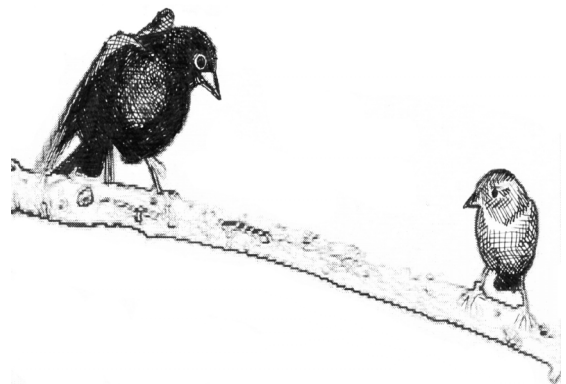


Fig. 1. Illustration from a single frame of a video recording of a male cowbird directing a song to a female cowbird.

435 feedback (Gibson, 1966) because young males can learn what notes to keep and what notes
436 to drop by attending to feedback from females who cannot sing (West & King, 1988). This
437 finding was provocative because prior research had assumed that auditory input and
438 feedback was the necessary and sufficient experiential variable for song development.
439 However, for behavioral sonar to work, males must produce directed song (oriented toward
440 a social partner, in this case the female; see Fig. 1) rather than undirected song (no song
441 recipient) and attend to the consequences of their singing. The attention span of the singing
442 male delimits the opportunities to receive social feedback that shapes acoustic form and
443 connects form and function. Thus, the songs that receive feedback from females during
444 development are those that elicit copulatory postures from those same females (White et al.,
445 2006).

446 In the most extensive studies of the social shaping of avian babbling, Smith et al. (2000),
447 West & King (1988) and King et al. (2005) found that the non-singing female companions
448 of immature male cowbirds provided different forms of non-vocal feedback which
449 influenced the rate of vocal development and phonological quality of male song. Frame-by-
450 frame measurements of male-female interactions revealed that female wing strokes and
451 gapes are performed in reaction to songs that are directed to females. A wing stroke is a
452 rapid flick of the wing that by definition must occur co-incident with song delivery and a
453 gape is rapid opening of the beak accompanied by raising of the head (Figs. 2a & 2b).
454 These behaviors led males to repeat the sounds and behaviors that produced social
455 responses from companions and eventually to drop sounds that did not produce reactions.

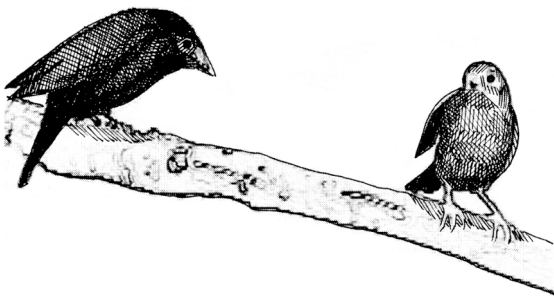


Fig. 2a. Drawing from a single frame of a video recording of a female cowbird reacting to a directed male song with a wingstroke.

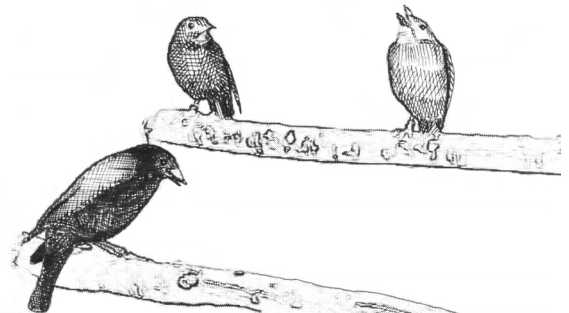


Fig. 2b. Illustration of a female cowbird reacting to a directed male song with a gape⁷

456 Furthermore, social feedback shaped the attention
457 span of the males as measured by looking (King et al., 2005) and the length and content of
458 social interactions (King, unpublished data). Directed song, a proxy for attentional focus,
459 predicts the acquisition of articulate and attractive song, as wing strokes and gapes
460 correlated with the earlier onset of stereotyped song and higher song quality as measured by
461 playback (King et al., 2005). Greater social feedback led to a faster rate of development and
462 faster progress toward stable articulation of the phonemic-like structures of their
463 vocalizations. Males producing more directed song have an advantage entering the breeding
464 season: having developed song at a faster rate and having better song repertoires, they court
465 earlier and more successfully (Smith et al., 2000). Thus, proper use of directed song and
466 accompanying attentional skills are a critical pragmatic dimension of communication in
467 cowbirds and should be considered a “prelinguistic” milestone that drives further
468 development.

469 Different social responses of females also affect neural development. Males housed
470 with more socially interactive females, compared to those housed with less interactive
471 females, had a greater volume and higher number of neurons in one of the visual nuclei
472 located in the thalamus that is thought to process information about form and motion
473 (Freeberg et al., 2002; Hamilton et al., 1998). As males were randomly assigned to
474 conditions, the differences in their repertoires and neural structures must reflect the
475 differential influence of their female companions’ social stimulation. Males learn to read
476 visual signals from females to modify their own vocal signals and they do so on-line while
477 interacting with females. Thus, it is likely that the neural differences between males housed
478 with responsive compared to unresponsive females stem from the demands of males
479 sustaining their attention in cross-modal tasks. Further indication that attention is a
480 significant component of communicative interaction comes from research showing that
481 differential ZENK gene expression is associated with the use of directed but not undirected
482 song (Jarvis et al., 1998). Therefore, the attentional aspect of social interaction is important

483 for communicative development from social, neural and molecular perspectives. And, we
484 believe, it is this attentional aspect that is the basis of the pragmatic dimension of
485 communication.

486 Directed vocalizations in infants, just as in cowbirds, are the critical pragmatic dimension
487 of communication between caregivers and infants and provide the opportunity for learning
488 through responding by social partners. Similar to our findings in songbirds, there is an
489 implied behavioral sonar mechanism in infant vocal development. Locke (2001) suggests
490 that vocalizations and other expressive behaviors are part of a developmental system that
491 necessitates that “signals be sent in order for information to be received” (p. 302). Infants
492 produce variable vocal or social behaviors and feedback to these behaviors is ‘bounced’
493 back to them, providing a potential source of information about the effectiveness of infants’
494 behaviors, a first step in learning what sounds to produce and how to use them. For
495 example, at around 4 months of age, infants can shift their gaze and exhibit more varied
496 vocalizations. Particular patterns of vocalizing, or vocalizations occurring concurrently with
497 attentional focus on an object are initially coincidences rather than being under voluntary
498 control (cf Collis, 1979). Nonetheless, regardless of the intentionality on the part of the
499 infant to communicate, the vocalizations elicit responses from caregivers (Bates et al., 1975;
500 Locke, 1996). The responses can bootstrap the infant to behaviors that appear more
501 ‘intentional,’ thus connecting form and function, by commenting on or manipulating the
502 object that the infant is vocalizing to (Collis, 1979; Halliday, 1979; Siegel, 1999).

503 An example of behavioral sonar in infants comes from Lawrence’s 1986 study of 20
504 mother-infant pairs when the children were nine months of age. Lawrence (1986) found that
505 different dyads produced different combinations of communicative gestures, tones, or proto-
506 words (see also Dore, 1974). These gestures, tones, and proto-words are the initial
507 behaviors emitted as ‘sonar.’ The mother’s decisions about which behaviors were
508 communicative led to differential feedback and thus her reactions represent a potential
509 source for vocal shaping (Papousek, 1992). Infants may, therefore, take different

510 developmental pathways and progress at different rates in their communicative skills due to
511 individual variation in early vocal and attentional behaviors and caregiver responses to these
512 behaviors. Such variability has been shown to predict the development of language and
513 coordinated joint attention in the second year (Markus et al., 2000), indicating that infants’
514 behaviors drive their own development through interaction with the environment as in other
515 domains such as locomotion (Thelen et al., 1996; Thelen & Ulrich, 1991) and as we have
516 seen in cowbirds.

517 Contingent responses during social interactions provide the mechanism for infant
518 phonological development similar to the social shaping that we discovered in cowbirds
519 (King et al., 2005; West & King, 1988). Specifically, differential feedback from caregivers
520 provided in moment-to-moment social interactions plays a central role in creating
521 developmental pathways. The intonational quality of infant vocalizations, in addition to their
522 acoustic structure, influences how caregivers respond (Beaumont & Bloom, 1993; Bloom et
523 al., 1993; Gros-Louis et al., 2006a; Papousek, 1989). The timing and nature of feedback has
524 now been shown to be important in both vocal and pragmatic development (Goldstein et al.,
525 2003; Goldstein & Schwade, under review; Gros-Louis & Ables, 2006; Gros-Louis et al., in
526 prep.-b). Goldstein et al. (2003) documented a significant increase in infants’ well-formed,
527 speech-like syllables (‘canonical syllables’-Oller, 2000) when mothers provided contingent,
528 nonvocal social feedback (smiles, touches) in response to their infants’ vocalizations.
529 Furthermore, infants continued to increase production of these vocalizations after the period
530 of structured maternal responding. By contrast, infants who received the same amount of
531 non-contingent stimulation did not increase their production of speech-like syllables.

532

533 To follow up on Goldstein et al.’s (2003) experimental evidence of social shaping, we
534 examined uninstructed maternal responsiveness during freeplay interactions in ten mother-
535 infant pairs (Gros-Louis et al., 2006a). Mothers responded to infant vocalizations with more
536 vocal responses than non-vocal, interactive responses, such as making eye contact and

537 smiling or touching the infant. Of these vocal responses, mothers delivered significantly
538 more differentiated feedback to vocalizations that were acoustically more mature. Mothers
539 responded with more imitations and acknowledgments ('oh really?', 'mmm-hmmm') to
540 phonologically advanced, syllable-like sounds ('bah') compared to vowel-like sounds
541 ('ah'). Mothers' differential, contingent feedback may shape the structure of vocalizations,
542 in addition to their usage, as acknowledgments provide a conversational-like framework for
543 vocalizing.

544 To explore the relationship between contingent stimulation and the development of
545 communicative behaviors, we conducted a longitudinal study of 12 infants over a period of 6
546 months starting when they were 8 months of age. Infants showed variation in their
547 attentional focus in relation to caregiver responses when they vocalize, similar to males
548 directing songs to females in cowbirds (Gros-Louis et al., in prep.-b). Directed vocalizations
549 included those produced to a parent or a toy (defined by direction of visual gaze), while
550 undirected vocalizations occurred when infants appeared not to be focused on any person or
551 object, such as when looking around the room. Mothers showed variation in how they
552 responded to their infants' vocalizations, with most offering information about the object of
553 infants' attentional focus but many also ignoring a fairly large proportion of vocalizations.
554 Mothers whose responses focused in on infants' attentional focus had infants who scored
555 higher on vocal comprehension and gesture on the MacArthur Communicative Development
556 Inventory (Gros-Louis et al., in prep.-b). Similar associations have been found for following
557 of infants' attentional focus and language development (Dunham et al., 1993; Rollins, 2003;
558 Tamis-LeMonda et al., 2001; Tomasello & Farrar, 1986).

559 We also found suggestive evidence that maternal responsiveness to prelinguistic
 560 vocalizations influenced the development of infants' pragmatic behavior. Infants who
 561 received more responses to their vocalizations from their mothers showed a larger relative
 562 increase in vocalizations that they directed toward their mothers between 8 and 14 months of
 563 age than infants who received fewer
 564 responses (Gros-Louis et al., in prep.-
 565 b; Fig. 3). Therefore, infants who
 566 received more contingent feedback
 567 increased their pragmatic use of
 568 vocalizations.

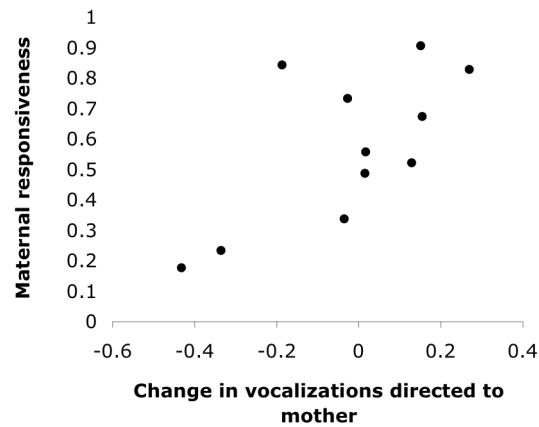


Fig. 3. The relationship between maternal responsiveness and the change in the proportion of vocalizations that infants directed to their mothers from 8 to 14 months old (n = 11). A negative change in directed vocalizations indicates a decrease over time. Maternal responsiveness of 0.1 = response to every sixth vocalization; 1 = response to every vocalization.

569 Results from our prelinguistic
 570 infant studies suggest a bidirectional
 571 influence on communicative
 572 development that is embedded in real-
 573 time social interactions, just as we have
 574 documented in developmental studies
 575 of cowbirds. Bidirectional effects of
 576 infant-caregiver interactions on development, often termed transactional processes, have
 577 been suggested previously (Bruner, 1977, 1983; Papousek & Papousek, 1975; Sameroff,
 578 1975; Vygotsky, 1962), but not at the level of identifying the specific mechanism whereby
 579 feedback shapes structural form and pragmatic force. Our research demonstrates that
 580 infants learn about the relative effectiveness of different behaviors through social
 581 interactions in which they are embedded (cf Bruner, 1978; Gibb Harding, 1983; Papousek,
 582 2007), suggesting a dynamic process of social shaping, where infants modify their
 583 behaviors in keeping with changing feedback from their ecology (e.g., Locke, 1993; 1996).
 584 At the heart of the social interactions are the behavioral contingencies that the infant receives
 585 to particular behaviors or joint behaviors (vocalizing and attentional focus). It is this

586 contingent feedback that leads the infant to produce behaviors with more specificity in terms
587 of their production, thus resulting in more precise pragmatics in terms of the ‘when,’ ‘who,’
588 and the ‘why’ of communicative interactions.

589

590 **Not too much, not too little: the perfect level of contingent responding**

591 The finding that socially contingent responding leads to infants producing sounds with
592 more complex phonological features suggests that, as in studies of social, emotional and
593 cognitive development (Rochat & Striano, 1999; Stern, 2000; Watson, 1985), contingency
594 may play a role in vocal development (see also Locke, 2001; Papousek & Bornstein, 1992).
595 This fact is not surprising given the early sensitivity that infants show to perfect
596 contingency, which later shifts to a preference for imperfect or ‘social’ contingency
597 (Bigelow, 1999; Bigelow & DeCoste, 2003; Gergely & Watson, 1999) and forms the basis
598 for social expectations in interactions with people compared to objects (Ellsworth et al.,
599 1993; Legerstee et al., 1987). Studies indicate that just the right amount of contingent
600 responding is necessary to be effective in driving development (Bigelow & Birch, 1999), a
601 suggestion that is supported with our studies of cowbird and infant vocal development
602 (Gros-Louis et al., in prep.-b; Miller et al., under review). In particular, variable contingent
603 responding rather than predictable delivery of responses is likely to be more powerful for
604 shaping behavior based on basic mechanisms of operant conditioning (cf. Neuringer et al.,
605 2000).

606 In cowbirds, females differ substantially in their level of responsiveness, although group
607 trends are reliably present. For example, local females respond more to local than distant
608 song and permit more directed songs to be sung by local males because they remain in
609 close proximity to the singing male (King et al., 2005). Female cowbirds also range
610 considerably in their degree of responsiveness to song playback with some females
611 showing much more choosiness than others (King & West, 1989). The variation in female

612 behavior suggests that the birds may display different communicative phenotypes, with
613 parallels to different styles of maternal responsiveness in humans (discussed below).

614 The effect of variable female responsivity on male vocal development is highlighted in a
615 recent study, with levels of contingent stimulation correlating with improvisation (Miller et
616 al., under review). Young males were more likely to improvise and develop variable songs
617 when they were housed with adult females who were more discriminating in their
618 interactions, and thus less responsive. By contrast, young males were more likely to copy
619 one another's song and showed less diversity in their song repertoires when they were
620 housed with juvenile females who interacted indiscriminately and were therefore extremely
621 responsive. Furthermore, when the males were switched between aviaries, they showed a
622 new pattern of vocal development consistent with the responsiveness of the social

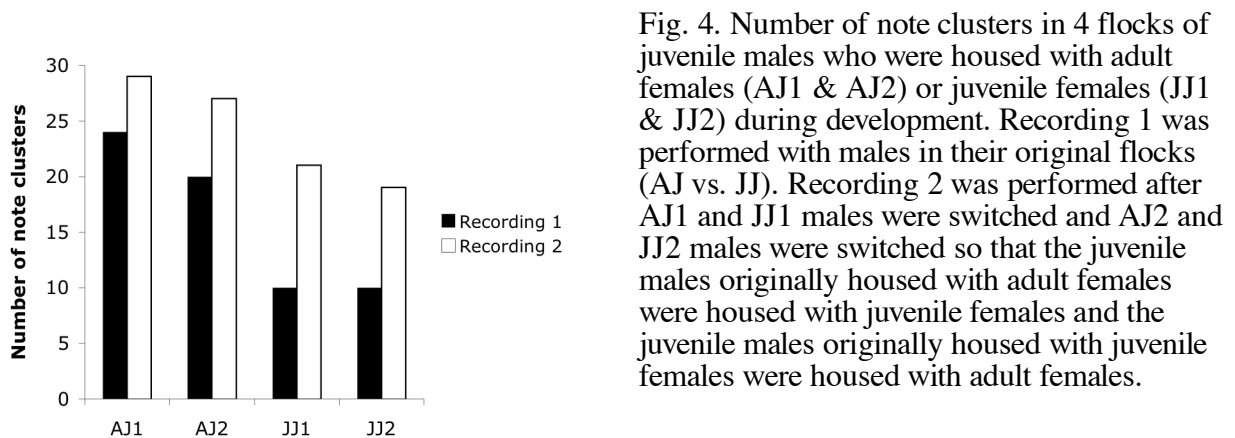


Fig. 4. Number of note clusters in 4 flocks of juvenile males who were housed with adult females (AJ1 & AJ2) or juvenile females (JJ1 & JJ2) during development. Recording 1 was performed with males in their original flocks (AJ vs. JJ). Recording 2 was performed after AJ1 and JJ1 males were switched and AJ2 and JJ2 males were switched so that the juvenile males originally housed with adult females were housed with juvenile females and the juvenile males originally housed with juvenile females were housed with adult females.

623 environment: juvenile males who had been with extremely responsive juvenile females
624 showed a dramatic increase in the number of note clusters that they produced in songs when
625 they were placed with less responsive adult females (Miller et al., under review; Fig. 4).
626 Furthermore, the juvenile males now housed with adult females showed an increase in
627 improvisation, likely related to the combinatorial possibilities introduced by the increase in
628 note clusters in their repertoires. Although individual variation in female responsiveness to
629 different song variants exists (White et al., 2006), it cannot account for the results of this

630 study, as the level of interactivity of juvenile females and adult females with juvenile males
631 showed distinct, non-overlapping distributions (Freed-Brown et al., 2006). Clearly, females
632 cannot be entirely unresponsive, as there would be no feedback available to males when they
633 sing; however, these results indicate that the level of contingent stimulation can be too high.
634 If any and all vocalizations receive feedback, the pattern of contingent stimulation is not
635 informative, thus losing some efficacy in the ability to elicit variable vocal behavior.

636 The findings of the important role of female feedback in male vocal development are
637 consistent with studies in other songbirds. Generally, there is a relation between variable
638 vocal behavior and variable social contexts, which we propose may be related to the level of
639 predictability of social partners. For example, nomadic sedge wrens show improvisation,
640 whereas marsh wrens who are site faithful do not (Kroodsma & Pickert, 1984). In addition,
641 male zebra finches show different strategies for song learning relative to the group size they
642 are in during development (Liu et al., 2004). And, directly related to our findings, male zebra
643 finches improvise more when they are housed with deafened females compared to hearing
644 females, suggesting that males are sensitive to feedback of female companions (H.
645 Williams, pers. comm.). Thus, our research fits with theoretical and experimental studies
646 that have recognized the role of *variability* in female preferences in the development of male
647 traits and behaviors (Coleman et al., 2004; Jennions & Petrie, 1997). Furthermore, it can be
648 speculated that the prevalence of markings and color patterns in many avian species--wing-
649 bars, eye-rings, stripes on the face--are likely effective in providing contextual information
650 about body posture, head orientation, direction of gaze, etc., which are exactly the sorts of
651 signals that would be useful in providing social feedback.

652 Similar to the patterns observed in female cowbirds, early during development human
653 mothers sometimes ignore sounds or behaviors altogether because they do not infer
654 communicative intent or simply are not attending closely to their infant. Mothers' ignoring
655 of signals, like the adult female cowbird's selective inattention to song, may make infants
656 more aware of what needs to occur for their behavior to be taken seriously. Thus, infants'

657 vocal repertoire development and variability may be tied to caregiver responsiveness. At this
658 point, we do not have a clear idea of what proportion of infant acts are treated as
659 communicative and how this varies across individuals. However, results from our
660 longitudinal study of 12 infants indicate wide variation across caregivers. Mothers verbally
661 responded to 17-83% of their infants' prelinguistic vocalizations. Similar to the findings in
662 the cowbirds, there is probably a level of contingent stimulation that is ideal. For instance,
663 we know from studies of depressed mothers that too little feedback is detrimental to
664 multiple aspects of communicative development. Depressed mothers may show less affect
665 in their voices, with fewer temporal and intonational patterns of infant-directed speech to
666 which infants attend (Kaplan et al., 2002). These infants are exposed to fewer of the
667 important prosodic cues available in infant-directed speech that are thought to assist
668 language learning (Kemler Nelson et al., 1989) and they experience fewer contingency-
669 based interactions or less appropriately timed responses (Cohn et al., 1986; Field, 1998). As
670 a result, these infants show communicative disorders in the first year of life, exhibiting less
671 optimal interactive patterns and becoming withdrawn (Field et al., 1988; Jones et al., 1997).
672 Furthermore, these infants show differential frontal lobe activation and neurotransmitter
673 levels (Dawson & Ashman, 2000; Jones et al., 1997), which is reminiscent of neural
674 differences in male cowbirds housed with females that differed in their levels of
675 responsiveness. Although we don't have parallel evidence for extremely responsive
676 caregivers, the findings for the extreme example of low levels of responsiveness of
677 depressed mothers indicate that optimal levels of contingent stimulation within social
678 interactions are necessary for communicative development from social and neural
679 perspectives.

680 Caregivers differ not only in their level, or frequency, of responses, but also in their style
681 of responding. One of the primary characterizations of caregiving styles identified in studies
682 of infant attachment, maternal sensitivity, may be familiar to many readers. Measures of
683 maternal sensitivity bring together a wide variety of maternal characteristics, including

684 maternal warmth and appropriate responding to emotional, attentional and communicative
685 aspects of infants' behavior using a numbered scale (Ainsworth et al., 1974; Ainsworth et
686 al., 1978). Here, however, we use terms that focus on one dimension of maternal sensitivity
687 that refer specifically to how caregivers respond to infants' attentional focus. Caregiver
688 responses range between two extremes, which have been labeled 'directive' and 'follow-in'
689 (Baldwin et al., 1996; Tomasello & Farrar, 1986). 'Directive' behavior involves caregivers
690 attempting to lead or direct infants' attention away from their current attentional focus (i.e.,
691 introducing or commenting on a toy that is not the infant's current focus). 'Follow-in'
692 behavior involves caregivers following in to the infants' attentional focus (i.e., commenting
693 on or labeling a toy that the infant is currently engaged with). There is experimental and
694 observational evidence that follow-in responses that are sensitive to infant's attentional
695 focus facilitate vocabulary learning and language development, whereas directive responses
696 that redirect infants' attention to objects outside of their current focus have a negative impact
697 on language learning (Baldwin & Tomasello, 1998; Baumwell et al., 1997; Tamis-LeMonda
698 et al., 2001; Tomasello & Farrar, 1986).

699 Recent studies in our lab revealed the impact of these different response styles on
700 infants' prelinguistic attentional and communicative behaviors. The first study explored
701 short-term effects of infants' interactions with unfamiliar adults who either followed-in or
702 directed the infants' attentional focus. Infants shifted their attentional focus more often in
703 the directive condition than in the follow-in condition not only to toys that the experimenter
704 introduced, but also more frequently to toys that the experimenter had not introduced. Also,

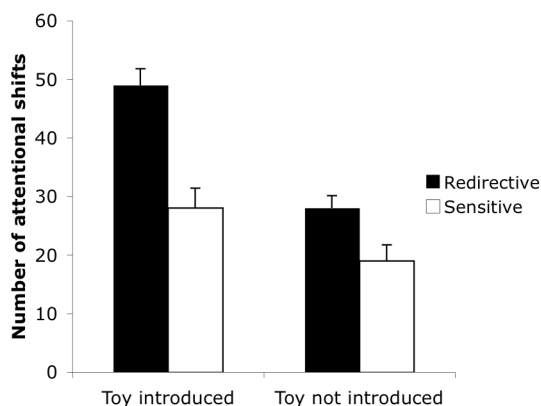


Fig. 5. Infant attentional shifts to introduced toys and toys not introduced by the experimenter in directive and follow-in conditions (n = 19).

705 in the directive condition infants focused their attention on one object or individual for
706 shorter amounts of time than in the follow-in condition, indicating they had shorter attention
707 spans (Ables et al., in prep.; Fig. 5).

708 The second, longitudinal study revealed that over time, such different response styles
709 can impact vocal usage, possibly related to infants not sustaining attention in social
710 interactions. For illustrative purposes, we provide examples from two mother-infant pairs,
711 representing the two extremes of responsiveness: ‘follow-in’ and ‘directive.’ The infant
712 whose mother displayed the most ‘follow-in’ behavior at eight months, responding to her
713 infant’s vocalizations by attending to her attentional focus, increased her percentage of
714 directed vocalizations by 14 months more than the infant whose mother was most directive,
715 leading her infant’s attention away from her current attentional focus. Specifically, the infant
716 of the mother who followed-in more increased vocalizations directed to her mother by 39%,
717 whereas the infant whose mother was directive decreased vocalizations directed to her
718 mother by 63%, thus appearing disengaged in interactions with her mother (Gros-Louis,
719 unpublished data). These data suggest that caregiver responses early in the prelinguistic
720 phase influences the development of communicative behavior, including pragmatics, prior to
721 the advent of language.

722

723 **Gating contingent stimulation**

724 Given that feedback in social interactions lies at the heart of learning about both acoustic
725 structure and pragmatics, West, King and colleagues have examined the effects of different
726 social environments, particularly the availability of social partners, on development. It was
727 discovered that wide variation in singing behavior of young male cowbirds was dependent
728 on the social contexts in which they were housed (e.g., Smith et al., 2000; White et al.,
729 2002a; White et al., 2002b). Young males showed very different outcomes in their singing
730 behavior (including song structure, song usage, repertoire size and rate of development) that
731 varied consistently with the age and sex of individuals housed with them. Different

732 environments resulted in different patterns of social associations and singing interactions,
733 which in turn led to different facultative developmental trajectories of young males in their
734 vocal production and communicative competency (vocal usage) as measured by reproductive
735 success. These results led to consideration of a mechanism termed the ‘social gateway’:
736 different social environments offer different opportunities for interactions, thus metering the
737 communicative behaviors that individuals produce and the feedback they receive (West et al.,
738 2003; White et al., 2002a). The existence of a social gateway is consistent with the
739 observations in several songbird species that indicate a relationship between social
740 responsiveness of the environment and vocal and social learning. More specifically, access
741 to and interactions with experienced individuals at specific points in development are key to
742 acquiring communicative competence (Beecher, 1996).

743 We propose that a social gateway provides a useful construct for examining how social
744 interactions between infants and social partners (caregivers, parents, siblings) affect vocal
745 development and vocal usage. We believe that human infants interacting with different social
746 partners in different environments are vulnerable to influences on development, just as we
747 have observed in songbirds. The structure of social interactions serves a ‘gatekeeping’
748 function, modulating the information available to infants through differential attention and
749 feedback. Future studies in our lab aim to document the variability of social contingencies
750 available in interactions with different social partners and how these impact infants’
751 communicative behavior.

752 Research that demonstrates that the social gateway is the critical predictor of pragmatic
753 competence bears on the nature-nurture question that often accompanies research in
754 cowbirds. As brood parasites, the young are never raised by their own species but instead
755 by over 200 different species and subspecies, leaving the question of ultimate outcome
756 open: how do they recognize their own species and what if they mistakenly mate with the
757 wrong species? This circumstance has led many theorists to suppose the hard wiring of
758 directed behaviors such as singing to females or males serves as a genetic safety net. What

759 better species to have innate modules than a brood parasite, as relying on postnatal learning
760 experience to guide development could have disastrous consequences?

761 Cowbirds were thought to be the model species for a closed developmental program
762 (Lehrman, 1971; Mayr, 1974, 1979), but research by West and King has found precisely
763 the opposite: lack of social experience leads to communicative and reproductive
764 incompetence. Even if isolate birds learn songs that are effective in eliciting copulatory
765 postures of females in playback experiments, there is no endogenous connection between
766 form and function. These same birds cannot successfully mate even if their songs elicit
767 copulatory postures. Thus, given that social experience is necessary to develop proper usage
768 of vocalizations, the safety net is external to the individual, rather than existing in innate
769 developmental programs. The social interactions that an individual experiences during
770 development are the safety net that ensures correct pragmatic function of communicative
771 behavior. It is possible that cowbirds, being brood parasites, are unusual in their reliance on
772 social feedback as juveniles in part because they lack early conspecific experience.
773 Unfortunately, to our knowledge there is no evidence available from other avian species that
774 confirms the importance of social feedback in shaping the pragmatics of vocal
775 communication because the research has not been done.

776

777 **Coordinated communicative behaviors**

Fig. 6. Male cowbirds engaged in a countersinging bout. The male performing a wingspread display is the one singing. The recipient directly in front of him then sings a song in return. Songs are exchanged until one of the two males flies away.



778 Thus far, we have been discussing relatively simple communicative behaviors such as the act
779 of singing or babbling. Can we see the role for pragmatics in more complex behaviors? An
780 example of such a behavior is counter singing (CS) in male cowbirds, i.e., exchanges of
781 directed songs by males (Fig. 6). CS highlights another dimension of the journalistic frame
782 of questioning as two males must simultaneously make the same decision about to whom
783 and when and where to sing. This behavior can only be studied when males live in flocks, as
784 it requires at least the cooperation of two males and sometimes more. Adult males differ in
785 how much they CS, varying from very frequently to not at all. The data show an underlying
786 pragmatic dimension that differs as a result of early experience with or without adults
787 (White et al., 2002b).

788 To examine how early interactions shape development, we conducted two studies which
789 revealed that the level of CS can be culturally transmitted, representing an excellent example
790 of a cultural trait that is not genetically controlled, but sustained through learning (White et
791 al., 2007). In the first study, we exposed two groups of juvenile males to adults who had
792 exhibited different levels of male competition via CS in the prior year. In the second study,
793 we gave two new groups of juvenile males either social access to competitive males or only
794 visual and auditory access to them. In addition, the juveniles in the second study were
795 exposed to the competitive males only for a brief period in the fall months when
796 countersinging is not occurring. In both studies, juvenile males developed behaviors that
797 matched that of their adult “models,” but only if they had social access, i.e. housed in the
798 same flock within an aviary. They also exhibited other behavioral differences regarding
799 courtship even though they had no opportunity to witness adult males performing courtship
800 behaviors in either study.

801 The form of social influence on behavior depicted here for pragmatic forms differs from
802 traditional concepts of cultural transmission where a behavior is directly copied. Because
803 juveniles in the second study learned to CS even when they were with adult males not
804 engaging in CS, it is clear that the juveniles were not merely copying an observed behavior.
805 How had the juvenile males come to exhibit behaviors of “models” whom they did not see
806 perform the target behaviors? We propose that the juveniles had learned to sustain their
807 attention span via social interactions. Learning what to attend to, rather than observation of
808 model behavior, shaped future interactions, resulting in the compounded behavior of CS
809 later in development. Adults’ behavior set the early conditions for the group’s pattern of
810 social engagement (see also White et al., 2002a), which put juveniles on a different
811 developmental pathway.

812 This study highlights the importance of considering how learning occurs in a social
813 environment. These data tell us that cultural transmission occurs for pragmatic dimensions
814 and that it happens within a group network where individuals may influence one another in
815 non-obvious ways. The importance of the group dynamic must be emphasized. Males
816 needed physical contact, not just visual and acoustic stimulation, in order to learn adult
817 behaviors. This is suggested from further findings in aviary studies: birds in adjacent
818 aviaries, who can see and hear one another, do not share song types, something that occurs
819 routinely within aviaries and in the wild (White et al., 2007). Males appear to need first-
820 hand experience within interactions, receiving reactions to their own behavior rather than just
821 observing other males’ interactions. Through particular interactions information becomes
822 accessible. In our words, the bioavailability of information is metered by the social gateway.

823 A rough parallel to countersinging in cowbirds is early proto-conversation in caregiver-
824 infant interactions. Infants primarily must learn when to respond in interactions, and later in
825 development they must learn to whom to respond when they start to engage in triadic
826 interactions with multiple social partners or caregivers and objects (Striano & Rochat,
827 1999). Proto-conversations develop in the first 2-3 months of life and involve the exchange

828 of mutual gaze and affect (Bateson, 1975; Trevarthen, 1979). Although proto-conversations
829 often focus on socio-emotional aspects of interaction, such as affect attunement (e.g., Stern,
830 2000; Stern et al., 1985), a key component important to our discussion here is the
831 coordinated timing of infants and social partners. The rhythm of vocal exchanges is a key
832 predictor of attachment and cognitive development in the first year (Jaffe et al., 2001) and,
833 we propose, turn-taking within interactions forms the initial pragmatic basis of
834 communication.

835 As with CS interactions in cowbirds, infants do not learn by observation, but by being
836 an active social partner. It is the structural aspect of early interactions, not their content per
837 se, that contributes to infant learning by modulating infants' attention (Menyuk et al., 1995;
838 Papousek, 2007). In particular, early games and social routines contribute to learning about
839 the *pragmatics* of conversational exchange, because infants learn turn-taking and turn-
840 giving in social interactions (Bruner, 1979; Mayer & Tronick, 1985; Ratner & Bruner,
841 1978; Snow, 1984; Watson, 1972). Studies that show that infants become sensitive to the
842 timing of social responses within games such as peekaboo at about 4 months of age
843 (Rochat et al., 1999) indicate that infants are learning about the temporal patterning of social
844 exchanges (see also Ninio & Bruner, 1978). 'Communicating about communicating' in
845 these early interactions (Bateson, 1956) thus provides information about the structuring of
846 social exchanges, a first step in learning about the effectiveness of communicative behaviors.

847 It is after infants learn to sustain attention in interactions that specific feedback between
848 caregivers and infants gives infants feedback about the effectiveness of their own behaviors.
849 'Shared meaning' develops in caregiver-infant dyads, which contributes to learning the
850 significance of particular behaviors (Halliday, 1975; Newson, 1979). Differentiated
851 responses to variable behaviors across contexts can provide the infant with information
852 about the communicative function of behaviors in social interactions (e.g., Gros-Louis et al.,
853 in prep.-a). Communication thus shifts from "communication by action to communication
854 by symbol" (Camaioni, 1993, p. 161). What is needed is a study that investigates the

855 contributions to this shift during development. Therefore, in addition to the many studies
856 that investigate the temporal coordination and sequencing of behaviors in infant-caregiver
857 exchanges (e.g., Hsu et al., 2001; Stevenson et al., 1992; Yale et al., 2003), studies must
858 explore the development of pragmatic significance of conversational exchanges (e.g., Dore,
859 1979).

860

861 **Pragmatics and evolutionary implications**

862 In our laboratory we have looked at evolutionary consequences by studying
863 reproductive outcomes of different developmental trajectories and associated social skills.
864 Parentage analysis of 1071 eggs from ten flocks (32 males and 57 females) documented
865 longitudinal reproductive histories over a 4-year period as birds experienced different social
866 contexts (unfamiliar males and females). We were surprised to discover that dominant
867 males who are characterized by aggressive behavior (e.g., displacements, fights, etc.) sired
868 only 1/4 as many eggs as the most successful males. The dominant males typically sing the
869 most potent songs, a finding we have replicated numerous times. This leaves social
870 pragmatics in the form of song use to distinguish individuals. Thus, traditional measures of
871 song quality or status are misleading in understanding reproductive success because they
872 leave out many pragmatic dimensions. The most successful males may be more attentive to
873 their potential mates or rivals and know they must integrate their behavior, not dominate
874 another's behavior.

875 An example of a critical constructor of successful reproductive behavior is the behavior
876 of staying or leaving when approached by another individual male. Juvenile males tend to
877 leave when adults sing to them whereas adults tend to stay. The juveniles must learn not to
878 leave so that social negotiations such as CS can develop, which is correlated with increased
879 levels of reproductive success (Gros-Louis et al., 2006b; King et al., 2003; West et al.,
880 2002). Juveniles learn the pragmatic aspect of staying versus leaving through interactions
881 with experienced males. For example, in White et al. (2007), direct social experience with

882 competitive adults led juveniles to interact socially more often. Under these conditions,
883 juveniles experienced different learning environments where different types of information
884 were available and different contingencies connected their behaviors. For example, early in
885 the fall when housed with adult males, these juveniles sang to adult males who, in turn,
886 rarely left in response to the juveniles' songs. As a result, the first significant difference
887 between the two groups of juveniles after adult males were removed from physical or visual
888 and acoustic proximity was in the behavior of leaving to song. Juveniles who had been
889 housed with adult males, and thus had experienced direct contact with adults, learned to
890 respond to song by staying, whereas juveniles who could only observe adults in another
891 aviary, seemed by default to leave to a song directed to them and thus rarely experienced the
892 consequences of singing. In effect, these observer juveniles constructed a condition of self-
893 imposed social isolation. They rarely engaged in male social interactions, rarely showed the
894 development of CS with other males, and in turn developed higher potency song, which is a
895 characteristic of males developing in experimentally imposed male social isolation (West &
896 King, 1980).

897 Until we discovered the role of pragmatics we were led to conclude, as many researchers
898 do, that males with high potency songs, as tested by playback, would be the most successful
899 in an aviary setting. Although females are attracted to potent song, only some males can
900 withstand the social pressure that comes with singing such songs, in particular, aggression
901 from other males. Thus, they must learn that what they sing depends on to whom they direct
902 their song and that the conditions for potent song may be rare, whereas the conditions for
903 moderate song sung repeatedly to males and females may take them farther. The story about
904 playback song potency is an example of a de-pragmatized narrative. The result is a good
905 story but an inaccurate one. We initially assumed that playback potency always correlated
906 with copulatory success but we were using the female's copulatory posture as a proxy for
907 copulation, an assumption we do not now make. One of the biggest lessons is that males
908 with good songs as judged by playback may not use their song in an effective manner.

909 Males have to learn song content but this learning is inadequate without understanding the
910 social conditions in which to sing it.

911 Similar to our identification of cultural transmission in cowbirds that differs from the
912 traditional view, Tomasello (2001) has indicated a similar process in language development
913 in infants that he terms cultural learning (see also Trevarthen, 1988). Though he focuses on
914 learning within an individual, he points out implications for evolutionary origins of
915 communicative behavior. The parallel with the mechanism that we identified in the
916 development of countersinging behavior is that children do not learn by directly emulating
917 behaviors of caregivers or attending to specific associations that are made clear to them by
918 their caregivers; rather, they learn through ongoing interactions with their caregivers. For
919 example, most of the words learned by children do not come from direct attentional focus
920 and labeling by a caregiver. In fact, this could only work for concrete nouns and some
921 action verbs. Therefore, it is through social conventions and being a participant in an
922 interaction that infants can learn the meaning of words by attending to nonverbal and
923 paralinguistic cues (Tomasello & Barton, 1994; Tomasello et al., 1996). And, most
924 importantly, similar to what we have concluded from our research on cowbirds, children
925 inherit ontogenetic niches that bring with them patterns of interactions and contexts of
926 learning that ensure cultural transmission.

927

928 **Conclusion**

929 Our research with both human infants and songbirds provides us with a comparative
930 framework from which to examine communicative development. Songbirds provide a good
931 parallel to infants because of similar developmental stages, and social and neural influences
932 (Doupe & Kuhl, 1999; Kuhl, 2003). Until recently, the conspicuous period of production
933 termed ‘babbling’ in both systems had been considered to be motor practice for the goal of
934 stereotyped song repertoires or speech with limited or no social/communicative function
935 (Bloom, 1993; but see Locke, 2001 where a “relational function of babbling is proposed;

936 Oller, 2000). However, our experience with vocal development in birds and infants
937 demonstrate a strong social interactive component of early vocal interactions that influences
938 communicative development (Goldstein et al., 2003; King & West, 1988).

939 Both animal studies and human communicative pathologies indicate that different
940 mappings between vocal and pragmatic development can occur (Locke, 1993). Vocal
941 learning (of birdsong or referential language) can progress without correct usage of vocal
942 forms in social interactions. The emergence of directed attention while producing
943 vocalizations provides a platform for pragmatic learning in both human and avian
944 communicative development (Miller et al., 2006). We believe that the emphasis on the innate
945 basis of vocal development, and the focus on the role of copying signals, has obscured the
946 importance of pragmatic development. For example, although most of the focus in bird song
947 learning is on imitation, improvisation is also a documented route, and one used by
948 cowbirds. Improvisation occurs not only with song content, but song use. Thus, in the
949 studies of CS, the young birds exposed to adults in the fall could not copy appropriate adult
950 courtship behavior because they never saw it. But those with social contact ended up
951 pragmatically competent because their social development created a pathway toward
952 knowing how to respond to song, i.e., by staying and responding to social partners.

953 In both birds and babies, the use of copied versus improvised vocalizations coupled with
954 directedness creates different learning opportunities. Specifically the use of directed
955 improvised vocalizations may accelerate learning the relationship between vocal structure
956 and its function because it provides varied contingent feedback to a range of vocalizations.
957 Preliminary data support this view in cowbirds: in two flocks where we have followed
958 juvenile males that were high or low improvisers, the high improvisers sang more directed
959 song to males and females during the fall than the low improvisers and six months later
960 were more successful courting females during their first breeding season (Miller,
961 unpublished data). Thus, to return to the theme of the journalistic practice or reporting
962 “who,” followed by “what,” “when,” and “where,” progressing to “why” and ending

963 with “how”, we propose that vocal improvisation may represent an important engine of
964 pragmatic learning which informs about these issues. Because vocal development in non-
965 mimicking birds is rooted in copying (Beecher, 1996; Nordby et al., in press), improvisation
966 is often treated as copying errors and thus obscures the possibility of programmatic
967 adaptive learning.

968 With respect to human vocal development, contrary to early views that imitation is the
969 primary mechanism of development, it is through contingent stimulation in interactions that
970 communicative behavior develops. Starting in the 1970’s researchers began to recognize the
971 potential extent of the relationship between vocalizations used in social exchanges and the
972 development of language (e.g., Bates et al., 1979; Bruner, 1977). It is the basic functional
973 understanding of early prelinguistic communicative behaviors that is thought to provide the
974 socio-cognitive structures necessary for the development of language. An important point in
975 prelinguistic infants and nonlinguistic species is that it is through the responses of social
976 partners that behaviors are shaped and acquire functionality (Dore, 1979; Halliday, 1975).
977 There need not be intentionality on the part of a young organism to communicate but,
978 through interactions, functional communication emerges (Cheney & Seyfarth, 1996; Smith,
979 1977; Sugarman, 1984). For example, as noted previously, infants will begin to disengage
980 their gaze and look around the room at about 4 months of age. Caregivers view this as
981 intentional or communicative and respond accordingly, providing feedback to the infant
982 about the function of gazing (cf Siegel, 1999). Thus, throughout development, infants’
983 production of novel vocalizations or actions provides new opportunities for caregivers to
984 respond and to respond differentially, thus potentially providing potent feedback about the
985 effectiveness of infants’ behaviors (Papousek, 1992; Snow, 1984).

986 The overarching purpose of our comparative research program is to discover principles
987 of development through the investigation of the ontogeny of experience. We define the
988 ontogeny of experience as the process by which an organism progressively creates and
989 selects stimulation from a rich ecology. We believe that by maximizing the extent to which

990 the organism can select information from its ecology, the opportunity to uncover common
991 denominators of developmental systems becomes apparent. For example, understanding the
992 role for attentional development to filter stimulation will be predictive of both social and
993 cognitive outcomes across taxa. Our studies of the cowbird demonstrate the limitations of a
994 reliance on innate modules to predict functional outcomes and suggest the even supposedly
995 “closed” developmental systems are inherently sensitive to developmental ecology. The
996 avian work has been predictive of our human prelinguistic work, as similar processes appear
997 to be functioning. Thus, the evidence suggests that developmental explanations of
998 communicative behavior will rely on an understanding of the recurring opportunities for
999 social experience, and the role of contingency-based learning within interactions, to
1000 understand the role of the developmental ecology to shape functional outcomes.

1001

1001

References

1002

- 1003 Ables, E., West, M. J., & King, A. P. (in prep.). Sensitivity of adult responses
1004 affects infant attention.
- 1005 Ainsworth, M. D. S., Bell, S. M., & Stayton, D. J. (1974). Infant-mother attachment
1006 and social development: "socialization" as a product of reciprocal
1007 responsiveness to signals. In M. P. M. Richards (Ed.), *The intergration of a*
1008 *child into a social world* (pp. 99-135). Cambridge: Cambridge University
1009 Press.
- 1010 Ainsworth, M. D. S., Blehar, M., Waters, E., & Wall, S. (1978). *Patterns of*
1011 *Attachment*. Hillsdale, NJ: Erlbaum.
- 1012 Akhtar, N., & Tomasello, M. (2000). The social nature of words and word
1013 learning. In R. M. Golinkoff, K. Hirsh-Pasek, L. Bloom, L. B. Smith, A.
1014 Woodward, N. Akhtar, M. Tomasello & G. Hollich (Eds.), *Becoming a word*
1015 *learner: A debate on lexical acquisition* (pp. 115-135). New York: Oxford
1016 University Press.
- 1017 Bakeman, R., & Adamson, L. (1984). Coordinating attention to people and objects
1018 in mother-infant and peer-infant interactions. *Child Development*, 55, 1278-
1019 1289.
- 1020 Baldwin, D. A., Markman, E. M., Bill, B., Desjardins, R. N., Irwin, J. M., &
1021 Tidball, G. (1996). Infants' reliance on a social criterion for establishing
1022 word-object relations. *Child Development*, 67, 3135-3153.
- 1023 Baldwin, D. A., & Tomasello, M. (1998). Word learning: a window on early
1024 pragmatic understanding. In E. V. Clark (Ed.), *The Proceedings of the*
1025 *Twenty-ninth Annual Child Language Research Forum* (pp. 3-23).
1026 Stanford: Center for the Study of Language and Information.
- 1027 Baptista, L. F., & Petrinovich, L. (1984). Social interaction, sensitive periods, and
1028 the song template hypothesis in the white-crowned sparrow. *Animal*
1029 *Behaviour*, 36, 1752-1764.
- 1030 Baron-Cohen, S. (1989). Perceptual role taking and protodeclarative pointing in
1031 autism. *British Journal of Developmental Psychology*, 7, 113-127.
- 1032 Barratt, M. S., Roach, M. A., & Leavitt, L. A. (1992). Early channels of mother-
1033 infant communication: preterm and term infants. *Journal of Child*
1034 *Psychology and Psychiatry*, 33, 1193-1204.
- 1035 Bates, E. (1976). *Language and Context: The Acquisition of Pragmatics*. New
1036 York: Academic Press.
- 1037 Bates, E., Benigni, L., Bretherton, I., Camaioni, L., & Volterra, V. (1979). The
1038 emergence of symbols: cognition and communication in infancy. New York:
1039 Academic Press.
- 1040 Bates, E., Camaioni, L., & Volterra, V. (1975). The acquisition of performatives
1041 prior to speech. *Merrill-Palmer Quarterly*, 21, 205-226.
- 1042 Bateson, G. (1956). The message: 'This is play'. In B. Schaffner (Ed.), *Group*
1043 *Processes: Transactions of the Second Conference* (pp. 145-242). New York:
1044 Josiah Macy Foundation.
- 1045 Bateson, G. (1975). Mother-infant exchanges: the epigenesis of conversational
1046 interaction. In D. Aaronson & R. W. Rieber (Eds.), *Developmental*
1047 *Psycholinguistics and Communicative Disorders* (Vol. 263, pp. 101-113).
1048 New York: New York Academy of Sciences.
- 1049 Baumwell, L., Tamis-LeMonda, C. S., & Bornstein, M. H. (1997). Maternal verbal
1050 sensitivity and child language comprehension. *Infant Behavior and*
1051 *Development*, 20, 247-258.

- 1052 Beaumont, S. L., & Bloom, K. (1993). Adults' attributions of intentionality to
 1053 vocalizing infants. *First Language*, 13, 235-247.
- 1054 Beecher, M. D. (1996). Birdsong learning in the laboratory and field. In D. E.
 1055 Kroodsma & E. H. Miller (Eds.), *Ecology and evolution of acoustic*
 1056 *communication in birds* (pp. 61-78). Ithaca, NY: Cornell University Press.
- 1057 Beecher, M. D., & Brenowitz, E. A. (2005). Functional aspects of song learning in
 1058 songbirds. *Trends in Ecology and Evolution*, 20, 143-149.
- 1059 Beecher, M. D., & Burt, J. M. (2004). The role of social interaction in bird song
 1060 learning. *Current Directions in Psychological Science*, 13, 224-228.
- 1061 Beecher, M. D., Burt, J. M., O'Loughlen, A. L., Templeton, C. N., & Campbell, S. E.
 1062 (in press). Bird song learning in an eavesdropping context. *Animal*
 1063 *Behaviour*.
- 1064 Beecher, M. D., Campbell, S. E., Burt, J. M., Hill, C. E., & Nordby, J. C. (2000).
 1065 Song-type matching between neighbouring song sparrows. *Animal*
 1066 *Behaviour*, 59, 21-27.
- 1067 Bigelow, A. E. (1999). Infants' sensitivity to imperfect contingency in social
 1068 interaction. In P. Rochat (Ed.), *Early Social Cognition* (pp. 137-154).
 1069 Hillsdale, NJ: Erlbaum.
- 1070 Bigelow, A. E., & Birch, S. A. J. (1999). The effects of contingency in previous
 1071 interactions on infants' preference for social partners. *Infant Behavior and*
 1072 *Development*, 22(3), 367-382.
- 1073 Bigelow, A. E., & DeCoste, C. (2003). Sensitivity to social contingency from
 1074 mothers and strangers in 2-, 4-, and 6-month-old infants. *Infancy*, 4(1), 111-
 1075 140.
- 1076 Bloom, K., D'Odorico, L., & Beaumont, S. (1993). Adult preferences for syllabic
 1077 vocalizations: Generalizations to parity and native language. *Infant*
 1078 *Behavior and Development*, 16, 109-120.
- 1079 Bloom, L. (1993). *The Transition from Infancy to Language: Acquiring the Power*
 1080 *of Expression*. Cambridge, England: Cambridge University Press.
- 1081 Bornstein, M. H., Tamis-LeMonda, C. S., Tal, J., Ludemann, P., Toda, S., Rahn, C.
 1082 W., et al. (1992). Maternal responsiveness to infants in three societies: The
 1083 United States, France, and Japan. *Child Development*, 63, 808-821.
- 1084 Brenowitz, E. A. (2004). Plasticity of the adult avian sound control system. *Annals*
 1085 *of the New York Academy of Science*, 1016, 560-585.
- 1086 Bruner, J. (1977). Early social interaction and language acquisition. In H. R.
 1087 Schaffer (Ed.), *Studies in Mother-Infant Interaction* (pp. 271-289). London:
 1088 Academic Press.
- 1089 Bruner, J. (1978). Berlyne Memorial Lecture Acquiring the Uses of Language.
 1090 *Canadian Journal of Psychology*, 32(4), 204-218.
- 1091 Bruner, J. (1979). The organization of action and the nature of the adult-infant
 1092 transaction. In E. Tronick (Ed.), *Social interchange in infancy* (pp. 23-35).
 1093 Baltimore: University Park Press.
- 1094 Bruner, J. (1983). *Child's talk: Learning to use language*. New York: Norton.
- 1095 Bruner, J. S. (1975). From communication to language: a psychological
 1096 perspective. *Cognition*, 3, 255-287.
- 1097 Camaioni, L. (1993). The development of intentional communication: A re-
 1098 analysis. In *New Perspectives in Early Communicative Development* (pp.
 1099 82-96). London: Routledge.
- 1100 Camarata, S. M., & Gibson, T. (1999). Pragmatic language deficits in attention-
 1101 deficit hyperactivity disorder (ADHD). *Mental Retardation and*
 1102 *Developmental Disabilities Research Reviews*, 5(3), 207-214.
- 1103 Carpenter, M., Pennington, B. F., & Rogers, S. J. (2002). Interrelations among
 1104 social-cognitive skills in young children with autism. *Journal of Autism*
 1105 *and Developmental Disorders*, 32(2), 91-106.

- 1106 Carpenter, R. L., Mastergeorge, A. M., & Coggins, T. E. (1983). The acquisition of
1107 communicative intentions in infants eight to fifteen months of age.
1108 *Language and Speech*, 26(2), 101-116.
- 1109 Cheney, D. L., & Seyfarth, R. M. (1996). Function and intention in the calls of
1110 non-human primates. *Proceedings of the British Academy of Sciences*, 88,
1111 59-76.
- 1112 Chomsky, N. (1965). *Syntactic Structures*. The Hague: Mouton.
- 1113 Cohn, J. F., Matias, R., Tronick, E. Z., Connell, D., & Lyons-Ruth, K. (1986). Face-
1114 to-face interactions of depressed mothers and their infants. In E. Z. Tronick
1115 & T. Field (Eds.), *Maternal depression and infant disturbance* (Vol. 24).
1116 San Francisco: Jossey-Bass.
- 1117 Coleman, S. W., Patricelli, G. L., & Borgia, G. (2004). Variable female preferences
1118 drive complex male displays. *Nature*, 428, 742-745.
- 1119 Collis, G. (1979). Describing the structure of social interaction in infancy. In M.
1120 Bullowa (Ed.), *Before speech: the beginning of interpersonal*
1121 *communication* (pp. 111-130). Cambridge, UK: Cambridge University
1122 Press.
- 1123 D'Odorico, L., & Cassibba, R. (1995). Cross-sectional study of coordination
1124 between infants' gaze and vocalization towards their mothers. *Early*
1125 *Development & Parenting*, 4, 11-19.
- 1126 Dabelsteen, T., & McGregor, P. K. (1996). Dynamic acoustic communication and
1127 interactive playback. In D. E. Kroodsma & E. H. Miller (Eds.), *Ecology and*
1128 *Evolution of Acoustic Communication in Birds* (pp. 398-408). Ithaca, N. Y.:
1129 Cornell University Press.
- 1130 Dawson, G., & Ashman, S. B. (2000). On the origins of a vulnerability to
1131 depression: the influence of the early social environment on the
1132 development of psychological systems related to the risk of affective
1133 disorder. In C. A. Nelson (Ed.), *The effects of early adversity on*
1134 *neurobehavioral development* (Vol. 31, pp. 245-279). Mahwah, N. J.:
1135 Lawrence Erlbaum Associates.
- 1136 de Boysson-Bardies, B., & Vihman, M. M. (1991). Adaptation to language:
1137 Evidence from babbling and first words in four languages. *Language*,
1138 67(2), 297-319.
- 1139 Dore, J. (1974). A pragmatic description of early language development. *Journal of*
1140 *psycholinguistic research*, 3(4), 343-350.
- 1141 Dore, J. (1979). Conversational acts and the acquisition of language. In E. Ochs &
1142 B. B. Schieffelin (Eds.), *Developmental Pragmatics* (pp. 359-361). New
1143 York: Academic Press, Inc.
- 1144 Dore, J. (1986). The development of conversational competence. In R. L.
1145 Schiefelbusch (Ed.), *Language Competence: Assessment and Intervention*
1146 (pp. 3-60). San Diego: College-Hill Press, Inc.
- 1147 Dore, M. (1983). Feeling, form and intention in the baby's transition to language.
1148 In R. M. Golinkoff (Ed.), *The Transition for Prelinguistic to Linguistic*
1149 *Communication* (pp. 167-190). Hillsdale, NJ: Lawrence Erlbaum
1150 Associates.
- 1151 Doupe, A. J., & Kuhl, P. K. (1999). Birdsong and human speech: Common themes
1152 and mechanisms. *Annual Review of Neuroscience*, 22, 5567-5631.
- 1153 Dunham, P. J., Dunham, F., & Curwin, A. (1993). Joint-attentional states and
1154 lexical acquisition at 18 months. *Developmental Psychology*, 29, 827-831.
- 1155 Dusenbery, D. B. (1992). *Sensory ecology: How organisms acquire and respond to*
1156 *information*. New York: W. H. Freeman.
- 1157 Field, T. (1998). Maternal depression effects on infants and early interventions.
1158 *Preventive Medicine*, 27, 200-203.

- 1159 Field, T., Healy, B., Goldstein, S., Perry, S., Bendell, D., Schanberg, S., et al. (1988).
 1160 Infants of depressed mothers show "depressed" behavior even with
 1161 nondepressed adults. *Child Development*, 59, 1569-1579.
- 1162 Freeberg, T. M., King, A. P., & West, M. J. (1995). Social malleability in cowbirds
 1163 (*Molothrus ater artemisiae*): Species and mate recognition in the first 2
 1164 years of life. *Journal of Comparative Psychology*, 109, 357-367.
- 1165 Freeberg, T. M., West, M. J., King, A. P., Duncan, S. D., & Sengelaub, D. R. (2002).
 1166 Cultures, genes, and neurons in the development of song and singing in
 1167 brown-headed cowbirds (*Molothrus ater*). *Journal of Comparative*
 1168 *Physiology A*, 188, 993-1002.
- 1169 Freed-Brown, S. G., King, A. P., Miller, J. L., & West, M. J. (2006). Uncovering
 1170 sources of variation in female sociality: Implications for the development of
 1171 social preferences in female cowbirds (*Molothrus ater*) *Behaviour*, 143,
 1172 1293-1315.
- 1173 Gergely, G., & Watson, J. (1999). Early socio-emotional development: contingency
 1174 perception and the social-biofeedback model. In P. Rochat (Ed.), *Early*
 1175 *social cognition: understanding others in the first months of life* (pp. 101-
 1176 136). Mahwah, N. J.: Lawrence Erlbaum Associates, Inc.
- 1177 Gibb Harding, C. (1983). Setting the stage for language acquisition:
 1178 Communication development in the first year. In R. M. Golinkoff (Ed.),
 1179 *The Transition for Prelinguistic to Linguistic Communication* (pp. 93-113).
 1180 Hillsdale, N. J.: Lawrence Erlbaum Associates.
- 1181 Gibson, J. J. (1966). *The senses considered as perceptual systems*. Boston:
 1182 Houghton-Mifflin.
- 1183 Goldstein, M. H., King, A. P., & West, M. J. (2003). Social interaction shapes
 1184 babbling: Testing parallels between birdsong and speech. *Proceedings of*
 1185 *the National Academy of Science*, 100, 8030-8035.
- 1186 Goldstein, M. H., & Schwade, J. A. (under review). Social feedback to infants'
 1187 babbling facilitates rapid phonological learning. *Psychological Science*.
- 1188 Golinkoff, R. M., & Gordon, L. (1983). In the beginning there was word: a history
 1189 of the study of language acquisition. In R. M. Golinkoff (Ed.), *The*
 1190 *transition from prelinguistic to linguistic communication*. Hillsdale, N. J.:
 1191 Lawrence Erlbaum Associates, Inc.
- 1192 Gottesman, I. I. (1963). Genetic aspects of intelligent behavior. In N. Ellis (Ed.),
 1193 *The handbook of mental deficiency* (pp. 253-296). New York: McGraw-Hill.
- 1194 Gottlieb, G. (1976). Roles of early experience in the development of behavior and
 1195 the nervous system. In G. Gottlieb (Ed.), *Studies in the Development of*
 1196 *Behavior and the Nervous System* (pp. 25-54). New York: Academic Press.
- 1197 Gros-Louis, J. (2006). The role of prelinguistic vocalizations in vocal and social
 1198 development. Paper presented at the International Conference on
 1199 Development and Learning.
- 1200 Gros-Louis, J., & Ables, E. (2006). Contextual influences on caregiver
 1201 responsiveness. Paper presented at the International Society of
 1202 Developmental Psychobiology.
- 1203 Gros-Louis, J., Ables, E., King, A. P., & West, M. J. (in prep.-a). Consistency and
 1204 differentiation of caregiver responses across contexts.
- 1205 Gros-Louis, J., West, M. J., Goldstein, M. H., & King, A. P. (2006a). Mothers
 1206 provide differential feedback to infants' prelinguistic sounds. *International*
 1207 *Journal of Behavioral Development*, 30(6), 509-516.
- 1208 Gros-Louis, J., West, M. J., & King, A. P. (in prep.-b). Caregiver responses
 1209 influence the development of communicative behaviors.
- 1210 Gros-Louis, J., White, D. J., King, A. P., & West, M. J. (2006b). Do juvenile males
 1211 affect adult males' reproductive success in brown-headed cowbirds
 1212 (*Molothrus ater*)? *Behaviour*, 143, 219-237.

- 1213 Hailman, J. P. (1977). *Optical signals: Animal communication and light*.
 1214 Bloomington: Indiana University Press.
- 1215 Halliday, M. (1979). One child's protolanguage. In M. Bullowa (Ed.), *Before*
 1216 *speech: the beginning of interpersonal communication* (pp. 149-170).
 1217 Cambridge, UK: Cambridge University Press.
- 1218 Halliday, M. A. K. (1975). *Learning how to mean: explorations into the*
 1219 *development of language*. London: Edward Arnold.
- 1220 Hamilton, K. S., King, A. P., Sengelaub, D. R., & West, M. J. (1998). Visual and
 1221 song nuclei correlated with courtship skills in brown-headed cowbirds.
 1222 *Animal Behaviour*, 56, 973-982.
- 1223 Hauser, M. D. (1996). *The Evolution of Communication*. Cambridge, MA: MIT
 1224 Press.
- 1225 Hsu, H. C., Fogel, A., & Messinger, D. S. (2001). Infant non-distress vocalization
 1226 during mother-infant face-to-face interaction: factors associated with
 1227 quantitative and qualitative differences. *Infant Behavior and Development*,
 1228 24, 107-128.
- 1229 Jaffe, J., Beebe, B., Feldstein, S., Crown, C. L., & Jasnow, M. (2001). *Rhythms of*
 1230 *Dialogue in Infancy: Coordinated Timing in Development*. Boston,
 1231 Massachusetts: Blackwell Publishers.
- 1232 Jarvis, E. D., Scharff, C., Grossman, M., Ramos, J. A., & Nottebohm, F. (1998). For
 1233 whom the bird sings: context-dependent gene expression. *Neuron*, 21, 775-
 1234 788.
- 1235 Jennions, M. D., & Petrie, M. (1997). Variation in mate choice and mating
 1236 preferences: A review of causes and consequences. *The American Naturalist*,
 1237 72, 283-327.
- 1238 Johnson-Laird, P. N. (1990). Introduction: What is communication? In D. H.
 1239 Mellor (Ed.), *Ways of communicating* (pp. 1-13). Cambridge, U.K.:
 1240 Cambridge University Press.
- 1241 Jones, N. A., Field, T., Fox, N. A., Davalos, M., Malphurs, J., Carraway, K., et al.
 1242 (1997). Infants of intrusive and withdrawn mothers. *Infant Behavior and*
 1243 *Development*, 20, 175-186.
- 1244 Jones, S. E., & Zimmerman, D. H. (2003). A child's point and the achievement of
 1245 intentionality. *Gesture*, 3(2), 155-185.
- 1246 Kaplan, P. S., Bachorowski, J.-A., Smoski, M. J., & Hudenko, W. J. (2002). Infants
 1247 of depressed mothers, although competent learners, fail to learn in response
 1248 to their own mothers' infant-directed speech. *Psychological Science*, 13(3),
 1249 268-271.
- 1250 Kasher, S., & Meilijson, A. (1996). Autism and pragmatics of language. *Incontri*
 1251 *Cita Aperta*, 4/5, 37-54.
- 1252 Keller, H., & Scholmerich, A. (1987). Infant vocalizations and parental reactions
 1253 during the first four months of life. *Developmental Psychology*, 23, 62-67.
- 1254 Kemler Nelson, D. G., Hirsh-Pasek, K., Jusczyk, P. W., & Cassidy, K. W. (1989).
 1255 How the prosodic cues in motherese might assist language learning. *Journal*
 1256 *of Child Language*, 16, 55-68.
- 1257 Kent, R. D., & Miolo, G. (1995). Phonetic abilities in the first year of life. In P.
 1258 Fletcher & B. MacWhinney (Eds.), *The Handbook of Child Language* (pp.
 1259 303-334). Cambridge: Blackwell Publishers.
- 1260 Kimura, D. (1993). *Neuromotor mechanisms in human communication*. Oxford, U.
 1261 K.: Oxford University Press.
- 1262 King, A. P., & West, M. J. (1983). Epigenesis of cowbird song: A joint endeavor of
 1263 males and females. *Nature*, 305, 704-706.
- 1264 King, A. P., & West, M. J. (1988). Searching for the functional origins of cowbird
 1265 song in eastern brown-headed cowbirds (*Molothrus ater ater*). *Animal*
 1266 *Behaviour*, 36, 1575-1588.

- 1267 King, A. P., & West, M. J. (1989). Presence of female cowbirds (*Molothrus ater*
1268 *ater*) affects vocal improvisation in males. *Journal of Comparative*
1269 *Psychology*, 103, 39-44.
- 1270 King, A. P., & West, M. J. (2002). Ontogeny of competence. In D. J. Lewkowicz &
1271 R. Lickliter (Eds.), *Conceptions of development* (pp. 77-104). New York:
1272 Psychology Press.
- 1273 King, A. P., West, M. J., & Goldstein, M. (2005). Nonvocal shaping of avian song
1274 development: Parallels to human speech development. *Ethology*(111), 101-
1275 117.
- 1276 King, A. P., White, D. J., & West, M. J. (2003). Female proximity stimulates
1277 development of male competition in juvenile brown-headed cowbirds,
1278 *Molothrus ater*. *Animal Behaviour*, 66, 817-828.
- 1279 Konishi, M. (1965). The role of auditory feedback in the control of vocalization in
1280 the white-crowned sparrow. *Zeitschrift fur Tierpsychologie*, 22, 770-783.
- 1281 Krebs, J. R., & Davies, N. B. (1993). *Introduction to behavioural ecology*. Oxford,
1282 U. K.: Blackwell Scientific.
- 1283 Kroodsmas, D. E. (1996). Ecology of passerine song development. In D. E.
1284 Kroodsmas & E. H. Miller (Eds.), *Ecology and evolution of acoustic*
1285 *communication in birds* (pp. 3-19). Ithaca, NY: Cornell University Press.
- 1286 Kroodsmas, D. E. (2004). The diversity and plasticity of birdsong. In P. Marler &
1287 H. Slabbekoorn (Eds.), *Nature's Music: The Science of Birdsong* (pp. 108-
1288 131). San Diego: Elsevier Academic Press.
- 1289 Kroodsmas, D. E., & Pickert, R. (1984). Sensitive phases for song learning: effects
1290 of social interaction and individual variation. *Animal Behaviour*, 32, 389-
1291 394.
- 1292 Kuhl, P. (2003). Human speech and birdsong: Communication and the social
1293 brain. *Proceedings of the National Academy of Sciences*, 100(17), 9645-9646.
- 1294 Kuo, Z. Y. (1967). *The dynamics of behavioral development: An epigenetic view*.
1295 New York: Random House.
- 1296 Lawrence, B. (1986). *Parent's perceptions of communication with prelinguistic*
1297 *children*. Unpublished PhD Dissertation, University of North Carolina,
1298 Chapel Hill, NC.
- 1299 Laws, G., & Bishop, D. V. M. (2004). Verbal deficits in Down's syndrome and
1300 specific language impairment: a comparison. *International Journal of*
1301 *Language & Communication Disorders*, 39(4), 423-451.
- 1302 Lehrman, D. S. (1971). Conceptual and semantic issues in the nature-nurture
1303 problem. In L. R. Aronson, E. Tobach, D. S. Lehrman & J. S. Rosenblatt
1304 (Eds.), *Development and the evolution of behaviour: Essays in the memory*
1305 *of T. C. Schneirla* (pp. 17-52). San Francisco: W. H. Freeman.
- 1306 Lenneberg, E. (1967). *Biological Foundations of Language*. New York: Wiley.
- 1307 Lickliter, R., & Gottlieb, G. (1985). Social interaction with siblings is necessary
1308 for visual imprinting of species-specific maternal preferences in ducklings.
1309 *Journal of Comparative Psychology*, 99, 371-379.
- 1310 Lindblom, B. (1990). On the communication process: Speaker-listener interaction
1311 and the development of speech. In K. Fraurud & U. Sundberg (Eds.), *AAC*
1312 *augmentative and alternative communication* (pp. 220-230). London:
1313 Williams & Wilkins.
- 1314 Liu, W., Gardner, T. J., & Nottebohm, F. (2004). Juvenile zebra finches can use
1315 multiple strategies to learn the same song. *Proceedings of the National*
1316 *Academy of Sciences*, 101, 18177-18182.
- 1317 Locke, J. L. (1983). *Phonological acquisition and change*. New York: Academic
1318 Press.
- 1319 Locke, J. L. (1993). *The child's path to spoken language*. Cambridge, MA:
1320 Harvard University Press.

- 1321 Locke, J. L. (1996). Why do infants begin to talk? Language as an unintended
1322 consequence. *Journal of Child Language*, 23, 251-268.
- 1323 Locke, J. L. (2001). First communion: the emergence of vocal relationships. *Social*
1324 *Development*, 10(3), 294-308.
- 1325 Lorenz, K. (1965). *Evolution and modification of behavior*. Chicago: University of
1326 Chicago Press.
- 1327 Markus, J., Mundy, P., Morales, M., Delgado, C. E. F., & Yale, M. (2000).
1328 Individual differences in infant skills as predictors of child-caregiver joint
1329 attention and language. *Social Development*, 9(3), 302-315.
- 1330 Marler, P. (1967). Animal Communication Signals. *Science*, 157, 769-774.
- 1331 Marler, P. (1970). Birdsong and speech development: Could there be parallels?
1332 *American Scientist*, 58, 669-673.
- 1333 Marler, P., Mundinger, P., Waser, M. S., & Lutjen, A. (1972). Effects of acoustical
1334 deprivation on song development in redwing blackbirds (*Agelaius*
1335 *phoeniceus*). *Animal Behaviour*, 20, 586-606.
- 1336 Marler, P., & Nelson, D. (1992). Neuroselection and song learning in birds: Species
1337 universals in a culturally transmitted behavior. *Seminars in the*
1338 *Neurosciences*, 4, 415-423.
- 1339 Marler, P., & Nelson, D. A. (1993). Action-based learning: A new form of
1340 developmental plasticity in bird song. *Netherlands Journal of Zoology*,
1341 43(1-2), 91-103.
- 1342 Marler, P., & Peters, S. (1982). Action-based learning-a new form of developmental
1343 plasticity in bird song. *Netherlands Journal of Zoology*, 43, 91-103.
- 1344 Mayer, N. K., & Tronick, E. Z. (1985). Mothers' turn-giving signals and infant
1345 turn-taking in mother-infant interaction. In T. M. Field & N. A. Fox (Eds.),
1346 *Social Perceptions in Infants* (pp. 199-216). Norwood, NJ: Ablex Publishing
1347 Co.
- 1348 Mayr, E. (1974). Behavioral programs and evolutionary strategies. *American*
1349 *Scientist*, 62, 650-659.
- 1350 Mayr, E. (1979). Concepts in the study of animal behavior. In J. S. Rosenblatt & B.
1351 R. Komisaruk (Eds.), *Reproductive Behavior and Evolution* (pp. 1-16).
1352 New York: Plenum press.
- 1353 McGregor, P. K., & Peake, T. M. (2000). Communication networks: social
1354 environments for receiving and signaling behavior. *Acta Ethology*, 2, 71-81.
- 1355 Menyuk, P., Liebergott, J. W., & Schultz, M. C. (1995). Early language
1356 development in full-term and premature infants. Hillsdale, N. J.: Lawrence
1357 Erlbaum.
- 1358 Miller, J. L., Freed-Brown, S. G., White, D. J., King, A. P., & West, M. J. (2006).
1359 Developmental origins of sociality in brown-headed cowbirds (*Molothrus*
1360 *ater*). *Journal of Comparative Psychology*, 120, 229-238.
- 1361 Miller, J. L., King, A. P., & West, M. J. (under review). Vocal improvisation in
1362 brown headed cowbirds (*Molothrus ater*) is sensitive to social ecology and
1363 social companions.
- 1364 Moore, C. L. (1984). Maternal contributions to the development of masculine
1365 sexual behavior in laboratory rats. *Developmental Psychobiology*, 17, 347-
1366 356.
- 1367 Morris, C. W. (1946). *Signs, language, and behavior*. New York: Braziller. Prentice
1368 Hall Reprint (1955).
- 1369 Nelson, D. A., & Marler, P. (1994). Selection-based learning in bird song
1370 development. *Proceedings of the National Academy of Science*, 91, 10498-
1371 10501.
- 1372 Neuringer, A., Dreiss, C., & Olson, G. (2000). Reinforced variability and operant
1373 learning. *Journal of Experimental Psychology: Animal Behavior Processes*,
1374 26, 98-111.

- 1375 Newson, J. (1979). The growth of shared understandings between infant and
 1376 caregiver. In M. Bullowa (Ed.), *Before Speech: The beginning of*
 1377 *interpersonal communication* (pp. 207-222). Cambridge: Cambridge
 1378 University Press.
- 1379 Ninio, A., & Bruner, J. (1978). The achievement and antecedents of labelling.
 1380 *Journal of Child Language*, 5, 1-15.
- 1381 Nordby, J. C., Campbell, S. E., & Beecher, M. D. (in press). Selective attrition and
 1382 individual song repertoire development in song sparrows. *Animal*
 1383 *Behaviour*.
- 1384 Nowicki, S., Searcy, W. A., Hughes, M., & Podos, J. (2001). The evolution of bird
 1385 song: male and female response to song innovation in swamp sparrows.
 1386 *Animal Behaviour*, 62, 1189-1195.
- 1387 Oller, D. K. (2000). *The Emergence of the Speech Capacity*. Mahwah, NJ:
 1388 Lawrence Erlbaum.
- 1389 Oyama, S. (2000). *The Ontogeny of Information: Developmental Systems and*
 1390 *Evolution* (2nd ed.): Duke University Press.
- 1391 Papousek, H., & Bornstein, M. H. (1992). Didactic interactions: Intuitive parental
 1392 support of vocal and verbal development in human infants. In H. Papousek,
 1393 U. Jurgens & M. Papousek (Eds.), *Nonverbal Vocal Communication:*
 1394 *Comparative and Developmental Approaches* (pp. 209-229). New York:
 1395 Cambridge University Press.
- 1396 Papousek, H., & Papousek, M. (1975). Cognitive aspects of preverbal social
 1397 interactions between human infants and adults. In *Parent-Infant Interaction*
 1398 (pp. 241-269). Amsterdam: Associated Scientific Publishers.
- 1399 Papousek, M. (1989). Determinants of responsiveness to infant vocal expression of
 1400 emotional state. *Infant Behavior and Development*, 12, 507-524.
- 1401 Papousek, M. (1992). Early ontogeny of vocal communication in parent-infant
 1402 interactions. In H. Papousek, U. Jurgens & M. Papousek (Eds.), *Nonverbal*
 1403 *Vocal Communication: Comparative and Developmental Approaches* (pp.
 1404 230-261). New York: Cambridge U Press.
- 1405 Papousek, M. (2007). Communication in early infancy: An arena of intersubjective
 1406 learning. *Infant Behavior and Development*, 30, 258-266.
- 1407 Payne, R. B., & Payne, L. L. (1993). Song copying and cultural transmission in
 1408 indigo buntings. *Animal Behaviour*, 46, 1045-1065.
- 1409 Pruden, S. M., Hirsh-Pasek, K., & Golinkoff, R. M. (2006). The social dimension in
 1410 language development: a rich history and a new frontier. In P. J. Marshall
 1411 & N. A. Fox (Eds.), *The Development of Social Engagement:*
 1412 *Neurobiological Perspectives* (pp. 118-152). Oxford: Oxford University
 1413 Press.
- 1414 Purvis, K. L., & Tannock, R. (1997). Language abilities in children with attention
 1415 deficit hyperactivity disorder, reading disabilities, and normal controls.
 1416 *Journal of Abnormal Child Psychology*, 25, 133-144.
- 1417 Ratner, N., & Bruner, J. (1978). Games, social exchange, and the acquisition of
 1418 language. *Journal of Child Language*, 5, 391-402.
- 1419 Reddy, V. (1999). Prelinguistic communication. In M. Barrett (Ed.), *The*
 1420 *Development of Language* (pp. 25-50). Hove, East Sussex: Psychology Press.
- 1421 Rochat, P., Querido, J. G., & Striano, T. (1999). Emerging sensitivity to the timing
 1422 and structure of protoconversation in early infancy. *Developmental*
 1423 *Psychology*, 35, 950-957.
- 1424 Rochat, P., & Striano, T. (1999). Social-cognitive development in the first year. In
 1425 P. Rochat (Ed.), *Early Social Cognition: Understanding Others in the First*
 1426 *Months of Life* (pp. 3-34). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.
- 1427 Rollins, P. R. (2003). Caregivers' contingent comments to 9-month-old infants:
 1428 Relationships with later language. *Applied Psycholinguistics*, 24, 221-234.

- 1429 Sameroff, A. J. (1975). Early influences on development: fact or fancy? *Merrill-*
1430 *Palmer Quarterly*, 21, 267-294.
- 1431 Scarr-Salapatek, S. (1976). Genetic determinants of infant development: an
1432 overstated case. In L. Lipsitt (Ed.), *Developmental psychobiology: The*
1433 *significance of infancy* (pp. 59-79). Hillsdale, N. J.: Erlbaum.
- 1434 Schaffer, H. R., Collis, G. M., & Parsons, G. (1977). Vocal interchange and visual
1435 regard in verbal and pre-verbal children. In H. R. Schaffer (Ed.), *Studies in*
1436 *Mother-Infant Interaction* (pp. 291-324). London: Academic Press.
- 1437 Schieffelin, B. B. (1983). Looking and talking: the functions of gaze direction in
1438 the conversations of a young child and her mother. In E. Ochs & B. B.
1439 Schieffelin (Eds.), *Acquiring Conversational Competence* (pp. 50-65).
1440 Boston: Routledge and Kegan Paul.
- 1441 Searcy, W. A. (1992). Measuring responses of female birds to male song. In P. K.
1442 McGregor (Ed.), *Playback and studies of animal communication* (pp. 175-
1443 189). New York: Plenum Press.
- 1444 Sebeok, T. A. (1962). Coding in the evolution of signaling behavior. *Behavioral*
1445 *Science*, 7, 430-442.
- 1446 Sebeok, T. A. (1965). Animal communication. *Science*, 147, 1006-1014.
- 1447 Siegel, D. J. (1999). *The Developing Mind: Toward a Neurobiology of*
1448 *Interpersonal Experience*. New York: The Guilford Press.
- 1449 Skoyles, J. R. (1998). Child development and autism: a cerebellar prefrontal
1450 model [electronic version]. *Cogprints*, Retrieved May 23 2006.
- 1451 Smith, L. (1998). Predicting communicative competence at 2 and 3 years from
1452 pragmatic skills at 10 months. *International Journal of Language &*
1453 *Communication Disorders*, 33, 127-148.
- 1454 Smith, V. A., King, A. P., & West, M. J. (2000). A role of her own: female
1455 cowbirds, *Molothrus ater*, influence the development and outcome of song
1456 learning. *Animal Behaviour*, 60, 599-609.
- 1457 Smith, W. J. (1977). *The Behavior of Communicating*. Cambridge, MA: Harvard
1458 University Press.
- 1459 Snow, C. E. (1984). Parent-child interaction and the development of
1460 communicative ability. In R. L. Schiefelbusch & J. Pickar (Eds.), *The*
1461 *Acquisition of Communicative Competence* (pp. 69-107). Baltimore:
1462 University Park Press.
- 1463 Stern, D. N. (1974). Mother and infant at play: The dyadic interaction involving
1464 facial, vocal, and gaze behaviors. In M. Lewis & L. A. Rosenblum (Eds.),
1465 *The Effect of the Infant on Its Caregiver* (pp. 187-213). New York: John
1466 Wiley & Sons.
- 1467 Stern, D. N. (2000). *The Interpersonal World of the Infant* (2nd ed.). New York:
1468 Basic Books.
- 1469 Stern, D. N., Hofer, L., Haft, W., & Dore, J. (1985). Affect attunement: the sharing
1470 of feeling states between mother and infant by means of intermodal fluency.
1471 In T. M. Field & N. A. Fox (Eds.), *Social Perception in Infants* (pp. 249-
1472 268). Norwood, N. J.: Ablex Publishing Corporation.
- 1473 Stevenson, M. B., Roach, M. A., & Leavitt, L. A. (1992). Early channels of mother-
1474 infant communication: preterm and term infants. *Journal of Child*
1475 *Psychology and Psychiatry*, 33, 1193-1204.
- 1476 Stoel-Gammon, C., & Otomo, K. (1986). Babbling development of hearing-
1477 impaired and normally hearing subjects. *Journal of Speech and Hearing*
1478 *Disorders*, 51, 33-41.
- 1479 Striano, T., & Rochat, P. (1999). Developmental link between dyadic and triadic
1480 social competence in infancy. *British Journal of Developmental Psychology*,
1481 17, 551-562.

- 1482 Sugarman, S. (1984). The development of preverbal communication: Its
 1483 contribution and limits in promoting the development of language. In R. L.
 1484 Schiefelbusch & J. Pickar (Eds.), *The Acquisition of Communicative*
 1485 *Competence* (pp. 23-67). Baltimore: University Park Press.
- 1486 Surian, L., Baron-Cohen, S., & Van der Lely, H. (1996). Are children with autism
 1487 deaf to Gricean maxims? *Cognitive Neuropsychiatry*, 1, 55-71.
- 1488 Tamis-LeMonda, C. S., Bornstein, M. H., & Baumwell, L. (2001). Maternal
 1489 responsiveness and children's achievement of language milestones. *Child*
 1490 *Development*, 72(3), 748-767.
- 1491 Tanguay, P. E., Robertson, J., & Derrick, A. (1998). A dimensional classification
 1492 of autism spectrum disorder by social communication domains. *Journal of*
 1493 *the American Academy of Child & Adolescent Psychiatry*, 37, 271-277.
- 1494 Thelen, E., Corbetta, D., & Spencer, J. P. (1996). Development of reaching during
 1495 the first year: role of movement speed. *Journal of Experimental Psychology:*
 1496 *Human Perception and Performance*, 22(5), 1059-1076.
- 1497 Thelen, E., & Ulrich, B. D. (1991). Hidden skills: a dynamic systems analysis of
 1498 treadmill stepping during the first year. *Monographs of the Society for*
 1499 *Research in Child Development*, 56(1, Serial No. 223).
- 1500 Tomasello, M. (1997). The pragmatics of word learning. *Cognitive Studies:*
 1501 *Bulletin of Japanese Cognitive Science Society*, 4, 59-74.
- 1502 Tomasello, M. (2001). Cultural transmission: a view from chimpanzees and
 1503 human infants *Journal of cross-cultural psychology*, 32, 135-146.
- 1504 Tomasello, M., & Barton, M. (1994). Learning words in non-ostensive contexts.
 1505 *Developmental Psychology*, 30, 639-650.
- 1506 Tomasello, M., & Farrar, M. J. (1986). Joint attention and early language. *Child*
 1507 *Development*, 57, 1454-1463.
- 1508 Tomasello, M., Strosberg, R., & Akhtar, N. (1996). Eighteen-month old children
 1509 learn words in non-ostensive contexts. 23, *Journal of Child Language*, 157-
 1510 176.
- 1511 Trevarthen, C. (1979). Communication and cooperation in early infancy: A
 1512 description of primary intersubjectivity. In M. Bullowa (Ed.), *Before*
 1513 *Speech: The beginning of interpersonal communication* (pp. 321-347).
 1514 Cambridge: Cambridge University Press.
- 1515 Trevarthen, C. (1988). Universal cooperative motives: How infants begin to know
 1516 language and skills of culture. In G. Jahoda & I. M. Lewis (Eds.),
 1517 *Acquiring culture: Ethnographic perspectives on cognitive development*
 1518 (pp. 37-90). London: Croom Helm.
- 1519 Trevarthen, C., & Hubley, P. (1979). Secondary intersubjectivity: Confidence,
 1520 confiding and acts of meaning in the first year. In A. Lock (Ed.), *Action*
 1521 *gesture and symbol* (pp. 183-229). London: Academic Press.
- 1522 Vihman, M. M., Ferguson, C. A., & Elbert, M. (1986). Phonological development
 1523 from babbling to speech: common tendencies and individual differences.
 1524 *Applied Psycholinguistics*, 7, 3-40.
- 1525 Vygotsky, L. S. (1962). *Thought and Language*. Cambridge, MA: MIT Press.
- 1526 Watson, J. S. (1972). Smiling, cooing and "the game". *Merrill-Palmer Quarterly*,
 1527 18, 323-339.
- 1528 Watson, J. S. (1985). Contingency perception in early social development. In T. M.
 1529 Field & N. A. Fox (Eds.), *Social Perception in Infants* (pp. 157-177).
 1530 Norwood, NJ: Ablex Publishing Corporation.
- 1531 West, M. J., & King, A. P. (1987). Settling nature and nurture into an ontogenetic
 1532 niche. *Developmental Psychobiology*, 20, 549-562.
- 1533 West, M. J., & King, A. P. (1988). Female visual displays affect the development of
 1534 male song in the cowbird. *Nature*, 334, 244-246.

- 1535 West, M. J., & King, A. P. (2001). Science lies its way to the truth...really. In E. M.
1536 Blass (Ed.), *Developmental Psychobiology*, Volume 13. (Vol. 13, pp. 587-
1537 614). New York: Kluwer Academic/Plenum Publishers.
- 1538 West, M. J., King, A. P., & Duff, M. A. (1990). Communicating about
1539 communicating: when innate is not enough. *Developmental Psychobiology*,
1540 23, 585-598.
- 1541 West, M. J., King, A. P., & Freeberg, T. M. (1996). Social malleability in cowbirds:
1542 New measures reveal new evidence of plasticity in the Eastern subspecies
1543 (*Molothrus ater ater*). *Journal of Comparative Psychology*, 110, 15-26.
- 1544 West, M. J., King, A. P., & White, D. J. (2003). The case for developmental ecology.
1545 *Animal Behaviour*, 66, 617-622.
- 1546 West, M. J., White, D. J., & King, A. P. (2002). Female brown-headed cowbirds'
1547 (*Molothrus ater*) organization and behaviour reflects male social dynamics
1548 *Animal Behaviour*, 64, 377-385.
- 1549 Wetherby, A. M., Cain, D. H., Yonclas, D. G., & Walker, V. G. (1988). Analysis of
1550 intentional communication of normal children from the prelinguistic to the
1551 multiword stage. *Journal of Speech and Hearing Research*, 31, 240-252.
- 1552 White, D. J., Gros-Louis, J., King, A. P., Papakhian, M., & West, M. J. (2007).
1553 Constructing culture in cowbirds (*Molothrus ater*). *Journal of Comparative*
1554 *Psychology*, 121(113-123).
- 1555 White, D. J., Gros-Louis, J., King, A. P., & West, M. J. (2006). A method to
1556 measure the development of song preferences in female cowbirds. *Animal*
1557 *Behaviour*, 72, 181-188.
- 1558 White, D. J., King, A. P., Cole, A., & West, M. J. (2002a). Opening the social
1559 gateway: Early vocal and social sensitivities in brown-headed cowbirds
1560 (*Molothrus ater*). *Ethology*, 108, 23-37.
- 1561 White, D. J., King, A. P., & West, M. J. (2002b). Facultative development of
1562 courtship and communication in juvenile male cowbirds (*Molothrus ater*).
1563 *Behavioral Ecology*, 13, 487-496.
- 1564 Wilson, E. O. (1975). *Sociobiology*. Cambridge, MA: Harvard University Press.
- 1565 Yale, M. E., Messinger, D. S., Cobo-Lewis, A. B., & Delgado, C. F. (2003). The
1566 temporal coordination of early infant communication. *Developmental*
1567 *Psychology*, 39(5), 815-824.
- 1568

1568 **Figure legend**

1569

1570 Figure 1. Illustration from a single frame of a video recording of a male cowbird
1571 directing a song to a female cowbird.

1572

1573 Figure 2a. Illustration from a single frame of a video recording of a female cowbird
1574 reacting to a directed male song with a wingstroke.

1575

1576 Figure 2b. Illustration of a female cowbird reacting to a directed male song with a gape.

1577

1578 Figure 3. The relationship between maternal responsiveness and relative change in the
1579 proportion of vocalizations that infants directed to their mothers from 8 to 14
1580 months old ($n = 11$). A negative change in directed vocalizations indicates a
1581 decrease over time. Maternal responsiveness of 0.1 = response to every sixth
1582 vocalization; 1 = response to every vocalization.

1583

1584 Figure 4. Number of note clusters in 4 flocks of juvenile males who were housed with
1585 adult females (AJ1 & AJ2) or juvenile females (JJ1 & JJ2) during
1586 development. Recording 1 was performed with males in their original flocks
1587 (AJ vs. JJ). Recording 2 was performed after males had However, recording
1588 2 was performed after AJ1 and JJ1 males were switched and AJ2 and JJ2
1589 males were switched so that the juvenile males originally housed with adult
1590 females were housed with juvenile females and the juvenile males originally
1591 housed with juvenile females were housed with adult females.

1592

1593 Figure 5. Infant attentional shifts to introduced toys and toys not introduced by the
1594 experimenter in intrusive and sensitive conditions ($n = 19$).

1595

1596 Figure 6. Male cowbirds engaged in a countersinging bout. The male performing a
1597 wingspread display is the one singing. The recipient directly in front of him
1598 then sings a song in return. Songs are exchanged until one of the two males
1599 flies away.

1600

1601

1602

1603

1604

1605

1606

1607

1608

1609

1610

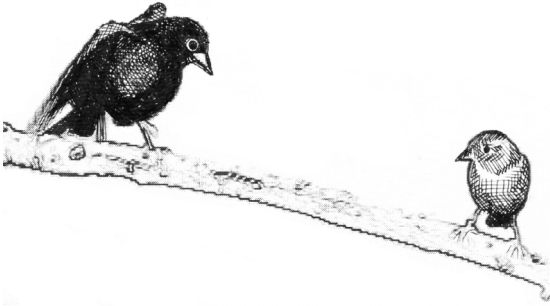
1611

1612

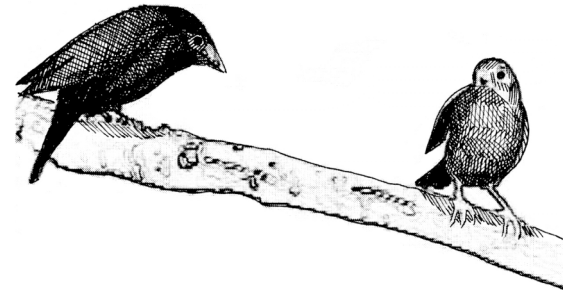
1613 Fig. 1

1614

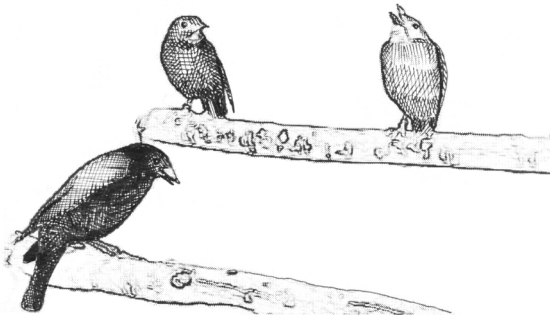
1615



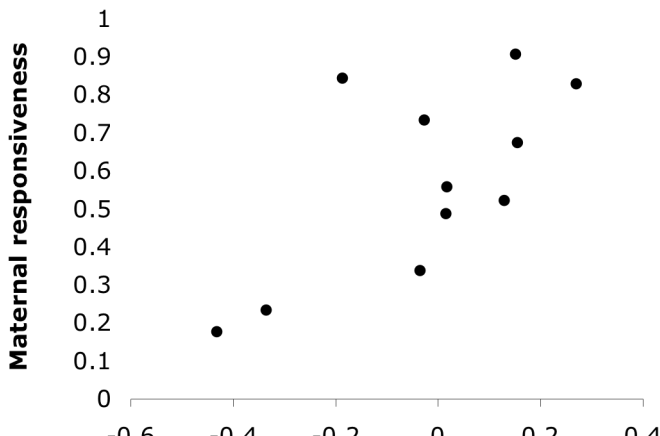
1616
1617
1618
1619 Fig. 2a
1620
1621



1622
1623
1624
1625
1626
1627
1628
1629
1630
1631
1632 Fig. 2b
1633



1634
1635
1636
1637
1638
1639
1640
1641
1642
1643
1644
1645
1646
1647
1648
1649
1650
1651 Fig. 3
1652
1653



1660

1661
1662
1663
1664
1665
1666
1667
1668
1669
1670
1671
1672
1673
1674
1675
1676
1677
1678
1679
1680
1681
1682
1683
1684
1685
1686
1687
1688
1689
1690
1691
1692
1693
1694
1695
1696
1697
1698
1699
1700
1701
1702
1703
1704
1705
1706
1707
1708
1709
1710
1711
1712
1713
1714

Fig. 4

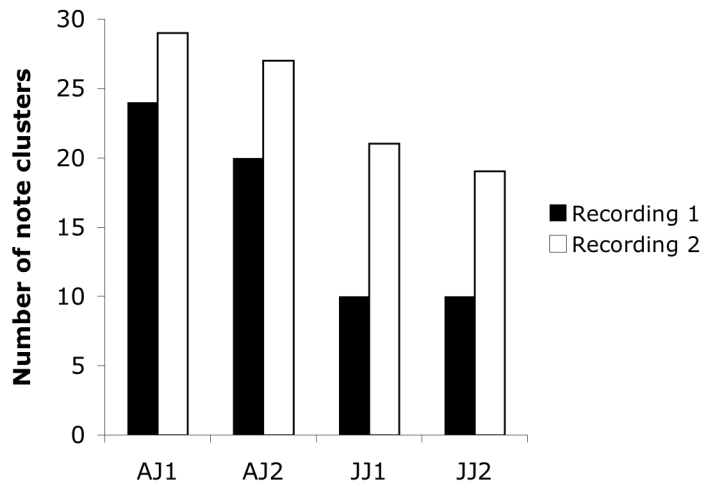
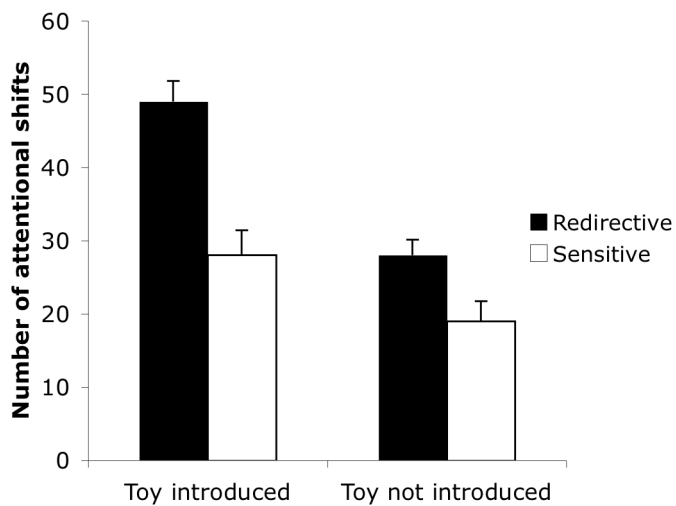


Fig. 5



1715
1716
1717
1718

Fig. 6



1719
1720
1721
1722
1723
1724