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Homology in the Development of Triadic Interaction and Language

ABSTRACT: *Conceiving of development with reference to homology can help identify developmental continuity where surface form shows considerable variation across age. I argue that there is a homology of structure between the object-centred, or triadic, interactions that emerge in infancy and later language. The structure of triadic interaction in infancy is first described as involving joint attention and joint engagement about a shared topic, and then a case is made that this structure is maintained through three levels of complexity in language—single word utterances, multiword utterances, and finally complex constructions. A focus on the homological relation between these social interactive structures may be useful in revealing developmental continuities where these may be obscured by quite different surface forms.* © *2012 Wiley Periodicals, Inc.* Dev Psychobiol 55: 59–66, 2013.

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INTRODUCTION

Developmental psychologists have struggled for the best part of a century with how to conceptualize behavioral and cognitive development (e.g., Baldwin, 1895/1906; Piaget, 1923/1959). The challenge for developmental psychology is to provide a framework to understand developmental continuity (or sameness) while allowing for developmental change. One concept that it is worth considering in this regard is the biological concept of ''homology.'' Since the inception of the concept of homology (Owen, 1843), characters are deemed ''homologous'' if they share a degree of sameness, but the degree is not complete: if there was not also variation, then there would be no need for the concept of homology—characters would simply be the same. Homology provides a fundamental concept for understanding characters across organisms. As Wake (1994) asserted in his review of Hall (1994), ''homology is the central concept for *all* of biology'' (p. 268, emphasis in the original).

At the outset, one must acknowledge certain limitations of the application of the homology concept to behavioral development. First, in the Darwinian era, it is understood that the sameness in homological characters derives from common ancestry (Hall, 2012, this issue). So, in this regard the analogy between development and evolutionary homology breaks down. Second, the application of the homology concept to the phylogeny of behavior is perhaps not as straightforward as it is for morphological characters (Atz, 1970; Wenzel, 1992).

Despite these caveats, D. Moore (2012, this issue) has provided a clear argument for how, despite it being a nonorthodox usage, the concept of homology may well apply profitably to developmental psychology. To my mind, there are two particularly valuable outcomes of the application of the homology concept to developmental psychology. One arises from the contrast between homology and what was originally termed ''analogy'' (Owen, 1843) and now more commonly ''homoplasy'' or ''convergence'' (see Hall, 2012, this issue). The concern is that apparent sameness in behavior over time may in fact not be a manifestation of a sameness derived from developmental continuity.

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Suddendorf, Ooestenbroek, Neilsen, and Slaughter (2012, this issue) have provided a thoughtful analysis of one case of a behavioral phenomenon—imitation—that needs more careful consideration in this regard. Imitation manifests at different developmental periods, including apparently in the period right after birth (Meltzoff & Moore, 1977), and these different manifestations have typically been assumed to be developmentally continuous. But whether neonatal imitation is indeed continuous with later imitation is very much undecided and requires careful empirical analysis. It is worth pointing out that we know from the comparative literature that imitation has evolved more than once and likely for different adaptive functions—communication in the case of psittaciformes and tool-use in the case of primates (B. R. Moore, 1992, 1996)—hence there is evolutionary precedent for the notion that different manifestations of imitation in development may not in fact be a product of the same kind of behavioral-functional pattern. So the consideration of behavioral development with respect to homology versus homoplasy may help to clarify whether similar behaviors manifested at different phases in development are or are not developmentally related.

The other insight provided by the homology concept is that characters that appear quite different—for example, the whale flipper and the bat wing—may in fact exhibit a degree of sameness under closer inspection, which reveals their evolutionary or developmental connection. In this paper, I present a case of apparent nonhomology, where the sameness is not evident superficially, that may actually be homology. The case involves a relatively complex behavioral structure that shows quite profound modification over developmental time but retains a sameness in organization consistent with a developmental homology. The complexity of the structure is evident in its dependence on a reliable and supportive environment (in this case, the social environment) and in the fact that it is manifested in quite different behavioral form at different ages, pointing to a homology that is deeper, or more abstract, than the overt structure of the motor acts. Critically, in this case, this homology cannot be understood without regard to function.

TRIADIC INTERACTION

The interaction among people in relation to some object or idea, provides a thread through much of development for the ways in which people acquire and utilize shared knowledge and the ways in which they manipulate each other's action. In developmental psychology, this kind of interaction over a shared focus is termed ''triadic interaction,'' and it arises in the second half of the first year of life. It is also evident in most of the social activity, particularly that which is linguistically mediated, exhibited by adults throughout life. You, the reader, are engaging in a form of triadic interaction with me as you read this paper. It is an act that is spread over time in that I wrote the paper well before you are reading it. It is also a quite abstract act of joint attention in that the focus of our interaction is a set of quite esoteric ideas represented in complex language. But, I argue, in a very real sense it is developmentally continuous with verbal conversation and even with the simplest acts of gaze following that herald the onset of object-focussed social interactions in the third quarter of the first year of life. I believe that this developmental continuity is not simply in the sense that the earlier form of social interaction is a precursor to the later form. Instead the earlier and later forms have a structural ''sameness'' that warrants the label ''homology.'' In this paper, I will sketch the developmental sequence that characterizes the ontogeny of triadic interaction. I will point to the important developmental transitions in this ontogeny. My overall goal is to elucidate the structure of certain aspects of complex linguistically mediated adult social interaction by pointing to its homology with the relatively simple object-focussed interactions that occur between infants of 9 months and their mothers.

In infancy, triadic interaction is generally recognized to begin when infants start to interact with a caregiver over an object of shared interest (Bakeman & Adamson, 1984; C. Moore, 2006). Several interactive behavioral phenomena that emerge in the second half of infancy characterize this phase of triadic interaction. These interactions involve infant and adult interacting over some other object. They are termed ''triadic'' because they involve three points of interest—infant, adult, and object—and are differentiated from earlier ''dyadic'' interactions in which infants interact with adults in a face-to-face way but not incorporating an object into the interaction (see Fig. 1).

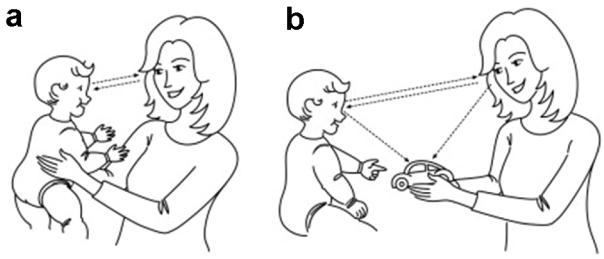

FIGURE 1 The basic structure of (a) dyadic and (b) triadic interaction in infancy.

Triadic interactions actually involve the coming together of two lines of development—one centered around social interest and the other centered around object interest. Infants start to show social interest almost from birth. They are attracted to social stimulation, such as the sight of faces and the sound of the human voice (see C. Moore, 2006). By 1–2 months they will smile preferentially to social stimulation (Sroufe & Waters, 1976). By 2 months, infants begin to engage with their caregivers in dyadic interactions, characterized by joint engagement—both participants in the interaction are engaged with the other with the goal of facilitating and maintaining the interaction (e.g., Cohn & Tronick, 1988). These episodes of joint engagement are typically face-to-face interactions and are suffused with positive emotion. As a result, they are highly motivating for young infants (and their caregivers). They are genuine interactions in the sense that both participants produce actions that are directed at the other and both react reciprocally in response to the other (C. Moore, 2006).

Later, towards the middle of the first year, infants become interested in objects—reaching, grasping, and manipulating them (C. Moore, 2006). This growing interest in exploring the world of objects is enabled by maturational changes in both sensory and motor systems. Improved visual acuity combined with improved coordination of gross and fine motor skills allows the infant much greater scope in the exploration and examination of objects.

Initially these two lines of development—social interest and the object interest—are somewhat separate. But by about 9 months, a new behavioral structure emerges as infants start to become able to involve objects in their interactions with others (Bakeman & Adamson, 1984; Trevarthen & Hubley, 1978). Examples of manifestations of these triadic interactions include gaze following, showing, object exchange (giving and taking), and early gestural communicative behaviors such as pointing. All of these triadic interactive behaviors involve joint engagement, whereby infant and adult are mutually oriented and actively attempting to interact and communicate with the other. They also involve joint or shared attention, whereby the infant and adult share attention to an object of their mutual interest. Through the combination of joint engagement and joint attention, infant and adult act in some way towards the object and at the same time use the object as a means to influence and enhance the interaction with each other. As I will later elaborate, this behavioral structure enables two main types of function. First, goals relating to objects can be achieved through adult intervention. For example, infants may want an out-of-reach object, perhaps for consumption or manipulation, and the adult can be used to achieve those object goals. Second, social goals can be achieved by using objects to enhance the quality and richness of the interaction.

Let's look first at how joint attention is achieved. Gaze following provides one of the simplest routes to joint attention. In its earliest appearance, gaze following involves the infant, while in an interaction with an adult, observing a gaze redirection (head turn) by the adult and then turning in the same direction relative to the environment. Considerable experimental work has been carried out on various aspects of this phenomenon using modifications around a standard paradigm (see C. Moore, 2008). This paradigm involves the infant seated face to face with an adult who engages the infant in interaction. Periodically the adult turns to one or other side to fixate a target object in the periphery and the infant's own gaze redirection is noted. Using this approach, researchers have studied the impact of varying different aspects of the situation, such as target location and type of gaze cue. For example, with respect to target location, we know that gaze following begins as early as 3–6 months when the targets are within the visual field and perhaps 3–6 months later when targets are outside the immediate visual field. At first gaze following involves the infant turning to the appropriate side but not necessarily fixating the same target as the adult, if there are more than one possible target. By the end of the first year, infants will use the adult's gaze to determine which of a number of targets is of interest. This development is important because it reveals how infants truly recognize the intentionality, or object-directedness of the other's gaze. Around the same time, infants will start to use gaze to find targets that may be hidden behind barriers or in containers. This transition suggests that infants are beginning to appreciate that the other's attention may be directed at absent objects.

Gaze following is one side of the achievement and maintenance of joint attention. Towards the end of the first year, infants also become adept at directing an interactive partner's attention. Infants will show objects to others by holding them up for others to see and by offering them to others. They also begin to direct attention using pointing, typically first to proximal objects and before long, to more distally located objects. With joint attention, a variety of forms of interaction become possible. For example, infants can use an adult's emotional display to determine how to act in an ambiguous situation, such as with a novel and perhaps unusual toy. Infants will approach a novel toy to which the adult has smiled but avoid one to which the adult has expressed fear. Together, therefore, following attention and directing attention demonstrate how infants incorporate

objects as ''topics'' about which interactions can take place.

Once joint attention has been achieved, joint engagement around the shared topic can occur. Joint engagement is fundamentally about orchestrating an interaction around the shared focus. There are many particular goals for joint engagement, but as mentioned earlier, a useful dichotomy is between using triadic interaction to service object goals, for example requesting that the other provides an object that the infant desires, and using objects to service social goals, for example showing an object to the interactive partner in order to stimulate an interaction with the adult (Bates, Camaioni, & Volterra, 1975). These two functions of joint engagement are evident from the earliest phase of triadic interaction and can be illustrated by the different ways in which pointing is incorporated into triadic interaction. As noted earlier, pointing is a basic attention-directing gestural device, but it may be used in different contexts with different accompanying gestures to service two separate goals (Bates et al., 1975). The protoimperative point is used to direct the partner's attention to a desired object and then combined with other behaviors such as whining or an expectant facial or vocal expression to convey the message that the partner should retrieve the object for the infant. The protodeclarative point is also used to direct the partner's attention to an object, which may already be within the reach of the infant, but now the function of the pointing gesture is to indicate that the infant wants the partner to comment on the object and engage in an interaction. To serve this function, the pointing gesture is combined with other behaviors such as eye contact and expressed satisfaction once the partner provides the appropriate attention and comment.

At this point, it is probably worth recapitulating the behavioral structure of infant triadic interaction. Triadic interaction involves the infant, an object that the infant is in some way interested in, and an adult with whom the infant is interested in engaging. There are two complementary components of the behavioral structure—behaviors that establish and maintain joint attention with the adult towards the object and behaviors that further the engagement with the adult, by in some way manipulating the adult's behavior. The behavioral structure can serve either or both object oriented goals and socially oriented goals. It is important to note that at this point of developmental origin of triadic interaction—approximately the final quarter of the first year—the structure is not simply an intra-individualistic structure. It depends on the involvement of another actor and cannot by definition proceed without this involvement. So, triadic interaction is really about the embedding of the infant and her behavior within a particular kind of social environment.

During the second year of life, a highly important transition in social interaction occurs—the onset of language. So is the use of language homological with the prelinguistic communication evident in triadic interaction? This question was addressed directly by Elizabeth Bates in one of the very few explicit attempts in the developmental psychology literature to consider behavioral ontogeny in terms of the biological concept of homology (Bates, 1979). Indeed, Bates provided a particularly clear analysis of homology in behavioral development, an analysis that has unfortunately been almost completely ignored in the 30 years since she addressed it. Bates (p. 8–9) contrasted three possibilities for the similarity relation between prelinguistic communication and language:

(1) ''Homology through direct causation'' whereby one structure is a direct prerequisite for the emergence of another.
(2) ''Homology through shared origins'' whereby both observable behavioral structures emerge from some underlying structure.
(3) ''Analogy through common task constraints'' whereby the two behavioral structures look alike only because the different tasks towards which they are organized require structurally similar solutions.

Bates (1979) examined the kinds of evidence that might differentiate among these possibilities, in particular correlational and training evidence, and settled on option (2) for the relationship between prelinguistic communication and language. I suggest that the common origin for this homology is in the associated object and social goals that characterize triadic interaction from the outset. Children remain motivated to further their object-oriented goals and their socially oriented goals and this fundamental coordination of object and social goals organizes the triadic interactions that become instantiated in language. In what follows, I will outline how this homology reveals itself for three aspects of language development—the emergence of words, the emergence of word combinations, and the emergence of complex linguistic structures. This approach is directly consistent with the functionalist approach to language development (Bates & MacWhinney, 1979), which holds that ''at every level of language acquisition, from the discovery of symbols to the use of complex embedded sentences, the child uses functions as his guide to the acquisition of forms'' (Bates, 1979, p.3). This approach is also evident in the more recent work on the social-pragmatic approach to language development, particularly by Tomasello (2003). Indeed Tomasello (2003, p. 21) suggests that ''language is nothing more than another type—albeit a

very special type—of joint attentional skill; people use language to influence and manipulate one another's attention.'' I would add that according to this approach, language is used by people to achieve both joint attention by manipulating others' attention and joint engagement with others around the focus of that shared attention.

THE EMERGENCE OF WORDS

For most children acquiring language at least in Western cultures, nouns make up the majority of the early lexicon. Most children acquire their first words around 12 months of age and within a few months, normally by the middle of the second year, children develop an insight that words stand for things—''the discovery that things have names'' (Bates, 1979, p.33). From this point on, nouns are acquired rapidly and the most effective contexts for such acquisition are triadic interactions in which joint attention to the to-be-named object is established (Tomasello, 2003; Tomasello & Farrar, 1986). A large literature on early word learning has established that in the earliest stages of language acquisition, children more easily acquire novel words when these are introduced by adult speakers during episodes of joint attention (see, e.g., Baldwin, 1995; Carpenter, Nagell, & Tomasello, 1998). So, words serve to establish the focus of joint attention. As Tomasello (2003, p. 8) puts it, words are ''social conventions by means of which one individual attempts to share attention with another individual by directing the other's attentional or mental state to something in the outside world.''

So far, we have been talking about triadic interaction involving joint *visual* (or perhaps perceptual) attention. Triadic interactions in infancy involve joint attention to actual real objects, but the onset of symbolic linguistic representation during the early part of the second year of life enables interactions around absent or even nonexistent objects. For there to be an effective triadic interaction involving an absent object, there has to be a representational medium for the consideration of such objects. Furthermore, because there must be joint attention with another person to the absent objects, the representational medium has to be one that is conventional, that is, both participants in the interaction represent the absent object in the roughly same way. The transition to language enables this critical shift from joint visual attention to joint *representational* or *conceptual* attention. Words are at first tied to concrete present objects and events but before long, infants become capable of using and responding to words in reference to absent objects. The reference to a nonpresent object by an adult serves to produce in the infant's mind an image of the referent. Similarly, the infant imagining something not present can use a word to refer to it and thereby re-present it to the adult for consideration. Once the object or topic is established through lexical representation, joint attention has been achieved, but now it is not joint visual attention but joint *representational* attention.

Object labels may be the most common of the early words, but words do not just represent the object or topic of the triadic interaction. From the earliest stages of language acquisition, words also serve a relatively small range of functions designed to organize the joint engagement. These functions can be mapped fairly directly on to the prelinguistic communicative functions mentioned earlier. In summarizing the first communicative functions of language, Tomasello (2003) identified the various categories listed in Table 1. The majority of these functions occur in triadic interactions where the child communicates with another person about some object or event. Interestingly, there are two main types of function. Continuous with earlier protoimperative gestures, children will often make requests to get the partner to provide an object or perform an action. Continuous with protodeclaratives, there are various indicative speech acts, whereby the child points out or describes an object or action to the other person. So at the outset of language acquisition, words are used by

Table 1. Joint Engagement Functions of Children's First Words (After Tomasello, 2003)

Function	Example
Request or indicate the existence of objects	*Daddy, baby*
Request or indicate the recurrence of objects or events	*More, again*
Request or indicate dynamic events involving objects	*Up, down, open, close*
Request or indicate the actions of people	*Eat, kiss*
Indicate the location of objects and people	*Here, outside*
Ask basic questions	*What's that?, where go?*
Attribute a property to an object	*Pretty, wet*
Use performatives to mark specific social events and situations	*Hi, bye-bye, thank-you, no*

children not only to represent the topic of triadic interactions but also to regulate the interaction in relation to that topic. There are thus primarily two kinds of words—those that serve to establish joint attention through naming the topic and those that serve to organize the interaction by facilitating the child's interests, whether object-oriented or socially motivated, in joint engagement.

COMBINING WORDS

The presence of these two kinds of words—those that establish the topic of joint attention and those that regulate joint engagement—enables the next major transition in language. Whereas the first words are used in isolation for one or other of these aspects of triadic interaction, by the end of the second year, children begin to use both kinds of words together and for the first time the structure of triadic interaction can be fully present within an utterance. Let's see how this works.

The first word combinations tend to show regularities with respect to certain words, sometimes called ''pivot'' words (Braine, 1976; Tomasello, 2003). For example, children may express a desire for a range of objects or events, using the pivot schema, ''*want-X*.'' In such utterances, one word (the ''*X*'') refers to the object of the triadic interaction, and the other word (the ''*want*'') regulates the joint engagement by expressing the requestive. This, therefore, is an example of a fully lexicalized triadic structure involving the representation of both the topic of joint attention and the organization of joint engagement to achieve a particular goal in relation to the object. Other pivot-schemas serve more social interests often by providing a new piece of information (a ''comment'') in relation to the topic of joint attention, so that the adult can add further comment. For example, young children acquire descriptive words, such as ''pretty'' or ''wet'' which may then be applied to a range of objects: ''pretty baby,'' ''pretty kitty,'' etc. The goal here, like much adult conversation, is to engage in verbal interaction over the topic, and it is achieved by including a reference both to the object of shared interest and indicating some novel piece of information about that shared object.

COMPLEX LINGUISTIC CONSTRUCTIONS

The distinction between establishing the shared topic and contributing new information provides an organizing principle for much of language from this point on. This distinction has been considered by many authors and has variously been referred to as ''given-new,'' ''old-new,'' ''topic-comment,'' ''free-bound'' among other contrasts (see inventory in Bates & MacWhinney, 1979, p.176). It even aligns quite well with the more formal ''argument-predicate'' distinction. To fully understand how the distinction pervades language, it is necessary to recognize two aspects of the structure. First, whereas so far we have been considering the topic of joint attention as an actual physical object, either present or absent, the topic can in fact be much more complicated. Topics can be events involving one or more objects or people (e.g., two people discussing an unexpected engagement: ''John gave Mary a ring''); they can be abstract propositions (e.g., the thesis of this paper: ''topic-comment structure in language is homologous with triadic interaction structures in infancy'')—indeed any event or proposition that can be represented in language can serve as the topic for a further comment.

Second, topic-comment structures can exist not only sequentially, but also hierarchically and recursively within a linguistic unit. Conversations typically consist of serial topic-comment structures where each participant produces utterances, which take as their topic, the prior utterance of the conversational partner, and add some further comment. More often, a text, a discourse, or even a sentence may contain multiple *embedded* topic-comment structures. Many linguistic and paralinguistic devices (e.g., word order, pronominalization vs. specific lexicalization; ellipsis vs. lexicalization; definite articles vs. indefinite articles; contrastive stress; etc.) exist to resolve the embedded topic-comment structure within complex language, for example, ''It was this beer, not the other one, which was drunk by the man who had only recently returned from Cincinnati (as opposed to the guy who came back from there a month ago)'' (see Bates & MacWhinney, 1979, p. 177). Perhaps one may view this feature of language as revealing a form of serial homology (see D. Moore, 2012) in the structure of linguistic interaction. Whereas serial homology in developmental biology usually refers to repetition through reduplication of a homologous structure (e.g., to produce the vertebrae of the spinal column), in this present case each structure becomes incorporated as the topic for the next layer of the topic-comment structure.

The use of linguistic structures to encode given and new information maintains the triadic structure of joint attention and joint engagement evident from the prelinguistic period. Joint attention is achieved through establishing the common ground of given information. With this basis in place, the new information serves to enhance the joint engagement by in some way manipulating the behavior, or more appropriately at this stage,

the mental state of the listener. Even when complex linguistic constructions are used to encode triadic interaction in this way, it can be argued that the same fundamental functions of requestive and indicative are present (Stephany, 1993; Tomasello, 2003). For example, one form of complex construction in language is the modal expression, whereby a speaker expresses an attitude to a proposition. A basic distinction in modal expression is that between epistemic and deontic modality. Epistemic modality expresses the speaker's commitment to the truth of a proposition (e.g., ''I think he's gone to the funeral'') whereas deontic modality expresses the speaker's commitment to the necessity or appropriateness of an action (e.g., ''He should go to the funeral''). In ontogeny, deontic modal expression is typically evident by 3 years of age in the contracted forms, such as ''hafta'' and ''needta'' (Gerhardt, 1991) and functions primarily to manipulate other people's action. Epistemic modality emerges a bit later but is typically in place by 4 years as children use the terms ''think'' and ''know'' to express their own, and comment on others' certainty (Shatz, Wellman, and Silber, 1983). So the emerging complex constructions in the language of young children still fundamentally reflect the structure and functions of triadic interactions seen in infancy—joint attention and joint engagement for the primary purposes of achieving social goals in relation to the environment.

CONCLUSION

I have argued that despite their dissimilarity in surface form, there is a fundamental sameness, or homology, between the nonverbal triadic interactions seen in the first year of life and language in both simple and complex forms seen in older children and adults. This sameness exists in structure, which consists of behaviors serving to achieve and maintain joint attention to some object or idea combined and coordinated with behaviors serving to engage the interactive partner through manipulating the partner's behavior or thought. Social and linguistic development through the early years requires representing these behaviors in verbal form and then organizing them into complex chained or embedded structures. Adopting a focus on the homological relation helps to reveal the developmental continuity in social interaction across prelinguistic and linguistic forms, especially where these forms may appear quite different. To date, this proposal for a developmental homology across prelinguistic triadic interactive structures and language has not been empirically verified. However having identified the sameness in structure, future research using correlational and training approaches may more easily address how development proceeds in this domain.

NOTES

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