Reconstructing U-Shaped Functions

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It is refreshing to read an issue devoted entirely to U-shaped developmental functions. These functions, and their N-shaped cousins, have intrigued developmental psychologists for decades because they provide a compelling demonstration that development does not always entail a monotonic increase across age in a single underlying ability. Instead, the causes of development are much more complex. Indeed, well-documented U-shaped developmental functions have often led to a re-evaluation of theory and/or a questioning of underlying assumptions.

Some U-shaped developmental functions have become so well known as to represent classics in our field. It is doubtful that there is a developmental psychology textbook that doesn’t include coverage of the U-shaped developmental functions in auditory localization, in infant stepping, in a perceptual preference for human faces, or in use of the irregular past tense. It has been suggested that a classic interpretation of this type of finding is that there is a temporary loss or regression in a particular competency which then re-emerges at a later point in development. We would argue, however, that the number of developmentalists who offer such an explanation today is close or equal to zero. Instead, heuristically quite valuable explanations have been offered. For example, in accounting for the U-shaped developmental function in preference for human faces, Morton and Johnson (1991) posited an instinct-like preference for human faces in newborns which is engaged only when face-like stimuli move in the peripheral visual field. This biologically based orienting bias, which they called CONSPE:IC, gives infants enough experience with human faces to facilitate the emergence by 3 to 4 months of a new mechanism, CONLERN, that enables preferential looking at human faces presented foveally, and supports further learning about particular faces. Morton and Johnson argued that the reason a preference is not evident for either peripherally or foveally

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The authors of the target articles in this issue are similarly in agreement that U-shaped development does not imply the loss of a unitary primary ability, though they differ in terms of the framework within which they explain U-shaped phenomena. Along with the development of infant stepping, Gershkoff-Stowe and Thelen (this issue) consider the perseveration that is commonly observed in the development of infant reaching and early object naming. Their dynamic systems account of these phenomena stresses the continuity of development and emphasizes the "soft assembly" of various constituent parts (e.g., perceptual and motor skills, memory, practice) that organize and re-organize themselves over time. Cashon and Cohen (this issue) focus on the development of infants' ability to integrate internal and external features of faces. These authors offer an information-processing account of the U-shaped development observed in this realm. As they develop, infants move from featural to integral processing of information, but the ability to integrate features may be obscured if the information processing system becomes overloaded. When this overload happens, infants simply revert to the earlier featural level of processing. Finally, Namy, Campbell, and Tomasello (this issue) explore the development of children's ability to use iconic gestures as symbols. The authors offer a two-part explanation for the U-shaped development observed in this arena. First, infants narrow their expectations about symbols as they enter into the task of language learning. Later, infants develop a more explicit awareness of symbolic representations, driven by their broadening range of symbolic experiences and a heightened sensitivity to others' communicative intentions.

U-shaped developmental functions are evident in much of our own work as well, and we too do not view them as implying loss or regression. As one example, young infants discriminate phonetic contrasts not used in their native language, but by the second half of the first year of life, they fail to discriminate some acoustically similar non-native contrasts. Werker and Tees (1984) showed this for two "d" sounds that are used in Hindi but assimilated to the single intermediate /d/ used in English, and for glottalized 'k' vs 'q' which are distinguished in Nthlakmpx but are both treated as /k/ by English listeners. Similar results were shown for other distinctions, including two high front rounded German vowels (Polka & Werker, 1994). Werker (1995) called this type of change a reorganization rather than an actual loss, as a number of studies have shown that English adults and even older children can discriminate some of the easier non-native contrasts that infants of 10 to 12 months fail to discriminate (e.g., Best, 1994; Polka & Werker, 1994), and can discriminate more difficult non-native contrasts when tested with sensitive psychophysical procedures (Werker & Logan, 1985). Moreover, recent ERP stud-
ies have shown that even at 10 to 12 months of age the brain retains the ability to
discriminate these non-native contrasts, albeit with different systems than are used
for the native distinctions (Rivera-Gaxiola, Csibra, Johnson, & Karmiloff-Smith,
2000).

Another example from our work was noted in two of the target articles in this is-
issue. This is the work by Stager and Werker (1997) showing that infants of 14
months of age, who are just beginning to learn words, confuse phonetically similar
words in a word-object associative learning task. Yet they can distinguish those
same words a few months earlier (at 8 months, when they do not yet treat the task
as one of word learning) and again a few months later when they are more accom-
plished word learners (Werker, Fennell, Corcoran, & Stager, 2002). The explana-
tion given here is also one of a reorganization rather than a loss. It is argued that for
a beginning word-learner, the task of linking words to objects is computationally
demanding, leaving inadequate attention for accessing the phonetic detail in a
word learning task. Support for this explanation is evident in word-recognition
studies showing that at this same age infants are sensitive to precisely the same
phonetic detail they fail to access in a word learning task (Fennell & Werker, 2004;
Swingley & Aslin 2002).

A further example from our own work, and one that is less commonly dis-
cussed within a U- or N-shaped context, concerns young children’s use of lexical
form class information in word learning. Children’s mastery of count nouns is
developmentally precocious: the earliest form-to-meaning link in the lexicon ap-
pears to be the connection between count nouns and object categories (e.g.,
Waxman & Markow, 1995). By the age of 2 years, children have learned to use
form class cues to draw appropriate inferences about the meanings of several
types of object labels. They interpret words modeled as count nouns as marking
object categories; words presented as proper names as designating individual ob-
jects; and words offered as adjectives as indicating object properties (e.g., Hall,
Lee, & Bélanger, 2001; Waxman & Booth, 2001). However, even after these
specific form-to-meaning links have been mastered, preschoolers often show an
apparent regression, interpreting words as designating object categories, regard-
less of their form class (e.g., Hall, 1991; Hall, Waxman, & Hurwitz, 1993;
Markman & Wachtel, 1988). This seeming step back occurs in situations in
which children hear labels for unfamiliar objects, and it may reflect a competing
constraint to interpret words for unfamiliar objects as object category terms (e.g.,
Markman, 1989). Yet this behavior does not reflect a loss of ability, because
children continue to interpret count nouns, proper names, and adjectives appro-
priately, when the words are given to already familiar objects. Moreover, both
preschoolers and adults use the form class cues appropriately when words are
given to unfamiliar objects, provided that a speaker’s intended meaning is made
clear (e.g., through the use of descriptive gestures).
The trough in U-shaped functions appears at times of profound change in infants’ development, variously termed “overload,” “representational change,” or “system re-configuration” in the articles in this issue, and “reorganization” in some of our work. A common theme running through our own work is to describe these times as periods during which infants’ relation to their input undergoes a shift, when they begin to change the way they construe the tasks facing them. We see this as implied in two of the target articles, but not mentioned specifically, and as a useful addition to the third. For example, the Cashon and Cohen (this issue) article suggests that the time during which infants first begin to deal with the social information conveyed by faces is the time when they no longer show the ability to process upright faces in an integrated fashion. Similarly, Namy et al. (this issue) suggest that the reason infants of 26 months fail to accept arbitrary gestures as signs is that they have adopted a more restrictive view of what is a possible symbol. Namy et al. suggest that 4-year-olds can relinquish this more restrictive view once they achieve the understanding that, as long as the speaker has the intention to label, a variety of forms can be used as symbols. By implication, a U-shaped change in performance is seen because the child begins to construe the information in the input differently. Even in the Gershkoff-Stowe work, it is when their vocabulary first begins to burgeon, that infants make perseverative naming errors. In our work, when infants first start linking words to meaning they make phonemic confusion errors, and when they hear labels for unfamiliar objects older toddlers can fail to use disambiguating form class information and erroneously treat the labels as count nouns. In all of these cases, the apparent decline to an earlier pattern of performance does not indicate a loss, but instead reveals the consequences of a reconstrual of the information at hand, made possible by the emergence of a new competency. We would thus add to the factors being considered in the models presented in the target articles, the explicit notion of a change in the way infants construe the tasks before them. We would suggest that a change in construal could even be among the elements involved in the “soft assembly” in a dynamic systems approach, not necessarily as the engine of change (as that would be very much counter to a dynamic systems approach), but as a contributing factor.

It was tempting for us to end our commentary here with a summary statement about how U-shaped developmental functions do NOT constitute loss, but instead reveal complex “reorganizations” that likely reflect the operation of a number of developmental forces, including a reconstrual of the same information that the infant has been perceiving all along. But we felt such an ending might prematurely close what should still be an open area of investigation. None of the explanations offered here—ours or those of the target articles—can predict in advance, in a new content domain, precisely when a U-shaped pattern of success might be seen. Surely this should be a goal of future work. We hope the notion of construal can be helpful in achieving this goal. To this end, it will be neces-
sary to describe more precisely what motivates a reconstrual, and to specify whether it stems from the accrual of experience, maturation of new neural substrates, and/or a combination of the two. In this way, a careful study of non-monotonic behavioral change can help us resolve some of the most intractable quandaries in developmental psychology.

REFERENCES


