In psychological development, person and context collaborate to produce action and thought. Although this statement or something close to it is now generally accepted by many developmental scholars, the full implications of the contributions of context are still not widely appreciated. Context does not merely influence behavior. It is literally part of the behavior, participating with the person to produce an action or thought.

Psychological systems in general arise from the collaboration of person and context. Most theories of psychological systems treat the person as the source of the systems and relegate the context to a minor role. An especially clear case of this mistake is the concept of competence, which characterizes a person's best knowledge—the upper limit of what he or she can say or do. A person is typically said to possess a certain competence, independent of its use in any context.

In this chapter we show that competence is an emergent characteristic of a person-in-a-context, not of the person alone. Competence arises from the collaboration between person and context, with competence changing when context changes. People are especially important in this collaboration, molding the context to support particular kinds of actions and thoughts in those they interact with. The effects of this sort of social support are dramatic, producing sharp shifts in competence level in individual children. Competence rises abruptly with the provision of support and drops dramatically when the support is removed.

Theories of mind have generally suffered from the fundamental mistake of focusing explanation primarily on either the organism or the environment as the primary source of knowledge or intelligence (Fischer & Bullock,
Theories of competence have been fundamentally flawed by their focus on the organism and their failure to recognize the contributions of context to competence. We suggest a different approach that grounds competence in the concept of skill, starting with the assumption that all behavior arises from collaboration of person and context. The dynamics of changes in competence are explained by analysis of developmental levels of skills as well as a neural network model.

THE FAILURE OF COMPETENCE THEORIES

Cognitive scientists and psychometricians often speak of a person's competence, or ability, as if the person possessed a fixed capacity analogous to the amount of liquid that can be placed in a glass. Whatever context the child is in, the competence remains the same, according to this view. Variations in performance across context and age provide a serious problem for such theories.

The most extreme versions of such competence theories have proved untenable. Chomsky (1965) treated the child's language competence as fixed from early infancy through the operation of an innate language acquisition device. To explain the vast developmental changes that researchers have documented in language and cognition, he and his students impute biological constraints to the child that somehow interfere with the Chomskian competence, preventing it from becoming fully evident in behavior until later years. Building on this analysis, neonativists have repeatedly searched for some early behavior that relates to a "competence" and then neglected to analyze how the purported competence develops or how it is affected by context (Fischer & Bidell, 1991).

Another example of an extreme competence theory is Piaget's hypothesized epistemic subject, defined as a knower uninfluenced by context, analogous to a moving object in a perfect vacuum, where there is no resistance from other objects, events, or energy fields. Although Piaget (1936/1952) was one of the early voices calling for an approach integrating organismic and environmental influences, he built a theory that focused primarily on the child and neglected the environment and the bothersome developmental decalage that it produced (Beilin, 1971; Broughton, 1981; Piaget, 1971). In the last years of his life, however, Piaget recognized the problems with his earlier view and outlined a different view giving a more important role to context (Piaget 1981–1983/1987).

As developmentalists, most of us have taken a path similar to Piaget's, rejecting extreme competence theories. In their place, competence/performance models have been proposed, providing more moderate characterizations of competence (e.g., Flavell & Wohlwill, 1969; Klahr & Wallace, 1976; Overton & Newman, 1982; Pascual-Leone, 1970). For a given domain and age, the child is considered to have a fixed competence, as reflected in his or her highest stage of performance. Variation below this highest stage occurs commonly and is attributed to factors like effort and task difficulty that impede demonstration of the true competence. As in the extreme competence theories, the person's competence is fixed at any one time, like the capacity of a glass to hold water. But unlike in the extreme theories, a set of processes are specified by which the competence eventuates in performance—ways that the person activates and utilizes the competence. Just as the glass can be half empty, people may only use a portion of their competence at any moment. When all the performance factors are controlled, people will show their true competence, the real upper limit on their performance.

Like their predecessors, these theories fail because they segregate the organism from the environment, locating most organismic factors in competence and most environmental ones in performance. This fundamental error not only fails to recognize the collaboration of person with context, but it also insulates the theory from test. The performance factors in the theory interfere both with the expression of competence and with the testing of the theory of competence. When findings do not support a prediction, they are interpreted as reflecting some performance factor rather than requiring a revision of the theory of competence. Like the Ptolemaic view that the stars and planets circle the earth, the competence theory is saved by post hoc epicycles in the performance component to maintain the perfect spheres of competence. The framework proposed in this chapter eliminates the segregation of organism from environment and makes competence a directly observable characteristic of individual people-in-context.

TAKING CONTEXT SERIOUSLY: THE ECOLOGY OF MIND

In recent years, there have been many calls for giving environment or context a more active role in explaining cognition and development. Bronfenbrenner (1979), Neisser (1976), J. J. Gibson (1979), and others have called for an ecological approach. For cognitive development, the works of Vygotsky and Gibson have been especially powerful in leading investigators to analyze the contribution of environment. Vygotsky (1978) focused on the social environment—how other people contribute to children's cognitive development and how children internalize these social influences. Gibson (1979) emphasized that the perceptual inputs for people in specific environments, called affordances, are richly structured and that people can detect and use them without the need for complex internal, mental construction.
Many voices argue currently that context is actually a part of people's action, perception, thought, and knowledge (e.g., Cole & Scribner, 1974; Magnussen, 1988; Rogoff & Lave, 1984; chapters by Bronfenbrenner, Meacham, Reed, Rogoff, Wozniak, this volume).

These views require a radical restructuring of developmental theories. It is not enough to recognize the importance of experience in cognitive functioning. Of course, people need to experience a specific context to master skills in it or to detect affordances in it. A mechanic who has mastered the repair of a Toyota four-cylinder engine will typically have difficulty when first faced with the fancy engine of a Porsche. Likewise, a person who has grown up in Peoria will often have difficulty making sense of a myth told by African hunter-gatherers. Examples like the auto mechanic and the person from Peoria are frequently cited to support contextualism, but they are not convincing to skeptics because they are too obvious, showing only a global effect of experience. Virtually any framework that allows for the effects of experience will predict effects like these, including competence/performance theories.

What is needed instead is analysis of the dynamic effects of context on skill. For competence in development, this analysis predicts that context affects the developmental level or stage of a person's competence even when the effects of experience and domain are controlled for. We describe research that shows powerful effects in which for a narrowly specified domain, a person's developmental level varies dramatically as a function of contextual support. This effect is so powerful that a person's competence or ability can no longer be treated as a fixed characteristic of the person independent of context.

**SKILL: COLLABORATION BETWEEN PERSON AND CONTEXT**

The concept of skill is a good starting point for the integration of person with context (Bruner, 1982; Fischer, 1980). In ordinary English usage, it implies both person and context simultaneously. People have a skill for riding a bicycle, a skill for listening to their friends, a skill for repairing Toyota engines, a skill for doing analysis of variance. A person cannot have a skill independent of a context. Skill requires a collaboration between person and context.

This conception means that skills vary not only between people but also across contexts for a given person (Fischer & Farrar, 1987). When a man borrows someone else's bicycle and rides it or rides his familiar bicycle on an unfamiliar kind of terrain (say, across a grassy field instead of on a road or sidewalk), he must adapt his skill to the context of the new bicycle or terrain. He cannot immediately ride skillfully by using the skill he possesses from before. He initially rides awkwardly, working to adapt the old skill to the new bicycle or terrain. Similarly, when a woman attempts to perform analysis of variance with a difference computer program or when she tries to analyze the data in a study with an unfamiliar design, she has to work to adapt her skill. It can take days or weeks of hard work to generalize the skill to the new context.

Notice that the skill concept includes the person as well as the context. It is as much a mistake to leave out the person as to leave out the context (Fischer & Bullock, 1984). Skills are characteristics of persons-in-contexts.

The concept of skill provides a foundation for building a theory of how person and environment collaborate to produce competence. Skill replaces the organismic definition of competence with the radical idea that capacities literally arise from the collaboration of person with context. A major goal of theory and research then becomes finding principles that specify how person and context collaborate to produce competences. Empirically, competence is defined most simply as an upper limit on the developmental level of behavior. Our research shows that behavior shows not one upper limit but different limits as a function of context.

**HOW CONTEXTUAL SUPPORT DIRECTLY AFFECTS DEVELOPMENTAL LEVEL**

A person does not have a single developmental level, even when assessment is limited to a specific domain. Level varies systematically both across people and across contexts within the domain. For example, within a few minutes a 7-year-old child will demonstrate, in Piagetian terminology, concrete operational thinking as his or her best performance in one context and then preoperational thinking as his or her best performance in a slightly different context.

The domains in our research were highly specific. In one series of studies, we assessed individual children acting out and telling pretend stories in which they made realistic dolls act nice and/or mean with each other. All assessment contexts involved the same setting, toys, and contents, the same experimenter, and similar procedures. Another domain involved individual children sorting blocks into boxes forming classification matrices based on color, shape, and size, again with each context involving the same setting, toys, contents, experimenter, and procedures. Yet another domain (described in a later section) involved adolescents and adults explaining how they made decisions about complex knowledge dilemmas.

Within each domain, the contexts varied primarily in terms of the degree and type of social support that the experimenter provided for the task. In
low support contexts, he or she simply asked a child to act out some mean and nice stories or to sort some blocks into boxes. In high support contexts, he or she provided explicit support for a particular behavior—for example, modeling a specific story or a way of sorting blocks.

The understanding of mean and nice social interactions was measured on the multistep developmental sequence shown in Table 4.1, which captures development between approximately 2 and 15 years of age. For example, for Step 3, the story involved one-dimensional social influence or reciprocity: One doll acted mean (or nice) to a second, and the second one acted mean (or nice) in return because of the first one's meanness (or niceness). The steps in Table 4.1 were specified in terms of the cognitive-developmental levels and transformations of skill theory, which was used to predict the sequence (Fischer, Hand, Watson, Van Parys, & Tucker, 1984; Hand, 1982; Rotenberg, 1988). The sequence was tested via the statistics of scalogram analysis, and in several studies it formed a virtually perfect Guttman scale.

Despite the narrowness of the domain, the individual child's competence varied dramatically with assessment context. Competence was defined as the upper limit on the child's performance, his or her highest step. In one type of context, as shown in Fig. 4.1, a typical 7-year-old produced stories at the upper limit of Step 3, as well as at lower steps. In another type of context, that same child produced a story at the upper limit of Step 6, as well as at lower steps. For both types of contexts, the data fit the basic empirical criterion for competence: Behavior often varied below the highest step (3 and 6, respectively), but it did not exceed that step.

We have replicated this phenomenon across a score of studies of stories and classification involving hundreds of middle-class U.S. girls and boys between 3 and 18 years of age (Elmendorf, in press; Fischer & Elmendorf, 1986; Fischer et al., 1984; Fischer, Shaver, & Carnochan, 1990; Lamborn & Fischer, 1988; Rose, 1990; Woo, 1990). The stories have included not only the domain of nice and mean interactions, but also various other social domains, including social roles (such as doctor–patient, mother–father–child, boy–girl, and child–adult), attributions about aggression, and perspective taking. The phenomenon has also replicated for several non-story tasks, including classification of blocks.

In the classification research, a developmental scale for classification that was generally similar to that in Table 4.1 was used with children between 1 and 7 years of age (Fischer & Bidell, 1991; Fischer & Roberts, 1991). When children were repeatedly tested in low and high support contexts over a 2-month period, they showed different competences (upper limits), with the low support context consistently evoking a competence several steps lower than the high support context.

In summary, the research showed that in diverse domains, children demonstrated two very different competences, which we have called their functional and optimal levels. These two competences were tied to different kinds of social-contextual support: Low support contexts allowing relatively spontaneous behavior produced functional-level competence, whereas high support contexts priming more complex behavior produced optimal-level competence. The interval between the two levels is called a child's developmental range (Lamborn & Fischer, 1988).

Spontaneous Contexts and Functional Level

In several kinds of spontaneous contexts, children showed the same upper limit—their functional level. For the mean and nice story tasks, individual children acted out or told stories spontaneously in two different contexts after they had seen an adult act out a series of stories about mean and nice interactions. In one context, called free play, the adult asked the child to make up some stories of her own while the adult went away to do something else for several minutes. In the other context, called best story, the adult returned and asked the child to show the best story she could.

Children's upper limit was the same in both spontaneous contexts. During free play, they produced several stories that ranged from the upper limit down to lower steps in the sequence. The 7-year-old in Fig. 4.1 showed at least one story at Step 3 and several other stories at Steps 1 and/or 2. In the best-story context, children produced a single story, and it was almost always at the highest step shown in free play. For the 7-year-old in Fig. 4.1, the best story was at Step 3.

To test whether the children were indeed showing a true upper limit, we introduced several procedures that could reasonably be expected to induce higher performance. The best-story context itself was one such check, and it supported the competence hypothesis: When asked to give the best story they could, 80%-100% of the children produced the same highest step as in free play, and most of the remaining children were within one step of that

![FIG. 4.1 Developmental range of a 7-year-old.](image-url)
<table>
<thead>
<tr>
<th>Level</th>
<th>Step</th>
<th>Skill</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rp1: Single representations</td>
<td>1</td>
<td><strong>Active agent:</strong> A person performs at least one behavior fitting a social-interaction category of mean or nice.</td>
<td>Child pretends that one doll hits another doll (&quot;mean&quot;) or gives another doll candy (&quot;nice&quot;).</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td><strong>Behavioral category:</strong> A person performs at least two behaviors fitting an interaction category of mean or nice.</td>
<td>Child has one doll act nice to another doll, giving it candy and saying, &quot;I like you.&quot; The second doll can be passive. Child has one doll say mean things and hit another doll, who responds by hitting and stating dislike for the first one. The second one's behavior is clearly produced by the first one's behavior.</td>
</tr>
<tr>
<td>Rp2: Representational mappings</td>
<td>3</td>
<td><strong>One-dimensional social influence:</strong> The mean behaviors of one person produce reciprocal mean behaviors in a second person. The same contingency can occur for nice behaviors.</td>
<td>With three dolls, child has one tease the others, while a second one hits the others. The third doll rejects both of the first two because they are mean.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td><strong>One-dimensional social influence with three characters behaving in similar ways:</strong> Same as Step 3, but with three people interacting reciprocally in a mean way (or a nice way).</td>
<td>With three dolls, child has one act friendly to others, while a second one hits others. The third doll responds nicely to the first doll and meanly to the second.</td>
</tr>
<tr>
<td>Rp3: Representational systems</td>
<td>5*</td>
<td><strong>One-dimensional social influence with three characters behaving in opposite ways:</strong> The nice behaviors of one person and the mean behaviors of a second person produce reciprocal nice and mean behaviors in the third person.</td>
<td>Child has one doll initiate friendship with a second doll but in a mean way. The second one, confused about the discrepancy, declines the friendship because of the meanness. The first then apologizes and makes another friendly gesture, which the second one responds to accordingly.</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td><strong>Two-dimensional social influence:</strong> Two people interact in ways fitting opposite categories, such that the first one acts both nice and mean, and the second one responds with reciprocal behaviors in the same categories.</td>
<td>With three dolls, child has one doll act friendly to a second one, while a third initiates play in a mean way. The second doll acts friendly to the first one and rejects the third, pointing out the latter's meanness. The third then apologizes for being mean, while the first one does something new that is mean. The second doll accepts the third one's apology and rejects the first one, pointing out the change in his or her behavior.</td>
</tr>
<tr>
<td>Rp4/A1: Single abstractions</td>
<td>7</td>
<td><strong>Two-dimensional social influence with three characters:</strong> Same as Step 6 but with three people interacting reciprocally according to opposite categories.</td>
<td>With three dolls, child has one doll act friendly to a second one, while a third initiates play in a mean way. The second doll acts friendly to the first one and rejects the third, pointing out the latter's meanness. The third then apologizes for being mean, while the first one does something new that is mean. The second doll accepts the third one's apology and rejects the first one, pointing out the change in his or her behavior.</td>
</tr>
<tr>
<td>A2: Abstract mappings</td>
<td>8</td>
<td><strong>Single abstraction integrating opposite behaviors:</strong> Two instances of interactions involving opposite behaviors take place as in Step 6, and the relations between the two interactions are explained in terms of some general abstraction, such as that intentions matter more actions.</td>
<td>With three characters, child has one act friendly to a second, while a third initiates play in a mean way. The second character responds to each accordingly, but then learns that the nice one had mean intentions while the mean one had nice intentions. The second character then changes his or her behavior to each to match their intentions and explains that he or she cares more about people's intentions than their actions.</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td><strong>Relation of two abstractions integrating opposite behaviors:</strong> Two instances of interactions involving opposite behaviors are explained in terms of the relation of two abstractions, such as intention and responsibility: People who have a deceitful intention can be forgiven if they take responsibility in a way that undoes the deceit.</td>
<td>With three dolls, child has two of them act nice on the surface to a third, both with the intention of deceiving him or her into doing their homework. When the deceit is discovered by the third character, the first one takes responsibility for the deceit by admitting the intention and re-establishing his or her honesty. But the second one does not show such responsibility. The third character forges the first one, but not the second, because he or she cares about people taking responsibility for their deceitful intention and undoing the deceit.</td>
</tr>
</tbody>
</table>

*Step 5 is transitional between Levels Rp2 and Rp3. Apparently it can be mastered at Level Rp2, but it is much easier to do at Level Rp3.
nit. When there was a difference between the two contexts, best story was usually one step lower than free play. This difference is predictable from measurement error, because the child had only one chance to show the highest step in the best-story context but multiple chances in the free-play context.

Other checks of the common limit in the two contexts included practice with the stories and instruction. Under both circumstances, the phenomenon replicated, with the same highest step continuing to obtain for both free play and best story. When practice or instruction produced a change in functional level in free play, it typically produced the same change in best story. Overall, however, the effects of practice and instruction were only modest. Average functional level improved at most one step when children were given both instruction and practice (Rotenberg, 1988).

Taken alone, these results would seem to support a simple competence view, because free-play and best-story contexts produced the same upper limit even with repeated assessment. However, the results for the second type of assessment context were dramatically different: The children's competence increased substantially in high support contexts.

Supportive Contexts and Optimal Level

The type of context that evoked a higher level involved immediate contextual support for performance: An adult presented key information to the child about a story, and then the child acted out or told a story based on that information. Across two different contexts providing such contextual support, children showed the same optimal level. In one, called elicited imitation, the adult acted out and explained the story in detail and then asked the child to make up a similar story. In the other, called memory prompt, the adult reminded the child of the gist and key elements of an earlier story and then asked the child to show that story. Both of these contexts prompted key elements in the story.

Children showed the same upper limit in both contexts—their optimal level. In both elicited-imitation and memory-prompt contexts, they correctly produced all stories presented up to the upper limit and failed all stories beyond the limit. For the 7-year-old in Fig. 4.1, the limit was Step 6—a jump of three steps above the functional level. This level is called optimal because it is hypothesized to reflect the best performance that children can produce on their own. We have argued elsewhere that it also shows stagelike discontinuities in development, whereas the functional level shows nonstagelike continuous change (Fischer & Pipp, 1984). But that issue is not essential to this argument.

Children showed consistent optimal levels across repeated trials. In studies where children practiced the stories repeatedly, there was only a modest increase in step, averaging at most one step in Table 4.1 (Rotenberg, 1988). Individual differences were consistent from trial to trial. Instruction also caused a small increase in performance beyond that of practice, and it was similarly reliable. The occurrence of optimal level was thus a stable, replicable phenomenon in individual children.

Figure 4.2 shows results of one of the studies of practice and instruction, in which children performed under four contexts—two supportive contexts (elicited imitation and memory prompt) and two spontaneous contexts (free play and best story; Rotenberg, 1988). Eight 7-year-olds, instructed in how to recall the gist of the story to help their performance, were tested on the stories for Steps 3, 5, 6, and 7 in Table 4.1. They were assessed three times with the elicited-imitation, free-play, and best-story conditions and once with the memory-prompt condition. In the latter, memory prompts were given for each story, with the prompt providing the gist of the story, including a few key actions and objects. In Fig. 4.2 the upper limit is shown for the third elicited-imitation assessment, the second and third free-play and best-story assessments, and the single memory-prompt assessment.

The highest steps elicited by the two supportive contexts were virtually identical, and those elicited by the two spontaneous contexts were lower and virtually identical. In elicited imitation, the stories were at Step 6. In free play and best story, they dropped precipitously to Step 3. Then, the memory prompts were given, and the stories again rose to Step 6, which was identical.
to the results for elicited imitation. Free-play and best-story contexts were repeated, and the stories again fell to Step 3. Every child showed the same general pattern of change, with some variation in the individual child’s optimal and functional levels.

Clearly, the optimal- and functional-level results are highly replicable. In these studies children showed distinct competences for spontaneous and supportive contexts. Their competences arose from the dynamic interplay of person with context, changing in a matter of minutes as the context changed. A child participates in one context, producing a specific level, and then the child changes to participate in a different context, producing a different specific level. Return to the first context produces a return to the initial level, and so forth. This kind of effect can be repeated trial after trial for each individual child.

DEVELOPMENTAL RANGE—WHERE COMPETENCES GROW

We propose that functional and optimal levels define the developmental range of a domain for a child—from skills that the child can produce easily on his or her own to skills that the child can produce only with strong contextual support (Bidell & Fischer, 1991). It is primarily within this range that short-term growth in skill occurs and that practice, instruction, and contextual variation have their effects.

Researchers or educators wanting to assess a child’s understanding need to think in terms of a range, not a point on a scale. And they need to always consider context as an integral part of any competence they assess. Context includes not only the dimension of social support but also issues of domain. Children’s functional and optimal levels vary substantially across domains. Failure to consider range and context leads to major errors of assessment.

The developmental range is related to Vygotsky’s (1978) concept of the zone of proximal development as well as the associated concept of scaffolding (Bruner, 1982; Wood, 1980). Like developmental range, these Vygotskian concepts emphasize that the child’s actions vary over a range closely tied to development and are strongly affected by the behaviors of other people.

There is at least one important difference between developmental range and zone of proximal development, however. In most of the studies of the zone, the adult actually intervenes in the task and performs part of it for the child. In our research, on the contrary, the adult does not directly intervene in the performance of the task. It is no surprise that a child and an adult together can perform a task better than a child alone. It is more surprising that the mere provision of social contextual support strongly affects the child’s solo performance. In the supportive context, an adult prompts a skill in the child and then does nothing more: The child has no direct aid from the adult. But even with the adult not doing any of the task, the child and the supportive context collaborate to produce optimal performance. The child truly demonstrates a competence to act on his or her own with support.

In addition, the research results show what appears to be a contradiction of the Vygotskian analysis. The zone of proximal development involves the child’s gradual internalization of interactions between two people, one of whom is an adult or an accomplished peer (Vygotsky, 1978). As the child becomes adult, he or she becomes able to control the structures individually, without scaffolding. Thus, the zone gradually decreases or even disappears with age. On the other hand, the developmental range does not shrink with age but grows larger, as shown in Fig. 4.3 for the mean and nice stories (Hand, 1982). In infancy and early childhood, children's functional level seems to be close to their optimal level, at least for familiar domains (Fischer & Hogan, 1989; Watson & Fischer, 1980). Starting at about 3½ years, the gap between functional and optimal level becomes strong, and thereafter it seems to grow ever larger with age.

CONTEXTUAL SUPPORT OF HIGHER REASONING: REFLECTIVE JUDGMENT

The developmental range does not end with childhood but extends into adulthood. A study of the developmental range for reflective judgment
how developmental range grows larger at least through the late 2os, s people construct high-level abstract reasoning about the bases of knowledge. Optimal and functional levels occur at these ages too, and the distance between them grows with age.

Reflective judgment is reasoning about the bases for knowing, especially when dealing with conflicting arguments about a complex issue. Kitchener and King (1981) devised an interview for assessing reflective judgment by asking people to deal with dilemmas in which at least two opposing opinions are stated about an issue. For example, one of the dilemmas deals with the health effects of chemical additives to food: Do these additives promote health or cause disease?

Longitudinal research has shown that people's judgments develop through the seven stages shown in Table 4.2. Children start out with the view that knowing is a concrete state based on direct experience. At the middle stages, they come to understand that knowledge depends on one's viewpoint and is therefore uncertain. In the later stages, they move beyond the focus on uncertainty and consider the justification and evidence for a conclusion and the process of inquiry by which it was reached. Kitchener and Fischer (1990) presented a skill analysis of the stages of reflective judgment.

To assess optimal and functional levels of reflective judgment, we asked students to reason about knowledge dilemmas in two contexts (Kitchener, Lynch, Fischer, & Wood, in press). The low support context was the traditional Reflective Judgment Interview (RJI), in which the person is presented with a series of dilemmas and for each dilemma is asked to state a position, and to explain the bases for it. The high support context was a new assessment interview, the Prototypic Reflective Judgment Interview (Kitchener & Fischer, 1990). People were presented with the same dilemmas as in the RJI, but contextual support was provided by presentation of a prototypic answer for each stage of each dilemma. (These prototypes were based on answers given by people in earlier studies using the RJI.) After a student read one of the prototypes, he or she was asked to explain it in his or her own words.

Subjects were 104 students between 14 and 28 years of age, half male and half female. Students were tested individually in two sessions, with each session including first the spontaneous context (RJI) and then the supportive context (Prototypic Reflective Judgment Interview). After the first session, students were also given a series of questions and guidelines to help them think about drawing conclusions about complex issues before the second session; these materials did not include direct statements about the actual dilemmas.

The results showed a clear separation of functional and optimal levels, with students performing approximately a stage higher in the supportive context than in the spontaneous one. These results held over both sessions. That is, producing higher stage responses in the supportive context in the first session and having 2 weeks to think about the dilemmas did not reduce the difference between optimal and functional levels, although there was a small overall increase in level between sessions.

Consistent with the previous finding that developmental range increased with age in childhood, the distance between functional and optimal levels of reflective judgment grew with age during adolescence and adulthood too. In the teenage years, the mean difference was about .6 stages, but by the late 20s it had grown to twice as much, 1.2 stages. The increasing size of the developmental range with age thus seems to extend well beyond the years of childhood into at least the years of early adulthood.

The reflective-judgment results thus illustrate the generality of the
developmental range across domains and ages. People show one developmental level—one competence—when they act in a spontaneous context and a much higher developmental level—a different competence—when they act in a socially supportive context. The difference is remarkably robust. Not only does it occur across many domains, but practice and simple instruction do not eliminate it.

**DYNAMICS OF COMPETENCE IN A NEURAL NETWORK IN CONTEXT**

The robustness and generality of the developmental range suggest that it is a basic characteristic of human cognition, a property of the way the human nervous system operates in context. To begin to understand the neural foundations for developmental range, we looked to modern neural network theory, especially models of parallel, distributed networks that involve a collaboration between top-down processes in the network itself and bottom-up processes from input to the network. Adaptive resonance theory (ART) has these properties and has been used with success to model many cognitive processes (Bullock, Carpenter, & Grossberg, 1991; Grossberg, 1980). ART networks have the capacity to learn and to function in many ways like intelligent organisms. As parallel distributed networks, they use a set of input to make generalizations about the form of that input, often producing surprises not built into the original network. Building on these properties, they achieve great power through specifying particular, diverse network architectures like those of human neural systems.

**Developmental Range In Neural Networks**

Within adaptive resonance theory, neural networks have exactly the dynamic properties we anticipated: They generate not merely one competence but a range of competences affected powerfully by input from the context in which the network is functioning. Especially relevant to this developmental range is the role of contextual input in stimulating complex neural activity that is sustainable through short-term memory processes.

The networks contain short-term memory components that can be activated without being directly encoded into long-term memory. Indeed, complex neural systems exhibiting short-term memory, long-term memory, and differentiation of the two would seem inevitably to produce a property like developmental range. When the short-term memory components are activated by context, they allow the consequences of the transient contextual input to persist without any input from long-term memory components. For a significant interval after the contextual input, the network exhibits this competence, but the ability is fragile because it depends on the induced short-term memory components, which are not subject to long-term memory encoding at the current level of network maturity. Therefore, after intervening activities push the system into some other state, the network cannot autonomously re-enter the state originally induced by the context. The competence associated with having entered the contextually induced state is real, but the state itself cannot be regenerated by the network alone without appropriate contextual input.

In general, when bottom-up input (like that coming from context) and top-down input (like that coming from individual goals or plans) show an appropriate match, they produce resonance in the circuit. When the match is absent because of the absence of one or the other input, the network can still function, but it functions differently, in a less complex way. Thus a single network can show one organization when it is functioning without matching inputs and a more complex organization when it is functioning with both contextual input and matching top-down input, such as that from short-term memory.

The structure of this network is illustrated in a highly schematic way in Fig. 4.4. The output process involving network sites R₁ and R₂ produces a simple activity state at an early stage of development when it is activated by signals along pathways S₁ and S₂. As development proceeds, this process is reorganized by hierarchical inputs from sites C₁ and C₂ to sites R₁ and R₂ along pathways S₃ and S₄. When sites C₁ and C₂ are activated even briefly, they can maintain their active state by virtue of the excitatory feedback loop.
the loop will be interrupted, and the reorganized processing will cease. Now reorganized processing through sites R and R2—optimal level behavior. However, when the system is reset by, for example, a change in context, the loop will be interrupted, and the reorganized processing will cease. Now all that the system can sustain is the simpler activity produced by signals S1 and S2—functional level behavior. To overcome this functional-level limit, the system must be able to generate the more complex activity through sites C1 and C2 on its own without contextual inputs I1 and I2. This development occurs when the long-term memory pathways M1 and M2 to sites C1 and C2 become functional. As further development and learning bring these long-term memory pathways into operation, a child can permanently encode the pattern induced at C1 and C2 in long-term memory. As a result, the child becomes able to endogenously regenerate the induced state at a later time in the absence of immediate contextual support. Now, what was previously optimal level becomes functional level: Behavior that previously depended on contextual support can now be produced spontaneously.

The partial independence of short- and long-term memory processes is only one part of the general complexity and diversity of animal nervous systems. A central nervous system (CNS) is made of many components in composite structure, including diverse neural circuits and diverse inputs to those circuits. The components are not only parallel and distributed but often distinct in structure. Advanced brains are built up from many separate local circuits that operate in partial independence of other local circuits. Although all regions of the CNS are ultimately linked, partial independence is assured by variability in linkage strengths, occurrence of both cooperative (mutually excitatory) and competitive (mutually inhibitory) interactions, radical differences among networks in sensitivities to inputs of various types, and highly diverse inputs from the environment and the body. In addition, partial independence is also assured by developmental delays in effective interaction between many component networks (Fischer & Rose, in press; Thatcher, 1991, in press), as in the delay in development of the M components in Fig. 4.4. Given all the complexity and independence of components, it is inevitable that among the system's multiple activity states, some will be dependent on specific contexts. In addition, some of these context-dependent states will eventually develop so that a child can generate them autonomously.

Advantages of Multiple Levels of Competence

In time, children typically develop the capacity to evoke the complex activity at sites C1 and C2 on their own through long-term memory sites M1 and M2. That is, after some key experiences, a child becomes capable of autonomously generating the developmentally advanced performance earlier exhibited only transiently—a capacity that Bullock, Carpenter, and Grossberg (1991) called autonomous supercession of (endogenous) control. This capacity has major advantages, of course, but there also seem to be good reasons that its development is delayed.

The advantages of autonomous control are clear. It is advantageous to be able to re-enter a state that generates an adaptive behavior without strong dependence on exogenous input such as social contextual support. Instead of a lengthy process of search for the supportive context to produce the behavior, the organism can directly generate the desirable behavior. Such re-entry to desirable states is a theme in both Piagetian theory, with its emphasis on circular reactions and the regeneration of sensorimotor states (Piaget, 1936/1952; see also Kaufmann, 1980), and conditioning theory, with its emphasis on the regeneration of positively reinforcing states (Skinner, 1969). In fact, there are many different kinds of autonomous supercession of control within and across species (Bullock, 1981; Bullock et al., 1991; Fischer & Bullock, 1984). Because of the emphasis on autonomous control, neural network theories of perceptual and motor skill learning have focused on showing how more endogenously activated input pathways to component networks can gracefully supercede more exogenously activated input pathways, as illustrated with the supercession of control by long-term memory in Fig. 4.4. (Note that in neural network models the supercession effect is graded rather than all-or-none.)

Despite all these obvious advantages, children do not develop autonomous control quickly in all domains. Instead, they develop it slowly and hierarchically, with vast arenas of behavior requiring social contextual support for years before children gain autonomous control over them. Of course, it is these delays that produce the developmental range, the difference between optimal and functional levels. This aspect of developmental range has not been a major subject of research in neural network theory or in other parts of cognitive science.

The key questions are: What does an organism have to gain by delaying the time that a level of supercession of control matures, and how is the delay achieved? Of these two aspects of the problem, how the delay could be achieved is easier to answer. The full functioning of neural connections can be readily delayed by many processes, including slow myelination of pathways. For example, if learned supercession of control depends, as in Fig. 4.4, on the correlated activation of sites C1 and C2 with long-term memory pathways M1 and M2, which project to C1 and C2 from remote brain regions, then supercession can be prevented by delayed myelination of pathways M1 and M2 prior to that time. Without myelin, signals will be transmitted slowly and with great attenuation along M1 and M2. The result
will be negligible long-term memory encoding of C₁ and C₂ activations, even if the cells that give rise to pathways M₁ and M₂ show functional connections within the local circuit to C₁ and C₂. In fact, myelination is a slow developmental process in human beings (Yakovlev & Lecours, 1967), and there are many other processes as well that delay the full functioning of neural connections (Thatcher, in press).

Questions about the adaptive value of such delays have seldom been asked by developmentalists. They seem to assume that developmental delays are explained in terms of intrinsic maturational factors, such as the inherent dependence of upper levels of a hierarchy on prior development of lower levels. We have argued since the early 1980s that timing of developmental transitions arises from a set of dynamically interacting factors, not merely from intrinsic maturation (Fischer, 1980; Fischer & Bullock, 1981).

The advantages of delaying autonomous supercession of control, we hypothesize, center on the relation between levels of organization in a hierarchy. When a higher level assumes control, there is truncation of the search process at the lower level—that is, reduction in the scope of search for adaptive combinations for generalization at the lower level. Consequently, delaying supercession of control by level n + 1 prolongs the search for new adaptive combinations at level n.

Delaying the control of level n + 1 not only allows time to find adaptive combinations at level n, but it reduces the risk of finding inadequate combinations there. The form that activity takes in a neural network depends very much on the input it experiences—its sampling base. With insufficient experience at level n, poor generalizations can be formed there. Delays in supercession of control to a higher level will avoid powerful generalizations drawn from insufficient sampling.

A self-organizing hierarchy can produce compact representations together with great generative power, but this potential requires that its generalizations be well suited to its task environments. The effectiveness of its generalizations are directly related to the thoroughness of its sampling of task environments. Indeed, Elman (1992) showed this limitation in a parallel, distributed network that learned to speak based on experience. For the network to learn adequate generalizations about lower levels of speech production, it required extensive experience at a lower level before moving to a higher level. When the network was not required to function at a lower level first, it missed important generalizations. There is a selective benefit to prolonging lower level sampling well beyond the minimum that is strictly necessary for construction of skills to begin at the next level.

Even while there is a disadvantage to truncating lower level sampling too early, there is also an advantage to being able to activate higher level generalizations that have been successful. The developmental-range phenomenon provides a way of having both advantages at the same time by separating the two levels. A child can sustain higher level generalizations when the context induces them, but the child can simultaneously delay higher level control in order to have extensive opportunity for learning important generalizations at the lower level. This kind of process has been outlined not only for development but also for multiple memory systems in primates (Levine & Prueitt, 1989; Mishkin, Malamut, & Bachevalier, 1984) and for alternative substrates for learning in neural networks (Grossberg, 1978).

The coexistence of lower level and higher level functioning in the developmental range essentially separates sampling and generalization processes. The collapsing of these separated processes would pose serious problems for a developing organism dependent on learning. Some neural network theories, such as back propagation models (McClelland & Rumelhart, 1986), have architectures that virtually collapse sampling and generalization, and as a result the networks must learn very slowly in order to prevent premature, poor quality generalizations (Bullock & Grossberg, 1990; Grossberg, 1987; see also Prince & Pinker, 1988).

The separation of competences evident in the phenomena of developmental range thus make sense in terms of how neural networks function and in terms of the demands of adaptation to a complex environment.

**SUMMARY AND CONCLUSIONS: THE DYNAMICS OF COMPETENCE**

Across domains and ages, context contributes directly to competence. That is, skill level is a characteristic not only of a person but also of a context. People do not have competences independent of context.

The phenomenon of developmental range shows one way that this person–environment collaboration works. Immediate context contributes directly to skill, affecting the developmental level of a child's behavior. By evoking specific skill components, context induces a particular skill. This effect is powerful, with performance varying from moment to moment and down a developmental scale as a function of degree of contextual support for high-level functioning. When the support changes, the child's level changes.

Traditional conceptions of competence and performance fail because they treat competence as a fixed characteristic of the child, analogous to a bottle with a fixed capacity. Performance factors are seen as somehow interfering with this capacity. The concept of skill overcomes these limitations by providing a dynamic framework for analyzing variations in behavior with context.

Our research shows that children do indeed have stable levels of