

THE DEVELOPMENT OF COGNITIVE FLEXIBILITY AND LANGUAGE ABILITIES

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A hallmark of human intelligence is flexible cognition: adapting inference to unfamiliar or unexpected situations, creatively combining concepts, and modifying familiar knowledge and habits to produce novel representational syntheses or action sequences. Language enhances and permits expression of flexible cognition. It permits the encoding and making public of innovative representations of present, absent, and imagined events, entities, and relations; and of mental states, ideas, and intentions. The potential for open-ended innovative conceptualization in natural language is demonstrated by this excerpt from a poem by Marianne Moore (1887–1972):

“I remember a swan under the willows in Oxford,
with flamingo-colored, maple-
leaflike feet. It reconnoitered like a battle-
ship. Disbelief and conscious fastidiousness were
ingredients in its
disinclination to move.” (“Critics and Connoisseurs,” 1924)

The swan is imbued with a military mode of perception. Its feet are likened to animal and plant, as perspective shifts from color to shape. Anthropomorphized mental states are likened to ingredients (a culinary metaphor); *ingredient* itself is a metaphor for *cause*. Such innovative conceptual blending, epitomized in poetry and other creative activities, reveals a species-specific cognitive ability: the activation and communication of flexibly selected, combined, and modified representations. Even those of us who are not poets can grasp an uncanny synthesis such as Moore’s (e.g., we can imagine a swan “reconnoitering like a battleship”). This ability, to make sense of unexpected combinations, reveals our normative preparedness to adapt—and understand—innovative representations of entities and events in our shared environment. The importance of this ability in human thought cannot be overstated: it is critical for mediating social interactions and sharing perspectives, for forming representations of unseen possible worlds based on heard or read descriptions, and for building socially coordinated action plans.

How does the ability to understand, evaluate, and produce innovative messages develop? To understand this critical function of natural language and its development, we must consider some fundamental representational skills that might or might not be restricted to language. For example, flexible language processing requires selecting and encoding information from a dynamically changing environment, based on contextual demands that must be periodically evaluated and updated. As MacWhinney (1987) puts it,

“In order to learn a language, a child must have available a rich representational system and flexible ways of deciding between representations. The child [must]

represent [an] intricate set of roles, positional patterns, cues, and conditions . . .
 [therefore] language [must] . . .utilize virtually every aspect of higher cognition”
 (pp. 249–250)

These aspects, or skills, are of course, developing concurrently with language. This makes for a very challenging problem: to learn how children’s language skill relies on, and reflects, flexible thinking. That is, how do children’s minds allow them to flexibly construct representations of others’ intended meanings, and flexibly manipulate verbal structures to express dynamically changing mental representations?

Part of the challenge comes from the fact that flexible cognition and language are codependent but not monogamous, so to speak. Learning language depends not only on flexible representation but on other, elusive skills of attending to and processing linguistic and nonlinguistic cues. Moreover, it depends upon an elaborate social environment, and children’s proclivities to make sense of this environment. At the same time, flexible cognition takes clients other than language: it is deployed in action systems including tool use, social interaction, spatial navigation, planning, and creative thought. Thus, flexible cognition and language learning are partly independent, and we do not know whether, and to what extent, they have been specialized for one another. This opens some fascinating questions. For example, do cognitive processes become more flexible as language is acquired? Does language learning facilitate or limit developmental changes in cognitive flexibility? Does cognitive flexibility emerge first in language use, and get recruited by other action systems? In this chapter I attempt to lay the groundwork for answering these questions by reviewing how children learn to flexibly process utterances and produce discourse-appropriate speech acts. In Section I, I define *flexible cognition* in a way that takes into account ecological and functional concerns of language and thought. In Section II, I briefly describe flexible language processing in adults. This suggests a new metaphorical construct, the *Multi-Aspectual Representational Medium*, or MARM (described in Section III). Finally, in Section IV, I review empirical and theoretical work on children’s developing ability to flexibly comprehend and produce language based on dynamic changes in their internal representational medium.

I. What is Flexible Cognition?

A. PAST AND CURRENT STUDIES OF FLEXIBLE COGNITION

Before defining flexible cognition it is useful to survey past ideas and treatments of flexibility. It is notable that *no* historical approach considered

the development of flexible cognition, which has been studied in earnest only since the 1990s. Also, historical approaches have not considered how language reflects or facilitates flexible cognition. Though a full historical review is beyond the current scope, four influential historical traditions are summarized here, with a focus on the limitations that have motivated the framework described in Section III.

Early studies in the Gestaltist tradition examined adults' flexible inferences about object functions (Dunker, 1945; Meier, 1931), and found that adults have trouble combining and using objects in innovative ways to solve problems (see also Finke, Ward, & Smith, 1992). In some situations, for example, prior knowledge of conventional object uses impedes innovative problem solving. This work thoroughly ignored language processes (but see Glucksberg & Danks, 1968) as well as developmental questions. German and Defeyter (2000), however, found that functional fixedness in one problem increased from 5 to 7 years, ostensibly as children learned the conventional uses of stimulus objects. This finding adds to the intrigue of functional fixedness effects, but their relation to other aspects of cognitive flexibility remains unclear. This is partly because functional fixedness problems are quite elaborate and difficult, and it is partly because the old Gestalt accounts are difficult to assimilate into cognitive science conceptual frameworks.

A second long-lived tradition defines flexible thinking as a component of creativity, and treats both as traits that vary across individuals (Guilford, 1967; Runco, 1993; Torrence, 1988). This camp once sought to define and measure flexibility as an independent, stable trait, but had only modest success (see Hocevar & Michael, 1979; Johnson & Fishkin, 1999). Early studies found a weak but reliable correlation between older children's verbal abilities and creative flexibility (O'Bryan & MacArthur, 1969), but those findings were hard to interpret, and since then little empirical or theoretical progress has been made.

Two other traditions hold more promise for understanding flexible cognition, its development, and its role in language learning and use. One, cognitive neuroscience, has begun to study brain bases of executive functions, some of which (e.g., selective attention; active inhibition) are relevant to flexible cognition (Roberts, Robbins, & Weiskrantz, 1998). Flexible cognition seems to rely on lateral frontal cortical structures (Damasio, 1985; Grattan & Eslinger, 1991; Pandya & Yeterian, 1998), and interactions among frontal, parietal, and temporal areas and basal ganglia (Robbins, 1998). Other data implicate right frontal and temporal areas in flexible interpretation of meaning in discourse (Beeman, 1998; Fiore & Schooler, 1998; Stemmer & Joannette, 1998). Recent evidence also links children's flexible interpretation of changing or unexpected messages to dorsolateral prefrontal areas (Diamond, 1998). Frontal cortex probably

plays a critical role in the development of flexible cognition and language processing, though it is likely that a variety of brain regions and neurotransmitter systems contribute materially to flexibility.

The second tradition addresses flexible thinking experimentally, using task-switching methods (Allport, Styles, & Hsieh, 1994; Meiran, Chorev, & Sapir, 2000; Monsell & Driver, 2000). Participants switch from one task to another, making different judgments about the same stimuli (e.g., reading words vs. naming colors in the Stroop task). Flexibility is measured as changes in response time (RT) across a task switch; a temporary RT increase is called a *switch cost*. This work considers processes of attention allocation, inhibition, forward and backwards priming, and task set (see Gilbert & Shallice, 2002; Meyer & Kieras, 1997). A few studies with children have used simplified task-switch designs, but error rate rather than RT is the measure of flexibility. The constructs used to explain adults' task-switch costs could be generalized to children's task-switch costs,¹ though no encompassing treatment has been published. In Section III, I will propose a generalized theoretical framework that can accommodate both children's and adults' task-switching data.

B. FLEXIBLE COGNITION: A DEFINITION

Flexible cognition entails the dynamic activation and modification of cognitive processes in response to changing task demands. As task demands and context factors (e.g., instructions) change, the cognitive system can adapt by shifting attention, selecting information to guide and select upcoming responses, forming plans, and generating new activation states to feed back into the system (e.g., goals, self-correction). If these processes result in representations and actions that are well-adapted to the altered task and context, the agent can be considered flexible.

I define flexible cognition as the dynamic construction and modification of representations and responses based on information (i.e., similarities, cues, relations) selected from the linguistic and nonlinguistic environment. That is, when there is a range of plausible ways to understand and respond to an problem, flexible thinkers *select* patterns that limit this range. The selected information must change over time as a function of shifting task

¹For example, processes investigated in task-switching studies include switch costs, task-set inhibition, proactive interference, paradoxical order effects, and preparatory facilitation (Allport, Styles, & Hsieh, 1994; Gilbert & Shallice, 2002; Mayr & Keele, 2000; Meyer & Kieras, 1997; Monsell, Yeung, & Azuma, 2000;), all of which can describe flexibility of children in linguistic and nonlinguistic tasks (most of the adult task-switching studies are only superficially linguistic).

demands. That is, as new problems and circumstances are imposed by the environment, the cognitive focus should shift to new, pertinent information. Flexibility is tested when changing task demands are to some degree unpredictable or novel (so the agent cannot rely on automated responses), and the conflict between alternative responses or representations is not trivial.

Because flexibility is a higher-order (i.e., derivative) property of cognition, assessment requires relatively complex paradigms and measures. Traditional cognitive psychology paradigms treat responses as independent (e.g., averaging RT across all trials). But to assess flexibility, we must consider the temporal and sequential context of past events and cognitive states. For example, Ceci and Bronfenbrenner (1985) studied changes in children's clock-checking rate as a deadline (i.e., taking cupcakes out of the oven) approached. Most 10- and 14-year-olds check the clock (i.e., select task-relevant information) fairly often at the start of the session (possibly to calibrate an internal "clock"), check less often until the deadline approaches, and then again check more frequently. This function of changing clock-checking rate indicates cognitive flexibility. Flexible clock-checkers adopt a covert, dynamic action plan to govern their responses over time, as their representation of task demands (based on activation states of an internal clock) changes.

This definition excludes some adaptive behavior from cognitive flexibility. Making different responses in different situations is not necessarily a sign of flexibility if each response is learned separately and elicited in such simple and different contexts that cue selection is trivial. Thus, learning several S–R pairings is *not* tantamount to flexibility, though it is a prerequisite (because flexibility requires selection from among a number of viable responses). However, a demand to switch or re-learn S–R associations (e.g., from red → left to red → right) could test flexibility. Most tests of flexibility build a response set for several trials, to generate response competition, and then change task demands and assess subsequent performance accuracy or efficiency. We also distinguish flexibility from *variability* of behavior over time. Children's responses naturally vary over trials or responses (Siegler, 1996), but flexibility implies more constrained, goal-directed or task-relevant (i.e., adaptive) changes in selected patterns and responses. Thus, randomly switching responses would not count as flexibility, by my definition. Finally, a common ambiguous result involves evidence that two or more samples randomly drawn from a population produce different responses to different tasks. This does *not* demonstrate flexibility; it merely *implies* it. Cognitive flexibility is a within-subjects variable: changing responses with changing task demands. This imposes challenges for testing flexibility in young children who, unlike young adults, will not indefinitely respond to pointless,

repetitive questions about boring stimuli. One can therefore collect only a very limited number of data points on flexibility from a single child, by administering several age-appropriate tasks within subjects.

The definition above allows us to separate two often conflated concepts: *flexible cognition* and *explicit* or *self-conscious* reasoning (e.g., Karmiloff-Smith, 1992). It is an empirical question whether flexible cognition requires controlled, explicit, or metacognitive representation, and, conversely, whether metacognitive access or control necessarily facilitates flexible thinking. There is little evidence of either dependency. Certainly, flexible cognition is most apparent when it is reflected on and reported, but it is just as clear that adults can be myopically inflexible in spite of metacognitive access and verbal self-reflection. Also, college students can be inflexible even when attempting to respond accurately and efficiently to changing problems (Luchins, 1942), and reflecting on their failure to solve the problems (e.g., Duncker, 1945). Even when adults are made aware of demands of a novel task *and* the relevant information, they do not necessarily arrive at flexible, adaptive solutions (Meier, 1931). When they *do* find a solution, they cannot explain how (Finke, Ward, & Smith, 1992; Meier, 1937). For these reasons we assume that conscious or metacognitive thought, and flexible cognition, are at least partly dissociated.

C. THE DEVELOPMENTAL ECOLOGY OF FLEXIBLE COGNITION

Not all cognition is flexible. Familiar, predictable tasks or problems (e.g., social formulas like greetings; navigating the everyday route to work) are best tackled with practiced, even automatic, cognitive processes and responses. In contrast, unexpected or unfamiliar tasks require flexible cognition: task analysis, selecting task-relevant information, forming appropriate representations, and preparing novel responses.

This opposition between the need for efficient response to familiar problems and the need for flexible response to novel problems poses challenges to anyone, and poses special challenges to young children. Young children are rapidly acquiring conceptual knowledge, learning routines (perceptual, motor, cognitive, language, and social), mastering tasks in complex environments (e.g., school), and acquiring skills to activate and manipulate mental states and representations. As all these develop, children engage in increasingly varied settings (e.g., preschool; elementary school) that demand flexibility. Starting day care or preschool, for example, means learning to interact with many new people whose actions, including utterances, are unpredictable. It also means learning about many materials and events, and engaging in varied tasks that are at least somewhat novel.

Thus, flexible cognition in young children lies at the intersection of settings of increasing variability, and an expanding cognitive and conceptual repertoire.

Language is the primary system that mediates this interchange. When preschool children encounter novel tasks they are typically in rich social contexts (e.g., play group, day care, on errands with parents) that are mediated by language. They incorporate conversation, questioning, description, explanation, narrative, and play. Verbal acts, coordinated with novel events and tasks, serve as the medium by which these unfolding events and tasks are mapped onto shared, rich representations. This suggests a critical developmental distinction: whereas in older children, generating endogenous task-shifting signals is a critical skill, in preschool children many cues about task demands are explicitly verbal (e.g., from parents). Preschoolers are expected, insofar as their burgeoning language skills allow, to respond to adults' suggestions, statements, and instructions. Similarly, preschoolers tend to narrate (i.e., verbally externalize) their plans and intentions to shift representations (e.g., in pretend play) or responses. During preschool, then, cognitive flexibility is integrally tied to overt language (Vygotsky, 1978). Changes in flexibility, therefore, couch the development of language skills from 2 to 5 years.²

For this reason, it is noteworthy that preschool children can be strikingly inflexible across changing tasks. In one sense this is unsurprising: flexible cognition involves many cognitive processes that are developing from 2 to 5 years. Some of these have been hypothesized to underlie the development of flexible cognition. One is the developing ability to inhibit prior thoughts or responses, plus memory for alternate responses and messages (Diamond, 1998). Another hypothesis is that cognitive control gradually expands to allow conscious mediation of more and more complex contingencies, and consequent improvement in task switching (Zelazo & Frye, 1997). A third proposal is that flexibility develops with the ability to notice, analyze, and select task cues, and changes in task cues (Deák, 2000).

These hypotheses are evaluated in Section IV. For now, it is important to note that these hypothesis require careful evaluation because evidence of

²Not all language processing entails flexible cognition, per the foregoing definition. For example, rote speech acts (e.g., greetings; politeness routines), and some well-practiced verbal cues and responses are excluded. Also excluded are processes that rest heavily on automated retrieval or association (e.g., accessing familiar, unambiguous root words; morphosyntactic generalizations like gender and/or case agreement; phonetic adjustments like vowel harmony) would be excluded. Language processing that relies on flexible cognition includes making sense of unfamiliar narratives, engaging in informal discourse (e.g., cocktail party banter; business negotiations; mealtime conversation); or following unpredictable instructions in novel settings.

developing flexibility is inherently ambiguous. Though some authors (e.g., Dempster, 1992; Houdé, 2000) ascribe development to a single mechanism, the capacity to inhibit prior representations, the underspecification of this claim is easily demonstrated. Consider the finding that children younger than 36 months, when sorting pictures of animals into “animals that fly” and “animals that walk,” tend to place several successive pictures of items from both categories into the same box (Zelazo & Reznick, 1991). Such *perseveration* (i.e., inappropriate repetition of a prior response) is common in 2- to 4-year-olds in certain kinds of tasks. It is commonly assumed that perseveration reflects a failure to inhibit primed responses. It could, however, instead be due to weak activation of the new association, or failure to remember the current task cue. Alternately, it might stem from failure of control over complex response choice, or failure to notice changing task cues, or failure to notice that successive questions/tasks are different. There are other possibilities, of course; the point is that we cannot just conclude that flexibility develops with cognitive inhibition.

The more general difficulty here is that inflexibility is polymorphous (Deák, 2000): it is not even always manifested as perseveration. In the Ceci and Bronfenbrenner’s (1985) study, for example, some children failed to take the cupcakes out, but others never reduced clock-checking.

In general, there are four possible relations between forms and causes of inflexibility: (a) one form of inflexibility with a single cause; (b) one form with multiple causes (cognitive, linguistic, or both); (c) multiple forms of inflexibility with a single cause (e.g., not understanding a task prompt might cause one child to perseverate but another to haphazardly switch responses); [d] multiple forms with multiple causes. The evidence reviewed in Section IV suggests the first two and probably the third are incorrect. In short, there seem to be multiple causes and effects of cognitive inflexibility. These might change as thought and language develop. To determine this, it is useful to begin with the normative developmental “end-point”: How is flexible cognition manifested in typical adults, and, in particular, how it is reflected in adults’ language?

II. Developing Toward . . . ? Adults’ Flexible Cognitive Processing of Meanings and Messages

To understand children’s developing flexibility in language processing and production, we need to understand the mature phenotype: adults’ flexible processing and production of messages and meanings. In this section, I briefly summarize evidence of flexible cognition in the language of neurologically intact adults.

A. DISCOURSE AND SHARED MEANING:
FLEXIBLE FORMATION OF MEANING

Generic kind terms (e.g., object nouns) were historically assumed to have dictionary-like meanings. It is clear, though, that word meanings are partly context-specific, and are flexibly activated by adults. Aspects of word meaning are activated according to task and context factors such as proximal words and phrases (Anderson & Ortony, 1975; Barclay *et al.*, 1974). For instance, typicality and similarity ratings of common nouns change with adjectival context (Medin & Shoben, 1988). Adults rate *blue bird* and *black bird* as more similar than *blue bird* and *green bird*, but rate *blue eyes* and *black eyes* as *less* similar than *blue eyes* and *green eyes*. Typicality ratings also can shift based on overt task demands (e.g., instructions to take a foreign perspective) or goals (Barsalou, 1989). Similarly, some aspects of word meaning are primed only in certain sentence contexts (e.g., an incidental property of *roof* such as “*can be walked on*” is evoked only by sentences about construction or repair; Barsalou, 1982, 1983). Activation of word meanings is thus best characterized as a dynamic system: semantic knowledge is selected and modified by recent experiences, cognitive activity, and the context of received messages.

Discourse provides important contextual cues for flexibly constructing meaning. Fluent speakers can choose from many descriptions of an entity or event (Brown, 1958; Cruse, 1977) that highlight different attributes (e.g., *collie, dog, mutt, animal, pet, Lassie, girl*). Descriptions, or *locutions*, often are chosen based on perspectives that are collaboratively formed and modified during discourse (e.g., Brennan & Clark, 1996; Clark, 1998; Garrod & Anderson, 1987). I assume that establishing and modifying shared meaning and reference in discourse requires dynamic updating of semantic representations from an indefinitely large space of possible mappings. Competent speakers select locutions that encode and highlight aspects of mental models shared by listeners at the current point in conversation.

Although adults sometimes fail to establish a shared perspective, we do not assume that this necessarily stem from cognitive inflexibility; it can, for example, result from speakers’ emotional investment in different perspectives (Danet, 1980). Yet we do assume that young children’s conversational disjunctions (e.g., toddlers’ “parallel monologues”) are due to some kind of cognitive inflexibility. This points to a need to know how development of discourse ability is related to changes in flexible cognition—for example, what cognitive processes contribute to social dysfluencies (i.e., inflexibility) in adult discourse (Garrod & Anderson, 1987)? Although there is no comprehensive answer to this, there is

neuropsychological evidence that right frontal and temporal cortical regions are critical for adults' discourse flexibility (Brownell & Martino, 1998). These regions also are implicated in processes of inhibiting and switching attention, and in updating working memory for larger units of meaning (e.g., multiple utterances, as in discourse). Perhaps the latter processes are critical to discourse fluency and flexibility; certainly they are immature in preschool children. Nevertheless, 2- and 3-year-olds can sometimes use pragmatic and discourse information to select and shift descriptions of a referent (e.g., Clark, 1997; O'Neill, 1996). Thus, whatever component cognitive processes are necessary for discourse flexibility, they are not categorically absent in preschool children.

B. FORMING AND SHIFTING CONCEPTUAL MAPPINGS

Evidence of discourse and context specificity in naming and comprehension is compatible with the cognitive semantics approach, wherein utterances are conceptualized as encodings of abstract, dynamic cognitive models, or mappings. I briefly describe this approach because it is unfamiliar to many developmentalists, despite its potential to enhance our understanding of child language and its relation to flexible cognition and conceptual development.

Fauconnier (1997) describes a mapping as a "correspondence between two sets that assigns to each element in the first, a counterpart in the second" (p. 1). For example, one waitress might say to another, "The ham sandwich at 12 wants a soda" (Lakoff, 1987), wherein *ham sandwich* designates a particular customer by reference to his or her order, *12* is a fixed designator of a table or station, and *a soda* stands for a more elaborate locution (i.e., "a glass of soda"). Far more elaborate, dynamic mappings than this can emerge in everyday discourse. We seldom notice these mappings, so fluidly do we construct, consult, and update them, but they support updatable representation of multiple referents, links, and relations. For this reason, having conversations both depends on and exemplifies cognitive flexibility. Successive "turns" require updating these mappings, and the shifts cannot be solipsistic: they are designed for sharing, and rely on common ground as well as conventional abstract meaning schemas, heuristics for efficient transmission of information, and negotiation of preferred locutions (e.g., Schober, 1993).

A critical point is that the real-time social context of conceptual shifts means that states of the conceptual mapping scheme cannot be prestored or selected from a look-up table; they are true products of flexible thought. Also, they are not unique products of conversation; they also emerge, for example, when we hear (or read) and comprehend a story, lecture, or argument. When reading a mystery novel, for instance, we make certain

inferences (e.g., who the culprit is) and the writer exploits this by setting up likely suspects, then, much later, revealing information that forces us to update or modify our extant model. The writer thereby “plays with” the audience’s cognitive flexibility. This highlights a more general conclusion: narrative, written or spoken, presumes the audience’s capacity for conceptual flexibility.

C. NEUROPSYCHOLOGY OF FLEXIBILITY IN ADULT LANGUAGE PROCESSING

Adults’ capacity for flexible language processing can be compromised by certain brain insults, and this evidence might shed light on limitation of flexibility in children’s language. Aphasiology offers intriguing cases of reduced flexibility in naming and reference. Deficient naming, or anomia, is common in aphasia following damage to inferior left temporal and frontal cortex. Perseverative naming errors—repeating a word inappropriately over a short time—are not uncommon (Albert & Sandson, 1986; Hirsh, 1998; Papagno & Basso, 1996). One explanation is that normal inhibition of activated words is impaired, so previously-retrieved words produce response interference (Vitkovitch & Humphreys, 1991). An alternative is that activation of appropriate lexical items is reduced, so prior lexemes compete more vigorously with current lexemes (Cohen & Dehaene, 1998). However, no successful single-process account of these errors has emerged, in part because anomic errors are polymorphous. Perseverative naming seems to be influenced by exogenous factors like stimulus type (e.g., words, nonwords, pictures) and semantic content (Tranel, Damasio, & Damasio, 1997), similarity (e.g., of stimulus features, phonology, or meaning), concurrent cognitive demands, and distracting information. They also are influenced by endogenous factors such as patient age, lesion site, age-at-lesion and recovery time, and interactive factors like familiarity or age-of-acquisition.

These findings might be relevant to children’s perseverative errors, which are often attributed to inhibitory failure. Findings from aphasic adults, however, suggest that children’s perseverative naming might be due to compromised understanding of the current appropriate lexical item. The relevance of aphasic naming errors to children’s errors is indicated by evidence that speech errors in anomic adults and young children are disproportionately perseverative, over a similar time-course, whereas typical adults’ errors include many anticipatory errors (Dell, Burger, & Svec, 1997; Gershkoff-Stowe, 2002; Stemberger, 1989).

Injuries to other cortical regions cause another type of language inflexibility. Pragmatic flexibility, like inferring the meanings of jokes and metaphors, relies on right hemisphere processing (Beeman, 1998; Brownell

et al., 1984; Brownell *et al.*, 1990; Stemmer & Joannette, 1998). Right hemisphere patients often make rigid, over-literal, and over-simplistic interpretations of jokes, stories, and indirect messages (Dennis, 1991; Grattan & Eslinger, 1990). For example, right-lesion patients may select anomalous punch lines for a joke, but cannot tell *which* anomalous punch lines are funny (Brownell & Martino, 1998). Young children also fail to grasp nonliteral, idiomatic or metaphoric word usage, and often do not “get” jokes. This parallel is complicated by a number of population differences (e.g., young children have less elaborate conceptual knowledge, less ability to infer others’ belief states, and less working memory capacity). Nevertheless, this evidence suggests a prevalent role of right temporal and bilateral frontal cortex in flexible inference about complex, socially contextualized, and nonliteral message meanings.

III. Toward a Model of Flexible Representation in Language Processing

Having defined flexible cognition and discussed its ecological role in early childhood, and sketched its manifestations in adult language, we can consider evidence of children’s flexible cognition. To render such evidence interpretable, though, it will be helpful to have a theoretical framework that can encompass children’s and adults’ flexible cognitive processes in language comprehension and production. I will therefore briefly digress to sketch such a framework. Though it cannot yet yield detailed predictions, it will hopefully aid in integrating diverse findings and accounts of what develops in children’s flexible language processing.

Flexible language processing critically depends on selective activation and suppression of linguistic forms and meanings. Flexibility also depends on synthesizing language cues, task demands, contextual factors, and internal cognitive states. These claims are based on the following assumptions:

- i. Meaningful descriptions (e.g., locutions) in speech encode a subset of information about the world. Locutions are chosen to share attention with other people by pointing out specific (real, remembered, or imagined) aspects of the world. Over successive utterances in discourse, denoted aspects of the world, and locutions that refer to them, change in unpredictable ways. Some open-ended, responsive cognitive process is needed to update underlying conceptual models and their mappings to successive utterances and locutions.
- ii. Conceptual knowledge is dynamic, not static (as, e.g., fixed property lists). Conceptual knowledge is activated partly based on the context of

setting, task, and recent cognitive activity. Languages use a variety of syntactic, semantic, and discourse devices to reflect and influence the activation of specific conceptual information.

iii. Dynamic, context-dependent processes of meaning activation and suppression are critical for understanding and producing messages. The same processes might also be central to flexible inferences about other types of information (e.g., face representation, Schyns & Oliva, 1999; tool use, Finke, Ward, & Smith, 1992; Meier, 1931; social judgment, Smith, Fazio, & Cejka, 1996). That is, there is no empirical basis for assuming that flexible meaning processing is a domain-specialized ability.

Representations are defined as dynamically emergent activation states that are accessible to processing and that constrain covert and overt responses. They are seldom prepackaged or immutable, though in the service of cognitive economy some representational content, including linguistic units (e.g., morphological and syntactic dependencies; “canned” lexical responses) is rigid in its form and/or conditions of activation.

A metaphor for dynamic, flexible representation in language processing is an amorphous mass within a fluid medium, akin to a “Lava Lamp.” Representations are akin to amorphous regions of higher energy within a fluid N -dimensional activation space. As these regions shift within the space, some surface or part of the region will approach the “top” of the medium (or lamp). This is analogous to a threshold level of activation (or energy state) that can trigger a response (e.g., lexical access). I call the space a *Multiple-Aspect Representational Medium* or *MARM*, and the representation a *Multiple-Aspect Representation* or *MAR*. It is *multi-aspectual* rather than *multidimensional* because *aspects* can be continuous dimensions, discrete features, nonlinear traits, or logically complex variables (e.g., hierarchical classes, thematic associates, roles): essentially any meaningful distinction that can be drawn about possible referents. Both *MARM* and *MAR* are dynamic. The shape of the *MAR* changes in response to input (metaphorically conceived as thermal energy currents) in the *MARM* (unlike a lava lamp, however, these currents are not restricted to one region of origin). These currents expand or contract different “planes” (i.e., representations of stimulus aspects) of the *MAR*. New planes can *unfold* as learning or attention activates a new distinction, feature, or perspective. Planes also *collapse*, as distracting or uninformative aspects are suppressed or neglected. Finally, a plane can be rarified or expanded by selective suppression of, or attention to, the aspect (see Smith & Heise, 1992). It is assumed that unfolding or collapsing a *MAR* plane takes time (i.e., switch costs). The nature of these processes must be established empirically—for example, a relatively stable *MAR* (i.e., one that

has not shifted for some time) might require more input energy or time to shift.

Input currents in a MARM are heterogeneous: they can be generated by perceived sensory data, linguistic messages, or internal activation states (e.g., a goal). But like thermal currents, input sources are both imprecise and subject to interaction and interference. Thus, if a verbal instruction fails to change the MAR, it might be that the current was not powerful enough to travel through the MARM to expand the relevant plane of the MAR, or that the relevant plane was collapsed (e.g., by suppression) so it was inaccessible to the input current, or that other currents dissipated the input current before it could influence the MAR. These possibilities correspond, respectively, to failure to encode or comprehend a message, inability to apply the instruction to the relevant aspect of the stimulus, and interference from competing, salient cues.

The main claims of this metaphor are consistent with empirical evidence reviewed above. It is therefore more defensible than traditional metaphors for conceptual knowledge (e.g., filing cabinet; dictionary; conceptual network), but (I hope) more accessible than a mathematical description. It differs slightly from other dynamic systems metaphors. In Thelen and Smith (1994), for example, representational states are described as activation *points* in multidimensional space. This does not aptly capture the fact that multiple aspects of a represented entity each can be simultaneously described as a multidimensional vector, and it is an array of aspect-vectors that changes dynamically. This vector array is changing within a similarly dynamic space of representational possibilities which, though large, is not unconstrained (a point captured by Smith & Heise, 1992). Also, the MARM can take many kinds of input, including linguistic information, task cues, the perceptual array, *and* internal, self-generated inputs (e.g., top-down construal of task demands). Internally generated input eventually greatly influences children's cognitive and linguistic Flexibility (Deák, 2000a; Deák & Bauer, 1995; Donaldson, 1978; Karmiloff-Smith, 1994; Siegal, 1991; Zelazo & Frye, 1996), though it plays little role in previous dynamic system accounts (e.g., Thelen & Smith, 1994).

In sum, the Lava Lamp metaphor captures the human ability to flexibly update complex representations in response to task-specific inputs and contextual contingencies.

IV. Children's Flexible Thinking About Meanings and Messages

Young children are believed to be qualitatively less cognitively flexible than are older children and adults. In this section, I explore that claim with

regard to children's language. A guiding concern is how children's language is flexible or inflexible. Normal language errors—retrieving the wrong word, say, or misconstruing an idiom—can reveal developmental limitations of flexibility that recur with some types of brain injuries (Brownell & Martino, 1998; Cohen & Dehaene, 1998; Grattan & Eslinger, 1990; Milner & Petrides, 1984). Young children are, however, seen as *qualitatively* inflexible, or globally restricted from applying processes described in Section I.B.

We need to sharpen that claim. Is the difference between children and adults, particularly in linguistic flexibility, qualitative or quantitative? What factors (e.g., age, verbal knowledge) predict a developmental shift toward adult-like flexibility? How many causes of inflexibility *are* there? For example, is children's naming perseveration truly like aphasiac adults' (Vitkovitch & Humphreys, 1991)? Do children's rule-switching errors (Zelazo, Frye, & Rapus, 1996) reflect the same processing challenges as adults' RT switch costs (Allport, Styles, & Hsieh, 1994)?

In laboratory studies of 2- to 5-year-olds, cognitive inflexibility often is manifested as perseveration. In fact, perseveration is typically the only form of inflexibility studied, and, in many tasks, the *only possible* manifestation. It is thus ironic that perseveration is often assumed to stem from immature inhibitory processes (Dempster, 1992; Harnishfeger, 1995; Houdé, 2000). An underlying assumption is that maturation of cognitive inhibitory mechanisms allows older children to suppress prior responses, whereas younger children are compelled to repeat them. It is questionable, though, that inhibitory failure explains children's inflexible responses to changing verbal tasks. To evaluate this claim we must examine children's response to a wider range of flexible language processing tasks. In Section IV.A, I review evidence of children's ability to flexibly select and re-select locutions to describe different aspects of a referent. In Section IV.B, I review evidence of children's ability to adapt to changing discourse messages, especially changes in verbal rules. In Section IV.C, I review data on children's ability to flexibly select linguistic cues to infer novel word meanings. Finally, in Section IV.D, I consider whether these diverse language skills reveal general age-related changes in flexible cognitive processing.

A. DEVELOPMENT OF FLEXIBLE NAMING

Piaget (1954) claimed preschool children are *centrated*: they think about a single dimension or aspect of reality at one time (i.e., cannot form MARs). In its weak form this claim is supported by some findings (e.g., Siegler, 1981). Other findings, however, show that young children form, modify, and maintain multifaceted representations of entities and situations. In what

ways, then, are young children inflexible in conceptual representation and naming?

Consider children's naming errors. Toddlers tend to perseverate; to inappropriately focus on one identity or aspect of a referent. This might show Piagetian centration, but it might also be a strategic response to any difficulty of the naming task (e.g., retrieving a word that is not too familiar; uncertainty about referent's identity; a hard-to-articulate name). Moreover, as explained previously, toddlers' perseverative naming could stem from either inhibitory or excitatory problems.

The basic problem of retrieving a word for the current referent rather than a previous one might be distinct from problems of higher-order language flexibility (e.g., interpreting an idiom in light of the speaker's ideological slant, as suggested by prior elliptical comments). The latter require *conceptual* flexibility. The most basic form of this is the selection of labels to highlight specific aspects of complex referents. As children's vocabularies grow, they can produce different locutions to describe different aspects of an event, entity, individual, or category. Maybe, though, young children cannot flexibly shift the aspects they represent, and therefore cannot flexibly produce alternate labels for a referent. For example, Siegel, Saltz, and Roskind (1967) reported that children younger than 8 years believe that a "father" cannot also be a "doctor." Similarly, Markman and Wachtel (1988) and Merriman and Bowman (1989) suggested that children have a default "one word *per* object" assumption (i.e., each thing takes one category label), so that, for example, they prefer to map a novel word onto an unlabeled rather than a nameable referent. Similarly, the *appearance-reality* test poses two questions (e.g., "what does this look like?" & "what is it really?") about objects that can be classified by function or by appearance, like an apple-shaped candle. Three- and 4-year-olds tend to answer both questions with the same label (e.g., *candle*), suggesting a rigid focus on one aspect (Flavell, Flavell, & Green, 1983; Flavell, Green, & Flavell, 1986). Such evidence suggests that preschool children are inflexible in their conceptual representations of an entity.

Other findings, however, show that children as young as 2 years *can* represent multiple aspects of a complex referent, and produce locutions for these. Evidence for this conclusion (Clark & Svaib, 1997; Deák & Maratsos, 1998; Deák, Yen, & Pettit, 2001; Sapp, Lee, & Muir, 1999) has been reviewed elsewhere (Clark, 1998; Deák, 2000b). Most pertinent are findings that 2- to 4-year-olds respond to a series of pragmatically and semantically sensible questions about a complex object by producing several different, appropriate labels. They are limited in this by the breadth of their lexicon, not by their conceptual inflexibility. Children can shift perspective, and labels, within a few seconds (depending on discourse and event context);

there is no evidence that they do so much slower than adults. Also, they do not simply generate and discard a series of labels, keeping only one active at a time: when asked to verify label pairs, 3- and 4-year-olds accept appropriate pairs but reject most “foil” pairs (where one word is replaced by a same-category associate). Neither training, nor familiarity with the specific label pair, is necessary. The following exchange (from Deák & Maratsos, 1998; Experiment 1), involving a novelty pen that looks like an ear of corn, exemplifies children’s facility:

Experimenter: “What do you think that is?”
 Child (3;5 female): “Pen.”
 Experimenter: “What else could that be? Anything else?”
 Child: “Corn.”
 Experimenter: “Corn. And what is corn? Is corn a kind of animal?”
 Child: [shakes head] “Food.”
 [Child then affirms each label pair, and reject several foil pairs such as “eraser and corn”]

This capacity is not isolated to novelty items. Deák and Maratsos found, contrary to Siegel, Saltz, and Roskind’s (1967) claims, that 3-year-olds readily, consistently accept several appropriate labels for a character in a brief vignette (e.g., “woman,” “doctor,” “mother,” and “person”). The results indicate that Siegel, Saltz, and Roskind results were attributable to procedural artifacts.

Such evidence falsifies three untenable claims about semantic inflexibility in preschoolers:

- Preschool children cannot simultaneously keep active more than one category representation for a referent (Flavell, Green, & Flavell, 1986).
- Preschool children produce or accept only one word for a complex entity (Markman, 1994)—or, more specifically, do not allow both function and appearance labels for a *representational object* (e.g., dog puppet; Merriman, Jarvis, & Marazita, 1995).
- Preschool children assume that a referent entity has only one label until they receive specific input or training is provided to demonstrate otherwise (Markman, 1994).

Several other possible limits on semantic flexibility are untested and therefore plausible:

- Preschool children are somewhat slower or less consistent than older children in shifting a MAR to focus on (and name) different aspects of a referent.
- Preschool children are somewhat slower or less consistent than older children in activating different words to describe a complex entity. That

is, after the representation has shifted, the selection of a new description is sluggish.

Two final hypotheses about limits on representational flexibility have empirical support:

- Preschool children attempt to simplify the task of learning a novel word. Strategies seem to include temporarily ignoring or inhibiting known words for a referent, or ignoring the novel label, while working out respective meanings (Deák, Yen, & Pettit, 2001). Some results (Deák, 2001c; Hughes-Wagner & Deák, 1999; Liittschwager & Markman, 1994; Rice *et al.*, 1997) suggest this increases with “cognitive load” (i.e., number of to-be-learned items; memory demands). When children learn novel words or infer complex semantic relations, they tend to adopt simplified schemes for mapping the words onto aspects of candidate referents. If only a few of each child’s naming responses are assessed, this tendency will make the child appear to accept only one word per referent; this is, however, misleading.
- Children younger than 4 or 5 years have trouble determining which aspect of a complex referent is indicated by each of several labels. Their difficulty may lie in mapping the predicate of each question to a specific stimulus aspect, and then to a corresponding label. For example, 3-year-olds can label a dinosaur-shaped crayon “dinosaur,” “animal,” and “crayon,” but cannot judge whether each word names “how it looks” or “what you do with it” (Deák, Yen, & Pettit, 2001). More strikingly, 3- and 4-year-olds who persevere in the appearance–reality test also persevere when answering two questions (e.g., “What is this?” and “What does it have?”) about nondeceptive items (e.g., picture of an ape holding cookies; Deák, Ray, & Brenneman, 2003a). Thus, perseverative naming as in the appearance–reality test stems from nonspecificity of predicate↔word mapping, not from inability to represent dual identities (Flavell, Green, & Flavell, 1986; Gopnik & Astington, 1988).

In sum, preschool children *can* select and interpret alternative labels for a given referent (though of course this ability will continue to develop). The process is temporarily obscured in difficult learning tasks, and there is another factor involved: discourse knowledge. When young children are asked a series of different questions, and they do not understand what each question is “about,” they are willing to use a strategy that adults would not consider: they will repeat the same answer. Adults seem to strongly expect different questions to imply different aspects of reality, and thus require different responses; preschool children do not hold this expectation.

B. DEVELOPMENT OF DISCOURSE FLEXIBILITY:
SHIFTING IMPLICATIONS AND INSTRUCTIONS

We have seen that some basic skills of flexible representation and locution-selection are observable in 2- and 3-year-olds. Yet young children seem rather inflexible conversational partners. Why? Certainly there is massive growth of the lexicon, and of background knowledge that contributes to common ground. But beyond this, does representational flexibility change categorically with age, as Piaget and others suggested? What is missing in preschool children from the more sophisticated adult capacity to respond flexibly to discourse or narrative?

One thing that does not change categorically from childhood to adulthood is the basic problem of discourse and narrative processing. A demand of everyday communication is flexible selection or representation of descriptive terms for topics of ongoing discourse and narrative (e.g., Brennan & Clark, 1996; Garrod & Anderson, 1987; Schober, 1993). Consider, for example, the demand to construct and modify conceptual maps from narrative. The mapping flexibility that novelists or dramatists presume of adults is “scaled down” for children: whereas adult readers can represent a story told in reverse (e.g., *Time’s Arrow* by Martin Amis) or with shifting perspectives (*Mrs. Dalloway* by Virginia Woolf), children’s books tend to have a linear story line and fewer (and better marked) shifts. Still, many enduring children’s stories compel their audience to represent a shifting sequence of mappings (albeit fairly simple, explicit ones). In some stories, a series of parallel mappings changes predictably. For example, in the toddler’s book *Are You My Mother?* by P.D. Eastman (Eastman, 1960), a baby bird searches for its mother and encounters a series of (implausible) candidate mother-objects. The young audience must represent a series of mappings, to assess the plausibility that each candidate could be the mother. Many stories for preschoolers incorporate shifting conceptual mappings that are imageable and concrete (and often supported by redundant perceptual information; i.e., pictures).

There are many intriguing questions about the role of narrative in children’s flexible language skills. What succession of representations is activated when children first hear a story; when they hear it multiple times? Does hearing many stories contribute to the ability to flexibly form novel conceptual mappings from narrative? At present, little evidence addresses these questions. There *is* evidence that preschool children have trouble integrating unexpected information with mappings constructed from narrative. Campbell and Bove (1983) read 3- to 5-year-olds brief stories in which the nondominant meaning of a homonym (e.g., /*hâr*/ = rabbit) was strongly implied by context (e.g., “The hare ran across the road”). Afterwards, when

asked to draw a picture of the /*hâr*/, many children depicted the dominant meaning (e.g., strands of hair) though it was completely inconsistent with the narrative. So *something* must develop in children's flexible construction of mappings from narrative. Though there is little data on this, there is evidence that as children become better readers, they can integrate information and judge consistency across more remote sentences (Schmidt & Paris, 1983).

There are, however, related data on children's flexible construction of meaning in discourse. This also improves considerably across the preschool years, possibly in parallel with narrative processing. In discourse, preschoolers often fail to notice that a message is uninterpretable or ambiguous (Cosgrove & Patterson, 1977; Markman, 1979; Revelle, Wellman, & Karabenick, 1985), fail to understand jokes, metaphors, and nonliteral idioms (Chukovsky, 1968; Gombert, 1992), and produce ambiguous referential messages (Glucksberg, Krauss, & Weisberg, 1966). Apparently, 2- to 5-year-olds do not use discourse context to resolve or represent ambiguity about possible meanings of a message. Given that preschool children can produce multiple labels for an entity, the problem is not one of producing multiple mappings, but of generating multiple meanings in response to complex linguistic messages (i.e., utterances with complex meanings). This difficulty is not trivial or artifactual: in training studies (Sonnenschein, 1983), children younger than 6 years do not learn to detect ambiguous messages. Nor is the difficulty one of syntactic or lexical competence, both of which are fairly advanced by 4–5 years.

One possible explanation rests in the limited ability of children younger than 6–7 years to detect indeterminacy (e.g., Fabricius, Sophian, & Wellman, 1987). Deák, Ray, and Pick (2003b) found that individual differences in this ability predict children's flexible response to appearance–reality questions. In the *Indeterminacy Detection* task, children are shown situations with indeterminate outcomes (e.g., what color chip would be pulled next from a box containing chips of many colors) or with determinate outcomes (e.g., all chips of one color). Children are asked to judge whether they could know the outcome “for sure” or whether they “have to guess.” Children who can judge whether a situation has a definite outcome or is unpredictable also select different labels for different aspects (i.e., “looks like...” and “is really...”) of deceptive objects. Although such correlational data are ambiguous, one interpretation is that children's growing awareness of *possibility*—the potential for alternative mental models to be consistent with given information about a question or problem—facilitates the activation and selection of multiple aspects (i.e., MARs) that cover multiple possible mappings. Nonverbal tasks show an age-related increase, between 4 and 7 years, in this ability to notice that there are multiple possible clues and answers to a problem (e.g., Vurpillot, 1968). In discourse or narrative, however, premature

resolution of a message's possible meanings would cause children to be relatively quick to judgment and rigid in their mappings (i.e., interpretations). This suggests that a higher-order logical skill—*noticing indeterminacy*—is a factor in the development of children's linguistic flexibility. This account is, however, speculative and in need of converging evidence.

1. Flexibility in Responding to Rules and Instructions

The ability to respond flexibly to changing and unpredictable messages, such as instructions or rules, improves substantially with age. Luria (1959) outlined a progression of skill in responding flexibly to verbal messages. When asked to retrieve a specific familiar object, 1-year-olds fail if a different, salient object is closer. Also, after making a response several times, they persist when a different response is mandated by the task (Diamond, 1994). When given a simple rule "If [X occurs], do [action1]," 2-year-olds tend to produce the action before X occurs. When given a salient but rule-invalid response signal, as in "Simon Says" (Reed, Pien, & Rothbart, 1984), 2- and 3-year-olds often impulsively produce the response. Also, in simple switch tasks involving bi-conditional rules (e.g., "When X happens, do [action1]; when Y happens, do [action2]"), 2-year-olds often fail to switch (Zelazo & Reznick, 1991). Switching between conditional rules for alternate responses (see below), or switching from familiar to novel responses (e.g., say "night" when you see a picture of the sun; Gerstadt, Hong, & Diamond, 1994), is difficult until 4 or 5 years of age.

These findings seem to show a clear progression in flexible message-processing skill, but the forces behind this progression remain to be specified. Empirical work has focused on children's flexible response to changing conditional rules. The Dimensional Change Card-Sort test (DCCS), refined by Zelazo and colleagues (e.g., Zelazo, Reznick, & Piñon, 1995), distills the rule-change problem. In this task children hear an unambiguous rule for choosing one of several responses (e.g., "blue things go in this box, and red things go in that box"). After several trials a new rule is given, demanding a response switch (e.g., "cars go in this box, and flowers go in that box").³ Usually each rule is easy; the question of

³The DCCS has been likened to a simplified Wisconsin Card-Sorting Test (Milner & Petrides, 1984), but there are significant differences: in the DCCS only 1–2 rules are used (and only two stimuli), yielding a much smaller problem space. Each rule is explicitly stated, making it a deductive, not inductive, test. Therefore, although both the DCCS and WCST test response switching, only the WCST assesses response-set learning rate or changes in learning rate (Lezak, 1995, Chapter 15), dependent variables that might differentiate adult frontal patients with different syndromes (Daigneault, Braun, & Whitaker, 1992; Taylor, Saint-Cyr, & Lang, 1986). Also, perseveration in the DCCS is less informative than perseveration in the WCST because *any* post-switch error in the former is, by default, coded as perseverative.

interest is whether the rule change carries a switch cost. The DCCS is schematized in Figure 1.

Table I summarizes results from several studies of preschoolers' DCCS performance. Between 3 and 4 years, the probability a child will switch responses according to the post-switch rule, rather than staying with the pre-switch rule, increases significantly. Because children who persevere seem to grasp both rules, Zelazo and Frye (1996) describe this as a dissociation of knowledge and action selection. Several other findings are notable. First, the age difference holds up when pre-testing is used to eliminate children who do not understand either the task or the shape and color words. This eliminates some mundane explanations of children's errors. Second, the rules are almost always "sort by shape" and "sort by color," applied to two simple, familiar shapes and colors combined in two low-dimensional stimuli (e.g., simple drawings of a red car and a blue flower). These are shown repeatedly

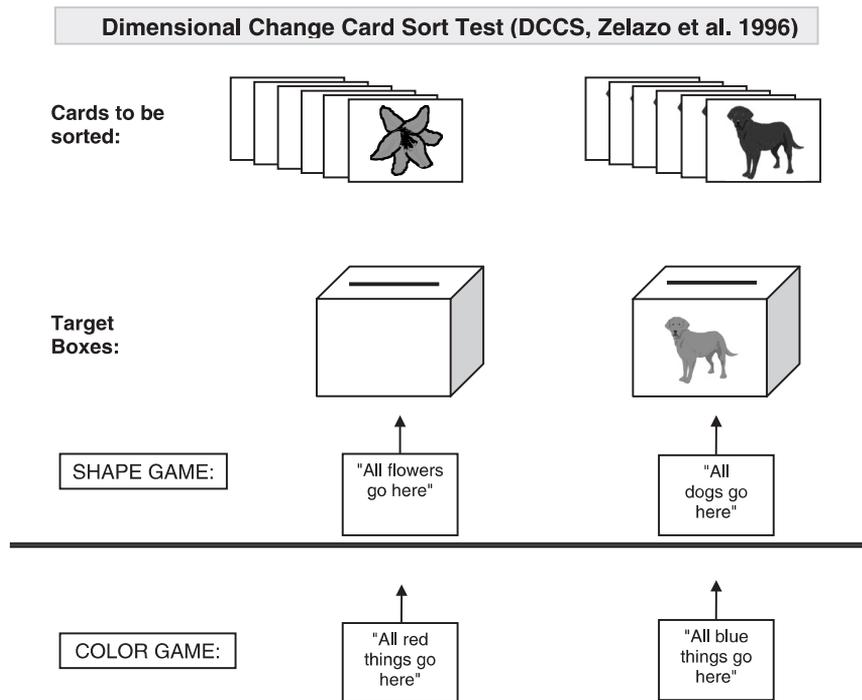


Fig. 1. Schematic illustration of the DCCS test: the pre-switch task includes an instruction and a sorting phase; the latter typically lasts from 1 to 6 trials. The post-switch task, which immediately follows, includes a re-instruction phase and a post-switch sorting phase. See text for additional information.

TABLE I

Summary of Reported Studies of the DCCS: Percentages of Children Who Perseverated on the Pre-switch Rule During the Post-switch Phase, by Age (3- vs. 4-year-olds)

Study	Percentage of perseverative children	
	3-year-olds	4-year-olds
Frye <i>et al.</i> (1995) Exp. 1 ($n = 40$)	87%	68%
Frye <i>et al.</i> (1995) Exp. 2 ($n = 40$) ¹	67%	27%
Zelazo <i>et al.</i> (1996) Exp. 1 ($n = 30$)	60%	10%
Mean	71%	35%

Note: Summarizes only those published experiments that report numbers of 3- and 4-year-olds who made 75–100% post-switch responses by a given rule (pre-switch: perseverative; post-switch: flexible).

¹Mean of two DCCS tests (given within-subjects).

across trials. In this task perseveration might stem from: (a) interference from a specific value (e.g., child cannot stop attending to red when it occurs), (b) a value–location association (e.g., once red things are associated with the right box, the child avoids putting them in the left one), (c) a value–location–motor response contingency (e.g., after placing red things on the right, it is hard to put them on the left), (d) selective attention to one dimension (e.g., after attending to color, it is hard to attend to shape), or (e) persistence of the first abstract rule (e.g., after adopting a color-sorting rule, it is hard to adopt a shape-sorting rule). The source of 3-year-olds' errors is therefore ambiguous.

Recent studies have reduced this ambiguity. Jacques *et al.* (1999) showed that children who perseverate on the DCCS judge that a perseverating puppet is correct but a rule-switching puppet is incorrect; conversely, children who flexibly switch rules make the opposite judgment (i.e., perseverating puppet is wrong). Also, Zelazo, Frye, and Rapus (1996, Experiment 3) showed that 3-year-olds perseverate just as much when making a verbal (nonsorting) response. Thus, motor responses are not critical. Perner and Lang (2002) found 3-year-olds can make a within-dimension rule switch that requires reversing a value↔location association, and Towse *et al.* (2000) found that using new boxes in the post-switch trials did not improve flexibility. Thus, perseveration is not based on interference from prior motor responses or locations (eliminating (b) and (c)). Also, 3-year-olds can, in some tasks, switch responses (eliminating (a)). It seems instead that their difficulty lies in updating the current rule, or switching attention to a new, relevant dimension.

Other evidence sheds light on the nature of children's switching errors, and the dissociation between knowledge and sorting response (Zelazo & Frye, 1996). For example, 2.5-year-olds show a similar dissociation in a simpler test of sorting cards into two categories (e.g., animals that fly vs. animals that walk). Sorting yields more errors than verbally verifying the relevant category each item (e.g., answering "yes" or "no" when asked "Does this one walk?") Zelazo & Reznick, 1991; Zelazo, Reznick, & Piñon, 1995). Stimuli in this paradigm are more diverse than DCCS stimuli, suggesting that repetition of specific items is not necessary for perseveration, though it should be noted that two-thirds of children's errors were perseverative, which is exactly what we would expect if children were responding by chance.

Are 2.5-year-olds' errors in Zelazo and Reznick's (1991) classification task due to the same factors as 3-year-olds' DCCS errors? In an important regard the classification task is different: it requires a simpler binary distinction, not a contingency choice between bi-conditional rules. That is, children's failure in the DCCS is in switching from one category-based response to another, or in updating the aspect implicated by the latest rule. Zelazo and Frye (1996) suggest that this added complexity accounts for the higher age of mastery. However, the age difference might be due to an added discourse demand. The DCCS requires knowing that social rules often are mutually exclusive, so a new rule replaces older ones. That knowledge is likely acquired in semiformal social contexts like preschool; thus, older preschoolers are more likely than younger ones to have this discourse knowledge and use it in a rule-switching situation.

In the following subsections (IV.B.1.a–c), I will elaborate on some alternative accounts.

a. Evaluating Rule-following Flexibility: Symbolic and Lexical Mapping. Why do children make perseverative errors if, in both the DCCS and the classification task (Zelazo & Reznick, 1991), they know enough to solve each problem? One possibility is an unrecognized mapping demand: the "right" response, in both sorting tasks, is arbitrary in a way that is rather odd to children. Nothing in the stimulus array or prior knowledge stipulates, for instance, putting blue things in a box on the left, or putting "animals that fly" into a box on the right. This arbitrary mapping is akin to algebra or predicate logic (e.g., "Let all red things be X"). Children might respond to such seemingly arbitrary mappings without understanding that they are merely conventional, and can be invalidated or switched by agreement or by a verbal signal. By contrast, mappings with which preschool children are more familiar—namely, word-referent mappings—also are abstract and arbitrary, but do *not* change spontaneously.

This is, perhaps, why knowledge tests in the DCCS and the classification test (e.g., “Is this a flying thing?”) are easier: they only require retrieval of a known (static, not arbitrarily changing) fact or designator of the referent.

Another idea concerns rule meaning rather than mappings. Maybe children perseverate if they cannot select the aspect designated by the predicate of the current rule (e.g., “In the shape game...”). That is, some children might have trouble selecting blue-ness or red-ness (rather than dog-ness) based on the aspect labeled in the rule (i.e., “*shape* game”). There is very little data on children’s understanding of dimension words like “shape” and “color”: Shatz and Backscheider (2001) reported that some toddlers map dimension words onto appropriate value words (e.g., “red”), but perhaps many 3-year-olds still have a tenuous grasp of the dimension labels. Munakata and Yerys (2001) suggested that this is why some 3-year-olds do not differentiate successive rules. They modified the DCCS knowledge question (e.g., “Where does the _____ go in the shape game?”) so items were described by both aspects (e.g., “red car”) of a picture. As a result, 3-year-olds did poorly answering knowledge questions. It seems they cannot use the aspect named in the rule to choose the correct word from a complex locution (e.g., “red car”).

Other indirect evidence comes from a variant of the DCCS with three rules (Narasimham & Deák, 2001): pilot testing revealed it was indeed harder for preschool children to use the abstract dimension labels “shape,” “size,” and “color” to classify complex items (e.g., a small red bird), even when the value labels (e.g., “small”) were familiar. This seemed to reflect uncertainty about the meaning of the rules. This could also explain Towse *et al.*’s (2000) finding that 3-year-olds’ perseveration diminished when the post-switch rule was demonstrated (like the pre-switch rule), and Bohlmann’s (2001) finding that 1–2 trials of feedback in the post-switch phase eliminated most 3-year-olds’ perseveration.

b. Evaluating Rule-following Flexibility: Complexity. The dominant account of children’s rule-following flexibility (Zelazo & Frye, 1996) is based on the degree of rule complexity a child can represent and use. Two-year-olds do not flexibly shift responses using a binary (or 1° level) rule contingency (see Figure 2). Three-year-olds do not flexibly choose a 2° level rule to select subordinate contingent responses (e.g., DCCS). Thus, from 2 to 4 years, children acquire controlled flexibility to make progressively more complex rule-based responses.

Challenges to the Cognitive Complexity and Control, or CCC, theory (Zelazo & Frye, 1996) have focused on whether contingency complexity is indeed the critical limiting factor in children’s flexibility, and whether

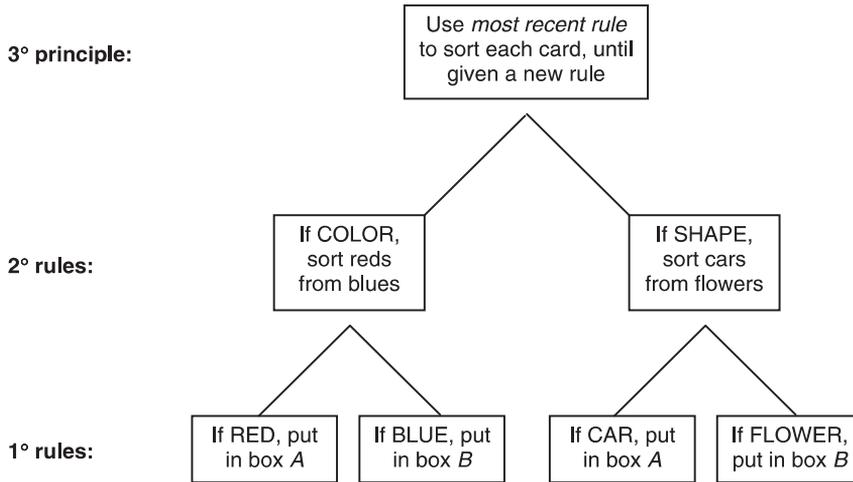


Fig. 2. Illustration of levels of complexity of the contingencies (rules) in the DCCS, after Zelazo and Frye (1996). We have added an overarching principle/rule concerning expectations for adapting successive responses to verbal instructions.

analyses of rule complexity are adequate (e.g., Perner, Stummer, & Lang, 1999). It is possible that Zelazo and Frye underestimate the complexity of the DCCS because an additional, implicit pragmatic rule or principle is needed to respond flexibly or consistently in different verbal or questioning situations: *on every trial, use the last rule to select a response, until a different rule is given*. Figure 3 adds this principle to the apex of the hierarchy. This should guide responses to *each* item, regardless of prior responses and the number of rule switch or time since a rule switch. The principle is presumed (but not stated) in, besides the DCCS, many formal problem-solving activities (e.g., school work), though not all social situations impose it; for example, free play in preschool is guided by the principle *choose from allowable activities and switch at will until instructed to stop*. Adults do not typically explicate these principles, so children may choose the wrong one. If, in the DCCS, children use a principle like *make the most familiar response until corrected*, which works perfectly well in many social situations, they will perseverate. This suggests children's perseveration might stem from incorrect interpretation of the pragmatics of rule-following tasks, instead of (or in addition to) limits on controllable rule complexity. Though there is limited evidence for this hypothesis, Perner and Lang (2002) gave 3- and 4-year-old children a standard DCCS, as well as three easier switching tasks. Three-year-olds produced the usual pattern of perseveration only in the standard DCCS, and only when it was given first. In contrast, they flexibly

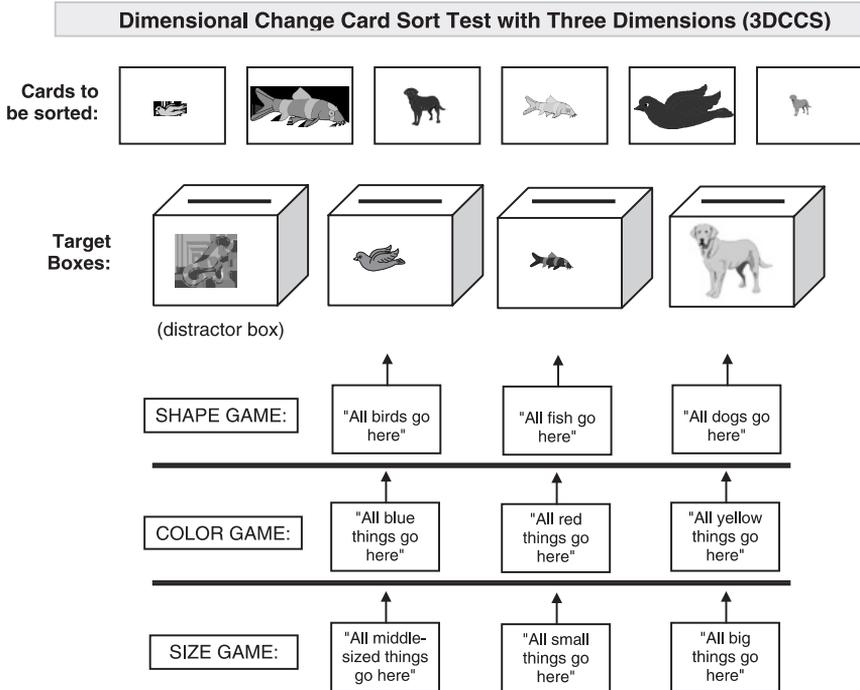


Fig. 3. Schematic illustration of the Three-Dimensions Change Card-Sort test (3DCCS). The pre-switch task is followed by two post-switch tasks, each with a different rule, and six diverse sorting stimuli per rule. On each trial children must choose between four boxes, one of which shows a shape (i.e., animal) match, one with a color match, one with a size match, and one with a distractor animal. See text for additional information.

switched rules for giving cards to cartoon characters, based on stated preferences. For instance, changing the rules from *Mickey Mouse likes red things* and *Donald Duck likes black things* to *Mickey likes circles* and *Donald likes squares* elicited near-ceiling performance. This task is as complex as the DCCS, so complexity was not governing performance. More strikingly, when 3-year-olds did any such easier task first, they then generalized the rule-switching strategy to the DCCS. This suggests that perseveration follows adoption of the wrong implicit pragmatic principle, and a “task set” for adopting the correct principle will yield nonperseverative performance.

Another problem for the CCC is that complexity limits do not seem to generalize across linguistic reasoning tasks. The syntax and morphology of a language, for instance, form complex contingency systems wherein multiple variables must be considered to produce or interpret utterances (Maratsos, 1998). Two- and 3-year-olds accurately sift through multiple, ambiguous

variables (e.g., definiteness, case, noun class, number, tense, aspect, etc.) and learn, without explicit help, to assign ambiguous constituents to roles in a sentence, to inflect constituents correctly, etc. (e.g., MacWhinney, 1978). Such variables are denoted, across languages, by diverse, hard-to-analyze, unpredictable markers. Yet for most markers in most languages, 3-year-olds can track and adapt to several unpredictably changing variables at once, and in real time (i.e., quickly). For instance, MacWhinney, Pléh, and Bates (1985) found that Hungarian 2- to 3-year-olds use case and animacy cues to assign nouns in transitive sentences to subject or object slots. Each child did this accurately over many sentences that varied unpredictably (and repeated constituents, thus requiring flexibility). Other studies have shown that English-speaking 2-year-olds take into account syntactic, semantic and conceptual contingencies to interpret sentences; for instance, they use definiteness and animacy to infer the referent of a novel noun (Katz, Baker, & Macnamara, 1974). Also, 2-year-olds consider object location and listener's knowledge when deciding how much descriptive and deictic information is needed to request an object from an adult (O'Neill, 1996). Detailed analysis of such examples reveals the difficulty of objectively formalizing the complexity of different linguistic contingencies, but it is clear that 2- and 3-year-olds, in everyday discourse, interpret messages with respect to combinations of linguistic cues that far exceed complexity limits proposed by Zelazo and Frye (1996).

Another question concerns branching complexity (i.e., rule breadth, not depth) and flexibility across changing rules. In the DCCS, stimuli, questions, and responses are simple and repetitive. Deák (2000) speculated that this reduces 3-year-olds' flexibility, because they are "lulled," during pre-switch trials, into believing that they have deduced the right response for each card, and thereafter they stop analyzing verbal input (i.e., instructions). When the new rule is stated, children's certainty in "known" responses (plus the extensive similarity of post- and pre-switch trials) outweighs the new instruction and corresponding opposite responses. For older children, in contrast, the *most recent rule* principle allows the new instruction to prevail.

Perhaps making the test more difficult and less predictable would push 3-year-olds from comfortable, practiced, confident responses toward reliance on a verbal rule. That is, children might rely on verbal cues (e.g., rules) when other salient cues become less predictable. This leads to a counterintuitive prediction: perseveration should *decrease* in more complex and variable tasks. Narasimham and Deák (2001) tested this in a modified card-sorting test. The 3DCCS varies three aspects of the stimuli, so cards are sorted by three different rules. This allows two rule shifts, rather than one, and increases the number of 1° level contingencies from four (in the DCCS) to nine (due to increased branching of the contingency tree at

the 1 and 2° levels). Thus, though the 3DCCS is unaltered in complexity as defined by Zelazo and Frye (i.e., branching depth), it has more variable and diverse stimuli as well as rule *cardinality*. In the 3DCCS, children sort cards showing an animal (dog, bird, or fish) in one of three colors (red, blue, or yellow) and sizes (“little,” “middle,” “big”). Six cards are randomly chosen so that each value is depicted twice, in different combinations. These are sorted into one of four boxes, each defined by a unique sample card (e.g., small yellow dog, medium red bird, large blue fish, and long black snake [distractor]). Children sort each test card three times using three different rules: shape, color, and size. The procedure is shown in Figure 3.

Results from the 3DCCS are compatible with data from the DCCS. As shown in Figure 4, 3-year-olds make fewer correct responses overall than 4-year-olds, and 3-year-olds’ rule compliance declines more sharply after the first block. Four-year-olds are more likely to follow both post-switch rules, demonstrating an age-related increase in flexibility using a more variable test with the same contingency depth as the DCCS. However, children produced a wider range of response patterns in the 3DCCS than in the DCCS. Some children (25%) followed one of the two post-switch rules; others (10%) changed their responses rather indiscriminately. Also, whereas in the DCCS

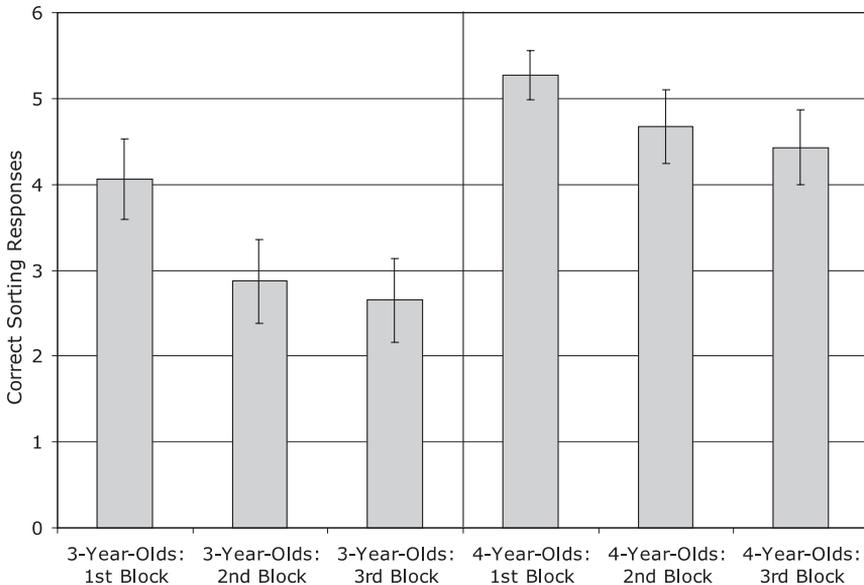


Fig. 4. Mean number of correct responses (out of 6) to the first, second, and third rules in the 3DCCS, by age ($N = 61$). Bars show standard errors.

TABLE II
 Number of Flexible, Partly Flexible, and Perseverative 3-year-olds
 ($n = 16$) and 4-year-olds ($n = 26$) in the 3DCCS

Age	Response patterns		
	Flexible	Partly flexible	Perseverative
3-year-olds	2 (12%)	6 (38%)	8 (50%)
4-year-olds	14 (54%)	6 (23%)	6 (23%)

most children follow one rule (pre- or post-switch) on all post-switch trials, in the 3DCCS they were not so consistent: 20% changed their selected aspect at least once *within* a block. Thus, a more variable test revealed that the dichotomy of flexible versus perseverative children (defined as up to 17% errors or at least 83%) is not so sharp as it appears in the DCCS (see Table II). So increasing number and diversity of rules and stimuli does not eliminate age differences, but it reveals a general problem with our focus on perseveration: in many popular tasks such as the DCCS, the only possible error is perseveration.

In sum, much evidence is consistent with the CCC theory, but a few findings (e.g., Perner & Lang, 2002) are not, and there are serious concerns that the theory cannot predict children's competency in language processing tasks that do not involve rules, but nevertheless require knowledge of complex contingencies.

c. Rule-following Complexity: Inhibitory Accounts. The most prominent alternative to the CCC focuses on general inhibitory capacity (Dempster, 1992; Houdé, 2000). Immaturity of prefrontal cortex (which persists until adulthood) is believed to prevent efficient inhibition of prior responses or representations, thus increasing perseveration. This account is appealing and parsimonious. If correct, it reduces preschoolers' inflexibility to a single cognitive process. Unfortunately, the account is so vague that it is unfalsifiable without much elaboration. Also, perseveration is not necessarily caused by inhibitory failure. We must specify exactly *what* perseverative children fail to inhibit, what neural processes are involved, and what tests could falsify a claim that every case of perseveration is due to inhibitory failure.

Consider the claim for a prefrontal cortical mechanism. No study has showed an increased rate, or biological milestone, in maturation of prefrontal cortex between 3 and 4 years. This would be important to demonstrate to support the claim that improvement in rule-switching

flexibility is a result of maturation of frontal cortex-controlled inhibitory processes. Also, no study supports a general inhibitory trait that predicts age and individual differences in children's flexibility. A study by Carlson and Moses (2001) found little coherence across tests of inhibition in preschool children. Across 10 tasks, all hypothesized to require cognitive inhibition of responses to rules or requests, the mean simple correlation was $r = .28$. With age, gender, and verbal IQ partialled out, $r = .16$. Thus, no unitary underlying trait was evident, and more homogeneous subsets of tasks, characterized by conflict between competing responses to instructions (e.g., DCCS), were not much more cohesive: their mean partial correlation averaged only $r = .22$. The idea that a general inhibitory trait can account for age and individual differences in flexibility thus remains unconfirmed.

Perhaps, however, a better specified inhibitory account is viable. Diamond (1998) argued that holding several relations in mind (e.g., lower-order response contingencies), while inhibiting highly activated responses, is difficult for children younger than 6 years, due to immaturity of a region of prefrontal cortex. That region is implicated in nonhuman primates' performance on tests of working memory-plus-inhibition (e.g., delayed nonmatch to sample; Diamond & Taylor, 1996). These demands are at levels in the DCCS that challenge typically developing 3-year-olds; the same demands are presumed greater in another test, the Stroop Day/Night (Gerstadt, Hong, & Diamond, 1994), that challenges older children. In that test, children must inhibit a learned verbal association: they are instructed to say "day" when shown a picture of the moon, and "night" when shown a picture of the sun. Note, however, that it has not been shown that the Stroop task has objectively greater inhibition-plus-memory demands. Regardless, Diamond *et al.* (1997) found that children with mild, treated phenylketonuria (PKU), which impairs the prefrontal system, perform worse than same-age controls on these tests. For example, children with PKU as old as 5 years showed increased error rates in the DCCS.

Diamond's theory provides much-needed sharpening of the general inhibitory account, but it cannot explain all available data. At issue is the claim that memory for rules or verbal input is a second demand that makes the DCCS, delayed nonmatch to sample, and Stroop tests difficult for preschool children. However, Deák, Ray, and Brenneman (2003a) found that several verbal capacities, but *not* verbal working memory span, predicted preschoolers' perseverative appearance-reality errors. Also, Zelazo, Reznick, and Pinoñ (1995) found little or no effect of working memory load on children's rule-following flexibility. Finally, Perner and Lang's (2002) finding that 3-year-olds fail the DCCS but succeed at other rule-switching tasks with similar inhibition and memory demands cannot easily be explained by Diamond's theory.

Thus, the role of working memory in flexible rule-following remains hypothetical. Diamond is probably correct that *some* process of encoding and retrieving representations of rules or instructions is critical to flexibility. Inability to remember rules would surely impair flexible rule switching. Also, switching from one rule to another would in some case require suppressing familiar responses. In some sense, then, Diamond's theory is probably correct, but there is little evidence that individual and age differences in working memory and inhibitory capacity can account for the difference between children who perseverate and those who are flexible.

d. Rule-following Complexity: Summary. These accounts do not exhaust the range of possible accounts of age and individual differences in flexible response to rules and instructions. For example, Deák (2000b) emphasizes the role of growing understanding of pragmatic cues to task demands and changes in the development of flexibility. But this account is not necessarily incompatible with either the CCC or a inhibition-plus-memory account. For example, a pragmatic cues account shares with CCC an emphasis on correctly representing task demands, though it differs from CCC by incorporating the child's knowledge of discourse conventions. Each account also can be accommodated by the MARM metaphor. For example, complexity can be coded as the number of aspects that remain active in the MAR. Working memory can be coded as the number of aspects that remain sufficiently active to be available for response or description. Pragmatic cues draw children's attention to the input currents intended by the adult.

Rule-switching paradigms have yielded important data on the development of children's linguistic flexibility. Yet they represent a limited range of language tasks. Though caregivers sometimes give young children explicit instructions or rules, they probably avoid giving series of changing instructions. Also, caregivers might tolerate a fairly high rate of noncompliance, and repeat rules or give assistance (e.g., feedback) as needed. Thus, it is unclear how results from rule-switching tests extend to everyday language processing. This limitation must be addressed with naturalistic studies of adult–children communication. For now, however, we can compare results from tests of rule-switching to results from other tests of linguistic flexibility. One of these, inferring word meanings, is considered next.

C. FLEXIBLE USE OF VERBAL CONTEXT TO INFER WORD MEANINGS

1. Age-related Changes in Flexible Induction of Word Meanings

In a few short years, children learn the meanings of thousands of words and locutions. The extensive literature on children's word learning and

vocabulary development (Bloom, 2000; Deák, 2000b) has only begun to address how children can flexibly respond to changing cues to the meanings of the unfamiliar words they hear. That is, though many studies have tested children's use of various cues to infer a word's possible meaning, few have tested how children adapt their representation of possible meanings as they hear new, unpredictable cues and messages. Yet flexible cue selection is critical because everyday discourse carries many kinds of cues to meaning, and these change from utterance to utterance. Even the same utterance can carry opposite meanings in two contexts (e.g., "Well, that was a great movie!"). As in this case, prosody may be the critical cue; often, though, it will not. The next utterance's meaning might rest on a different combination of syntactic, lexical, semantic, discourse, and paralinguistic cues. Even this does not exhaust the complexity of the problem: listeners must also consider physical, social, emotional, and cognitive contextual variables (e.g., nearby objects; speaker's interests; recent notable events). In short, the meanings of messages hinge on a changing, unpredictable series of diverse, shifting linguistic, paralinguistic, and nonlinguistic cues.

So far I have described the general problem, but preschool children face a particularly concentrated version: to build a lexicon from the unfamiliar words that liberally pepper the utterances they hear. For this they have available a wide spectrum of cues to words' meanings; yet their grasp of these cues is profoundly limited. Therefore, they are faced with the need to infer more meaning with less useable information.

The dual challenge to preschoolers, then, is to use an unpredictable array of cues to interpret the meanings of changing messages with unknown words, and to learn the words as well. This challenge could be exacerbated by cognitive inflexibility, as in rule-switching tasks (Section IV.B). However, the outcome of the challenge is near-complete fluency, and a sizeable lexicon, by the fourth birthday. This is a paradox: preschoolers are inflexible in rule-switching tasks, but they learn very many words from a shifting, uncertain platform of linguistic cues. Perhaps young children are more flexible when inferring meanings from probabilistic, unpredictable cues than when following simple, deterministic rules. How can we make sense of this apparent paradox?

I have studied how preschool children meet the practical demand to infer meanings and learn words by flexibly mining an unstable cue-lode. A starting assumption is that the most useful information about a novel word meaning is in its predicate—the phrases and words that surround it and form a coherent message meaning. Novel words are hard to interpret from nonverbal or syntactic cues alone (Deák, 2000b), but the predicate context of a novel word typically carries enough semantic, syntactic, and morphological information to powerfully constrain its likely meaning (Deák, 2000a,b; Goodman,

McDonough, & Brown, 1998). It is therefore critical that children pull information about word meaning from the predicate context. Predicates are, however, changeable and unpredictable. Especially when children hear several unfamiliar words within a situation or conversation, they must adapt to each word's specific predicate context. This might be particularly important in settings with low-frequency referents (e.g., zoos; museums), or during special activities (e.g., preschool field trips). But more centrally, children might hear multiple unfamiliar words in conversation (see Beals & Tabors, 1995, on word learning at mealtimes), when hearing a new story, or when accompanying parents on errands.

The Flexible Induction of Meaning (*FIM*) test requires children to infer the meanings of novel words by using changing predicate cues to flexibly shift attention among aspects of the referent. In the *FIM-Ob* children infer meanings of words for object properties (Deák, 2000b). In a newer version, designated *FIM-AI* (for *aliens*; Narasimham & Deák, 2001), children infer meanings of novel words for properties of strange creatures. The logic of the test is as follows:

- Sets of items are presented several times. Each set includes a *standard* and four comparison items that share different properties with the standard. In *FIM-Ob*, comparison objects have novel (i.e., not readily nameable) body shapes, materials, and affixed parts that differ from set to set. In each set one comparison object has the same shape as the standard, one is made of the same material, one has same affixed part, and a fourth is a dissimilar distractor. An example is shown in Figure 5.

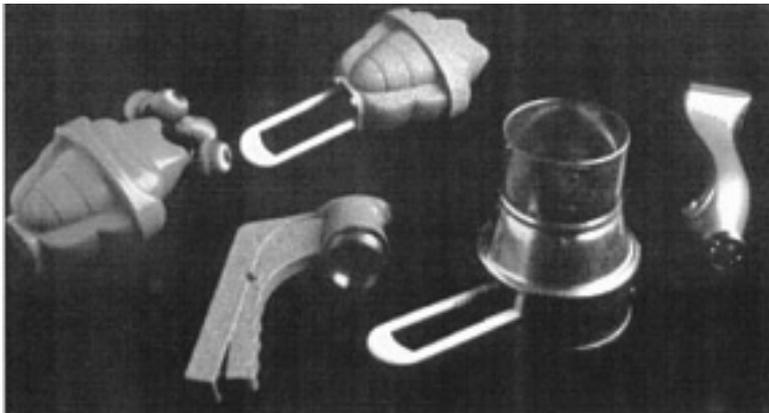


Fig. 5. Example of set from the *FIM-Ob* test (Deák, 2000b), including standard object and four comparison objects (same-shape, same-material, same-part, and distractor).

- Each time a given set is presented the standard is described, somewhat ambiguously (like real word-learning situations), by a novel word modified by a *predicate cue*. The predicate implies a specific referent meaning. In the FIM-Ob, each word follows one of three predicates: “looks like a . . .” (or “is a”), “is made of,” or “has a.” These imply the novel shape, material, or part, respectively.
- After hearing a predicate-word declarative (e.g., “This one is made of plexar”), the child is asked to generalize the word to one of the comparison items (e.g., “Find another one that is made of [novel word]”). Inductive responses are classified as predicate-appropriate (e.g., judging the same-material object to be “[also] made of plexar”) or predicate-inappropriate.
- Each set is presented several times with a different predicate and novel word. For example, the first time a set is shown the child might hear that the standard “is made of stylar,” and, on subsequent trials, that it “has a graggle,” and “looks like an introm.” Flexibility is related to predicate-appropriate responses, particularly in later trials (i.e., generalizing the second and third words for a set to the properties implied by those predicates). A useful dependent measure is the number of *predicate-appropriate switches*: number of post-switch (i.e., second or third trial) choices of previously unselected, predicate-appropriate objects as referents.

Because children choose from several comparison items over several trials, for each of several sets, this paradigm can reveal more varied flexible and inflexible response patterns than can other tests of flexibility (e.g., DCCS). This allows testing (described below) of simple generalizations like “3-year-olds persevere; 4-year-olds don’t.” Also, unlike the DCCS, FIM tests *inductive flexibility*: cues are not hear deterministic rules but predicate cues with probabilistic implications relative to some physical array. Nevertheless, 5- and 6-year-olds make mostly appropriate responses in the FIM-Ob (Deák, 2000b). Thus, the predicate cues are sufficiently informative.

The FIM also permits control of temporal and sequential parameters relevant to response set, interference, and flexibility. For example, predicate order might be relevant because even if children grasp each predicate meaning, some are easier than others. Predicates that specifically imply a single available aspect or property have high *implicature specificity* and permit easy mapping. Predicates that are weakly associated with a single aspect are close to equally associated with two or more aspects having low implicature specificity, and are harder to map. Baseline task difficulty is a critical factor to consider because it is ecologically important (i.e., when we switch from one task to another, it is rare that the tasks are equally

interesting, easy, and motivating to us), because the difficulty of any given task is likely to change with age, and because difficulty might interact with order. For instance, switching to an easier versus a harder task impacts adults' task-switching costs (Monsell, Yeung, & Azuma, 2000). In the FIM, flexibility might be greater when switching to an easy versus a hard predicate.

When children's first inference about a set is based on an easy predicate, they make more perseverative errors on subsequent trials than when the first predicate is difficult. In the FIM-Ob, "is made of" specifically implies material kind, whereas the less-specific predicate "looks like a" (or "is a") is ambiguous to preschool children.⁴ When the first word follows "is made of," 3- to 6-year-olds usually generalize it to a same-material object. In post-switch trials, though, when generalizing words following "looks like a," 3- and 4-year-olds often perseverate by selecting the same-material object again (Deák, 2000b). Figure 6 shows the mean number of predicate-appropriate responses in the first, second, and third trials, contingent on the initial predicate. The decline of appropriate responses in later blocks, especially in 3-year-olds, reflects perseveration on initial responses. This, in turn, depends partly on whether the first inference was supported by highly specific predicate–aspect implication. Selecting a strongly cue-implied aspect interferes with 3-year-olds' later responses to the same stimulus array.

Predicate order does not, however, fully explain the development of flexible induction of word meaning. Increasing sensitivity to the implications of various predicate cues, and awareness that successive word meanings should be independently inferred, also contribute. To better show this, children's appropriate switches (Deák, 2000b, Experiments 1–2)

⁴The "looks like a" predicate was chosen to pit predicate specificity against the *shape bias* hypothesis. Smith and colleagues (see Smith, 1999) argued that preschool children learn to map object count nouns onto shape (as opposed to color, size, or other properties). Results from the FIM-Ob support the predicate specificity account: though children in a no-word pre-test judged same-shape objects as most similar to standards, 3- and 4-year-olds did not selectively generalize nouns following "looks like a..." or "is a..." to the same-shape objects. Because these predicates are ambiguous semantically but not syntactically—that is, they create a count noun syntactic frame—the finding shows that children do not invariably map count nouns to shape categories. The nonmatching part, incidentally, did not ameliorate selection of same-shape objects: children did not disproportionately choose same-part objects as an alternative. Deák (2000b) concluded that preschoolers do not simply learn to map object count nouns to object shape. A shape bias might emerge when children generalize labels to simple line drawing or objects, which emphasize shape (Deák & Bauer, 1996). Notably, in most of their studies Smith and colleagues showed children the same objects, all with simple and distinctive shapes. In general, though, children seem rather flexible in mapping label to object properties, taking into account a variety of patterns, properties, and similarities.

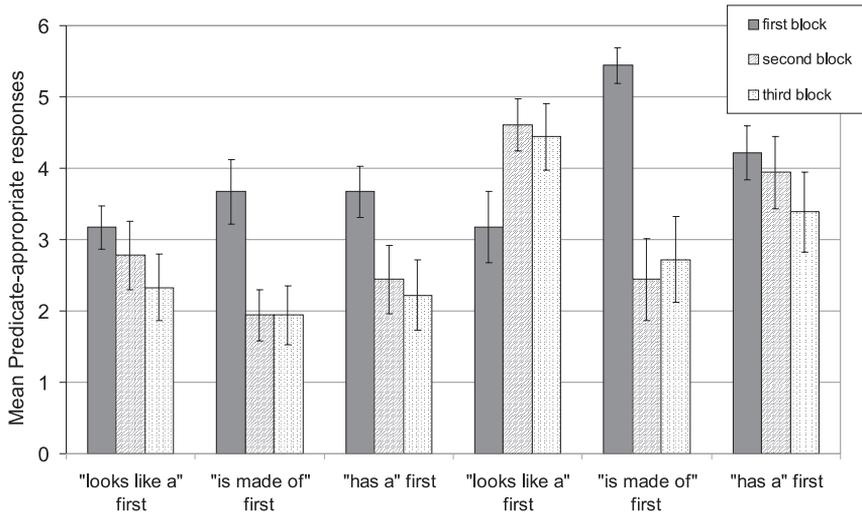


Fig. 6. Mean appropriate inferences about the first, second, and third words for an object, based on first predicate and child's age (from Deák, 2000b, Experiments 1–2 aggregated). Bars show standard errors.

were weighted by a predicate order difficulty coefficient.⁵ Weighted means are shown in Figure 7. Appropriate switches increased with age, from 2.9 (out of 12) at 3 years to 5.9 at 4 years. Four-year-olds, but not 3-year-olds, made more predicate-appropriate switches than expected by chance. It is critical to note, however, that 3-year-olds make more appropriate responses than expected in the first block, suggesting that can draw the implications of these predicates, but cannot reliably do so in the face of conflicting prior responses. The shift from inflexible responding at 3 years to partly flexible responding at 4 years and fully flexible responding at 5 or 6 years is only moderated, but not dependent, on predicate order.

Nevertheless, predicate specificity is a critical factor in word learning. The FIM-Ob was designed in part to pit this claim against the *shape bias* hypothesis—the idea that children learn to map object count nouns onto

⁵The specific weighting procedure was to take, for each group, the ratio of mean first-block appropriate responses to a given predicate by the mean for all three predicates. Only first block responses are used because they are not complicated by switching. These ratios deviate from 1.0 to the extent that the predicates differ in specificity (e.g., an easy predicate receives a weight above 1.0). The reciprocal of the weight is multiplied by the number of correct switches produced by a child in response to that predicate in a later block. In this way, correct switches to an *easier* predicate receive less “credit” than correct switches to a *harder* predicate.

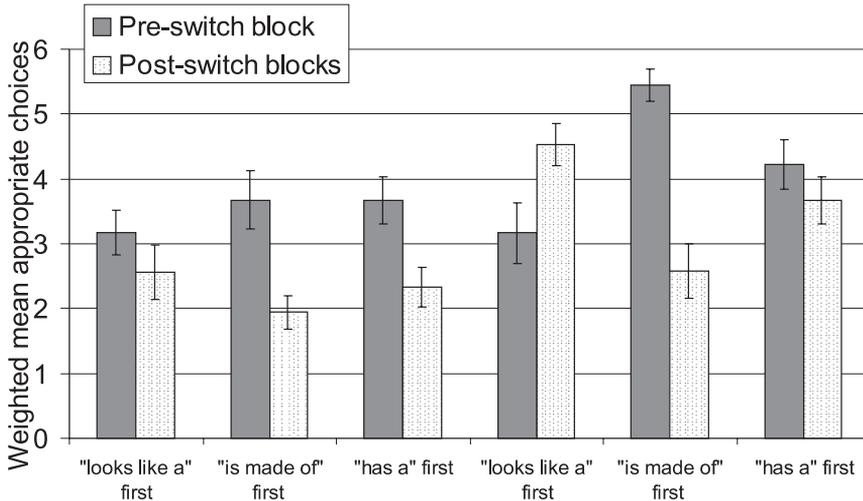


Fig. 7. Mean predicate-appropriate response switches (weighted to reflect cue order difficulty) in blocks 2 and 3 (from Deák, 2000b, Experiments 1–2). Bars show standard errors.

shape rather than other properties like color or size (see Smith, 1999, for review). Deák (2000b) found that predicate implications, and children's adaptation to predicates, overrides simple associations between aspects (shape) and a syntactic class (count noun). Three- and 4-year-olds did *not* selectively extend nouns predicated by "looks like a" or "is a" to same-shape objects, and 4-year-olds selectively generalized count nouns predicated by "has a" to small parts rather than objects with the same body shape. It was not that shapes were subtle or uninteresting—in a pre-test, children judged the same-shape objects to be more similar than the other comparison objects to the standards.⁶ Nor was it that a same-shape interpretation of words predicated by "looks like a..." was conceptually implausible, because 5- and 6-year-olds overwhelmingly made this choice. Finally, there is no syntactic ambiguity—"looks like a" and "is a" *must* modify count nouns (if the noun phrase is a single lexeme). The best interpretation, then, is that because the predicate "looks like a..." is semantically ambiguous (i.e., has nonspecific implications), children with less semantic knowledge either cannot or will not use this cue to guide their response—in fact, its ambiguity seems to dissuade them choosing the most perceptually salient match! Deák (2000b) concluded that a shape bias

⁶The fact that standard and same-shape objects differed by one part, incidentally, did not seem to reduce shape-based choices; see Deák (2000b) for details.

might emerge when children generalize words for simplified drawings or objects that emphasize shape (Deák & Bauer, 1996), but in general, young children will flexibly choose from a variety of aspects as meanings of novel words, based on the specific meaning context of a word, not on rigid associations between properties and syntactic categories.

The data from the FIM, however, show a restriction on younger children's flexibility in inferring multiple word meanings within a situation. Though early word learning is often described as precocious, even 4-year-olds had trouble using predicate cues when the inferred referents of previously learned words were present. This was true even if the later predicate cues were interpretable, and if children were given preliminary practice with those predicate cues. Children's errors show a blind spot in their lexical problem solving: they do not require word meanings to be consistent with the semantic implications of the immediate linguistic context. The other meaningful elements within an utterance that modify a word are the final arbiters of its meaning—not, for example, what one happens to be thinking about when the word is uttered. Yet 3- and 4-year-olds in the FIM sometimes map a new word onto the same referent of a previous word. This shows a baffling "leakage" of implication across utterances, and thus ignorance of the relative importance of different kinds of cues (i.e., local predicates vs. past utterances) for determining word meaning, as well as ignorance that different words for a referent typically refer to different aspects (excepting the rare true synonym). Thus, in situations that test these conflicts, some preschool children do not demonstrate practical knowledge of these basic characteristics of word meanings.

2. Individual Differences in Children's Flexible Induction of Meaning

In addition to age differences, the FIM reveals individual differences in preschool children's flexibility. Even among children who make more predicate-appropriate switches than expected by chance, some children shift their responses to all three predicates; others shift for only one of the two predicates. If the former is defined by at least 80% appropriate responses to each predicate (25% is expected by chance), no 3-year-old, 28% of 4-year-olds, and 73% of 6-year-olds meet the higher criterion (i.e., fully flexible). Partial flexibility—defined by at least 80% appropriate responses to only two predicates—shows a notable pattern: children are most likely to perseverate in post-switch responses to "looks like a" words, and never perseverate in post-switch responses to "is made of" words. Thus, children on the cusp of flexible word learning are heavily dependent on predicate specificity.

Among inflexible children, some (about 25–30%) consistently perseverate, seldom if ever switching responses after the first. Half of these children

perseverate on single aspect; for example *always* choosing the same-material objects. The chosen aspect is usually that implied by the first predicate (indicating that even these children pay some attention to predicate context), unless the first predicate is “looks like a.” The remaining children persistently focus on a specific item from each set, with no apparent pattern across sets. Perhaps these children do not notice the predicate cue, or do not know whether it should override salient perceptual similarities. Other inflexible 3- to 6-year-olds (about 16% of sample), mostly 3-year-olds, are *indiscriminate*: they switch some responses over trials, but not based on predicate cues. Perhaps these children notice a change between successive questions (e.g., a different novel word), and expect different words to have different meanings, but fail to notice or draw the implication of each predicate cue. Perhaps they then switch responses in hopes of receiving feedback from the adult (Speer, 1984).

I have described these results to show that perseveration is not the inevitable alternative to flexibility. Also, perseveration is probabilistic (i.e., the same child might perseverate from task A to B, but not C) and mediated by factors like task order (see also Perner & Lang, 2001). This is revealed only by more complex tests than the DCCS or the Stroop. Perseveration also follows different kinds of interference (e.g., attributes or specific items). Conversely, flexibility also is graded and context dependent. Understanding patterns of meaning (e.g., in the lexicon), and various meaning cues, is important for adaptation to changing contexts of meaning. Children who do not notice changing meaning cues (e.g., predicates), or do not know their implications, will be inflexible. They might perseverate (at least in some inferences), or select meanings haphazardly. How children construe meaning cues, and the importance of changes in these cues across utterances, determines their flexibility in inferring meaning. Other, poorly understood factors determine how inflexibility is manifested. In the FIM at least three variables shift from trial to trial: object array, words, and predicate cues. If children do not expect different words to have different meanings, and different predicates to imply different stimulus aspects, there is no reason why they should not perseverate. It does not mean that they are *incapable* of inhibiting prior responses; it is at least as plausible that they do not recognize the demand to suppress that response. In contrast, if children realize that the question is changing across trials, but fail to focus on the relevant information (i.e., predicate cue), they might respond indiscriminately.

Even if these claims are true, they do not presuppose that individual differences in ability to flexibly induce meaning are stable within a child. That is, are some 3- and 4-year-olds consistently more flexible in inferring meaning? To address this, Deák and Narasimham (in preparation)

administered both the FIM-Ob and the FIM-AI to a group of 3- and 4-year-olds. The partial correlation between appropriate switches in the two tests was $r = .53$, indicating that they tap the same skills (though the FIM-AI was slightly harder than the FIM-Ob).

3. Age and Individual Differences in Flexibility: Relation to Inhibition

Perhaps all these data can be explained more simply: maybe some preschool children lack the inhibitory capacity to de-select prior responses, and this explains perseveration in the FIM. This is inconsistent, however, with a control test (Deák, 2000b, Experiment 3) that used stimuli analogous to FIM-Ob sets, except critical attributes and words were familiar (e.g., a square made of paper with an affixed button). Children were asked, for instance, to find another object “made of paper” or (on another trial) one that “has a button.” Here the demand to use predicate cues is reduced (because property labels are familiar), but the demand to inhibit prior responses is held constant. Three- and 4-year-olds performed very well in this test, indicating that they can inhibit prior responses when redundant cues are available. This further suggests that a central inhibitory capacity cannot account for age and individual differences in children’s flexibility.

Young children’s perseveration in the FIM still must be explained. Recent work (Deák & Narasimham, 2003) tested the relation among perseveration, inhibition, and flexibility in the FIM-Ob. To test whether perseveration stems from inability to inhibit prior responses, we varied response set activation strength by manipulating the delay between responses or between blocks, and by changing the number of successive questions with a single predicate cue. In one study, a group of 3-year-olds were given the FIM-Ob with a 90-sec delay between blocks (trials were blocked by predicate). During the delay, children were primed for the next predicate (e.g., if “has a” was next, object parts were pointed out and described using that phrase). If inhibitory capacity is important, the delay and priming should reduce proactive interference and thereby reduce perseveration. Yet perseveration was no less common in this group than in the original, no-delay sample Deák (2000b). In a second study, one group of 3- and 4-year-olds received a random mix of predicates in each block of trials, and another group had trials blocked by set (i.e., all three questions about a set were given in succession). If inhibitory ability determines flexibility, mixing predicates should reduce perseveration because there is no chance to build a response set. Conversely, blocking by sets should increase perseveration because there is no chance for release from proactive interference between responses. Alternately, rapid predicate switching in both conditions might increase indiscriminate responding. Yet neither condition influenced children’s response patterns: the previously described age difference in flexibility was

replicated, there was no difference in appropriate switches between either group and the original sample. Thus, switching rate and interval between successive problems does not seem to affect flexibility, at least within the parameters studied.

In a third study, 3- and 4-year-olds assigned to *high-* or *low-interference* groups did six familiar-attribute trials (as in Deák, 2000b, Experiment 3, described above) before the FIM-Ob. In the high-interference group, all six trials used the same predicate as the first FIM-Ob test block, so children completed 12 (six easy; six hard) trials with one predicate before switching. The low-interference group's familiar-attribute trials used all three predicates, so they switched predicates several times before starting the first test block. If response interference causes perseveration, repetition of one type of response should increase perseveration. However, there was no difference between the two groups. Also, there was no correlation between any measure of flexibility in the FIM and any measure of flexibility in the Stroop Day/Night test—another strike against the idea that differences in flexibility depend on a general inhibitory trait.

These findings suggest perseveration does not change with the number of pre-switch trials (see also Zelazo, Frye, & Rapus, 1996), number of intervening trials, or number of task switches. Perhaps, then, perseveration in 3- to 5-year-olds is not sensitive to interference from prior responses, as mediated by repetition of one type of response, or by delay since the last response. This narrows the possible roles of cognitive inhibition in flexible induction of meaning.

4. Age and Individual Differences in Flexibility: Verbal Knowledge and Memory

Perhaps children's flexibility in inferring word meanings follows their comprehension of predicate cues. Several findings make this an unlikely explanation for all FIM findings. First, 3-year-olds make more predicate-appropriate responses than expected by chance in the first block, but not in later blocks (Deák, 2000b); this difference disappears with age. Second, in an unpublished study (Deák, 1995), 3-year-olds produced words for object shapes, materials, and parts, in response to questions that used the FIM-Ob predicates. Children were asked "What does this look like?" and "What is this made of?" about a wooden star, paper rectangle, metal disk, glass cube, cloth letter A, sponge heart, Play-Doh ball, and a plastic triangle. They were asked "What does this look like?" and "What does this have?" about a toy teacup, dinosaur, fire truck, raccoon, telephone, rabbit, biplane, and snail. Predicate-appropriate answers were shape or object kind labels for "looks like" questions (mean = 14.7 of 16 labels), material kind terms for "made of" (mean = 3.5 of 8 responses) and part labels for "has a" (mean = 7.3 of 8

responses). This confirms that even these 3-year-olds have reasonably accurate knowledge of these predicate meanings. Third, Yen (1997) showed children objects such as a large star covered with smaller stars and with a medium-sized wooden star in the center, and asked, on different trials, which other object “looks like a star,” “is made of star,” and “has a star.” The comparison objects were, for example, a large star covered with circles, a square covered with small stars, or a triangle with a medium-sized star attached. Thus, the word is familiar but totally ambiguous, so the predicate is the only useful cue. Three-year-olds made mostly predicate-appropriate responses, suggesting that they can use the predicate even in ambiguous situations.

Though most preschoolers at least marginally comprehend the predicates, some added processing demands might reduce children’s application of this knowledge. Perhaps, as Bishop (1997) suggests, working memory demands (e.g., novel words; complex stimulus array) impair performance especially when sentences are complex and delivered quickly. In the original FIM protocol, however, sentences were spoken slowly, enunciated clearly, and repeated. Also, they were syntactically simple. Thus, I suspect working memory is not a major factor in age and individual differences, but this has not been tested directly. In contrast, FIM-Ob test flexibility seems to depend on children’s tendency to consistently attend to predicate cues and notice when they switch, and the knowledge that the local predicate should “trump” other response cues.

5. *Summary: Children’s Flexible Induction of Word Meanings*

Children’s ability to flexibly use predicate information to constrain inferences of word meanings undergoes substantial development from 3 to 6 years. Many obvious possible causes of development can be ruled out; see Table III for a summary of findings. A fascinating question is whether this development is reiterated when language skills are transferred to the modality of written language. Making inferences from text is a critical reading skill by which many new words are learned. Individual differences in flexible induction of (spoken) word meanings might predict abiding differences in children’s ability to infer meaning from text (see Yuill & Oakhill, 1991). On the one hand, variance in preschool children’s inductive flexibility might reflect age-specific attainments, for example, awareness of the “operating principles” of language. That is, flexible children assume that different novel words have distinct meanings. They notice when speakers signal a change to a new predicate—akin to a clear topic change. This sets the stage for flexible selection of cues to meaning. Because these principles are already familiar when children begin reading, different processes might account for flexible induction in reading. On the other hand, Olson (1977)

TABLE III
Summary of Questions and Findings about Preschool Children's Flexible
Induction of Word Meanings

Question	Result
Can children use predicate cues (e.g., "has a..."; "is made of...") to flexibly infer novel word meanings?	About one-third of 3-year-olds are above chance; most persevere or switch responses indiscriminately. ^a Two-thirds of 4-year-olds are above change in post-switch responses; a minority still persevere. ^a
Is there independent evidence of this age difference?	Yes, in children's judgments about the breakability or location of unusual "hybrid" objects, based on different predicates. ^b
Is the FIM test too confusing or tedious for children?	No: In a control task using objects with familiar attributes and labels, performance is near ceiling. ^c
Do children persevere because they cannot ignore previously chosen objects?	No: See previous entry. ^c
Do 3-year-old children understand the predicate cues?	Most are above chance in mapping the FIM-Ob predicates to the appropriate aspects. ^d
Is training on the task necessary or important?	Brief training on the predicate meanings has no effect on performance. ^a
Effects of between question delay, number of successive same-predicate trials, or number of predicate switches?	There is no evidence that any of these factors significantly affect performance. ^e
Is a child's performance stable or predictable across word-learning tasks?	Preschoolers' performance on two versions of the FIM task has a partial correlation of $r = .53$. Neither vocabulary nor Stroop Day/Night performance correlate with FIM. ^e

Note: ^aDeák (2000b, Experiments 1–2); ^bKalish & Gelman (1992); ^cDeák (2000b, Experiment 3); ^dUnpublished studies (see text); ^eDeák & Narasimham (in review).

suggests that ability to decontextualize messages, and use text meaning *per se* to draw inferences, is crucial for acquiring written language. This ability also can be seen as essential in using the predicate, rather than distal context (e.g., prior responses), to infer meaning.

D. COMMON FACTORS IN CHILDREN'S FLEXIBLE COGNITIVE PROCESSING OF MESSAGES AND MEANINGS

The empirical results reviewed here suggest a complex developmental pattern. The DCCS tests rule-use flexibility; the FIM tests word learning flexibility. Each uses unique stimuli, cues, and procedures. Nevertheless, they show roughly parallel results: significant improvement from 3 to 4 years, many perseverative errors in younger preschoolers, and no impact of

factors like number of pre-switch trials and number of rule switches. Before concluding that we have found a general developmental phenomenon in flexible language processing, however, recall that 3-year-olds perform flexibly in some analogous tasks (Deák, 2000b, Experiment 3; Perner & Lang, 2002). The picture is not clear and simple.

Perhaps a broader survey of cognitive changes during the preschool years will provide some clues. In general, preschool children are rapidly getting better at solving problems by selecting task-relevant aspects of complex stimuli. In many cases, knowing what is “task-relevant” depends on semantic and pragmatic sensitivity to task content. Children by 2 and 3 years can produce MARs, but cannot reliably use explicit instructions as an input to shift the active aspect of the MAR. The problem seems to lie in choosing the aspect implied by a specific request, *by virtue of* the semantic content *per se*. Thus, though 3-year-olds can produce several words for an object, they cannot judge whether these words specify “what it looks like” or “what it does” (Deák, Yen, & Pettit, 2001). Similarly, 4-year-olds, but not 3-year-olds, flexibly select aspects (e.g., “fur” or “bowl”) from novel compounds (e.g., “fur bowl”) according to specific aspects implied by the question (e.g., “Will it break?” vs. “Does it go in the kitchen?”) (Kalish & Gelman, 1992).

This skill—to use specific semantics of questions to choose an answer—cannot be deficient because it is ecologically irrelevant. In preschoolers’ everyday settings (e.g., home, school, laboratory), tasks and events are described by command, instruction, and description. Older children are expected to organize their actions in accordance with the “text” of instructions. The importance of message interpretation skills suggests that 2- and 3-year-olds’ inflexibility is due to some rather pervasive cognitive limitation.

One possibility is that message interpretation and responsiveness requires an “uncertainty stance”: tolerance for (and expectation of) indeterminacy of upcoming messages, and assumption that some cues, which change unpredictably, can resolve this ambiguity. The most informative cues to the current utterance’s meaning are not homogeneously distributed over time. All else being equal, cues to an unfamiliar term’s meaning are concentrated in the same utterances. The fact that, for instance, we talked about an object’s material a few minutes ago (e.g., “That’s a nice finish . . . Is it solid maple?”) is no guarantee that the next unfamiliar word also will refer to material. Yet many 3-year-olds do not know the scope or “sphere of influence” of different linguistic cues—for example, a novel word’s predicate context “trumps” prior responses. In flexible rule use, children’s problem might be inferring the operative principle for rule selection. For instance, “Where does this go in the shape game?” presents a conflict between the current predicate cue’s (i.e., “shape game”) implication (e.g., dogs go in the left box), and a previously practiced implication and response. In both cases,

selecting the current message meaning is critical. Thus, in quite different tests, flexibility requires knowing *which* linguistic cues should govern inferences about meaning.

V. Questions and Conclusions

Available data on children's flexible language processing contradict outdated and simplistic views of its development. These also highlight difficult questions. Outlining the most pressing of these is important for guiding future empirical efforts. These are summarized below; those that were discussed above are only briefly re-stated.

A. HOW DO LOGICAL AND METACOGNITIVE ABILITIES INFLUENCE FLEXIBILITY?

I have hypothesized that flexibility requires sensitivity to the independent indeterminacy of the meaning of each question or utterance in a series. Existing empirical evidence for this dependency is, however, only correlational. Experimental tests that manipulate or train children's awareness of indeterminacy would be informative.

B. HOW DOES INHIBITION INFLUENCE THE DEVELOPMENT OF FLEXIBILITY?

Inhibitory processes probably play an important role in children's rapidly developing ability to respond flexibly to changing messages and meanings. Available data and theory do not, however, provide a coherent or falsifiable account that adds teeth to this vague supposition. I suspect our concepts of cognitive inhibition are too primitive to advance much further, and a radical reconceptualization of the construct must precede any substantive progress. The best approach using the available construct of cognitive inhibition is to specify the kind of information that might interfere with children's response switching. This can reveal developmental changes; for instance, children 3 years and older are seldom confounded by changing stimulus locations, whereas 1- and 2-year-olds are susceptible to location-based interference (Zelazo, Reznick, & Spinazzola, 1998).

C. IS LANGUAGE CENTRAL TO FLEXIBLE COGNITION?

The MARM metaphor implies a general, multimodal representational process that is reflected in flexible language processing, and in nonlinguistic

perception and action systems. For example, from 3 to 6 years there is improvement in the flexible deployment of encoding and recall strategies (Ceci & Howe, 1981; Miller *et al.*, 1986), spatial inference (e.g., Fabricius, Sophian, & Wellman, 1987; Hermer-Vazquez, 1997), graphical representation (Picard & Vinter, 1999), and mental state inferences (Wellman, 1990). This parallel development might result from domain-general representational changes, for example in metarepresentation (Karmiloff-Smith, 1992), but it is also possible that language plays a unique role in cognitive flexibility.

Language reflects and facilitates our most pervasive, open-ended manifestations of cognitive flexibility. The basic function of language *is* fast, flexible production and reconstruction of a practically unlimited range of selectively sculpted mental representations. No other behavior system in nature matches this potential for flexible representation. Though laboratory tests of flexible cognition (e.g., task-switching) typically ignore the role of symbolic knowledge, virtually all of these tasks use instructions to orient participants to the task, and abstract symbols to cue task switches. Perhaps, then, basic symbol mapping knowledge is needed for cognitive flexibility (Deacon, 1997). One candidate is the expectation that messages are unpredictable in meaning, and that some linguistic cues determine a message's meaning, even if the listener does not endorse or understand it. This is critical knowledge shared by no cognitive system, to our knowledge, outside of humans above the age of 2 years. This knowledge might facilitate flexibility in processing problems that are not primarily linguistic. For example, children's ability to produce complex descriptions of specific locations predicts their ability to flexibly use spatial cues to infer object location (Hermer-Vazquez, 1997). Even adults, in functional fixedness paradigms, often need detailed cues labels or verbal "hints" to eventually solve the problems (Glucksberg & Danks, 1968; Meier, 1937). Though such evidence does not resolve "chicken-or-egg" questions about the evolution of flexible cognition and language, it suggests that development of ability to produce and understand complex, specific locutions is linked to the development of ability to choose between conceptual distinctions in complex, ambiguous situations or arrays. Perhaps knowing or inducing labels for different aspects of a stimulus provides a conceptual toehold for switching attention among aspects of reality.

D. METHODOLOGICAL PROBLEM: FILLING THE GAPS

Flexibility in any system, linguistic or otherwise, is difficult to study in a controlled manner. Meaningful series of responses must be elicited, and critical dependent measures concern change over time. Thus, some of the challenges of microgenetic methods (Siegler & Crowley, 1991), such as fairly

dense observations, also characterize rich tests of flexibility. A practical challenge is that child participants, unlike most adults, do not cheerfully tolerate long series of boring test questions or problems. This limits the number of responses and task switches obtainable from children within a session. Another challenge of comparing flexibility across a wide age range is that preferred dependent measures change with age. One possibility is to use RTs to measure switch costs in young children, but this introduces new challenges. For instance, young children's response times are quite variable, so if each child contributes only a few switch time data points, large samples must be tested to detect reliable group differences. A related problem is that the distribution of preschoolers' response times has a very long tail, yet most of the long responses seem valid: children may stay attentive, oriented, and "on-task," and take as long as 30 sec to respond to an FIM trial! Because long responses cannot be discarded as anomalous, they present a sticky analytic problem. More generally, changes with age in the nature of switch costs reveal a critical aspect of the development of flexibility. In simple tasks, children's switch costs are manifested as a high rate of perseverative errors, whereas adults show a modest, transitory increase in RT. What does this indicate about changes in inhibition, executive control, and strategic responses to imputed principles of a task? For example, why are adults' task switch costs limited to 1–2 post-switch trials (Monsell, Yeung, & Azuma, 2000), whereas preschool children's perseveration persists for many post-switch trials (Zelazo, Frye, & Rapus, 1996)? No data are available to answer this question.

E. CONCLUSIONS

Cognitive flexibility allows humans to adapt successive inferences or responses to changing task demands, by selecting task-relevant information that may change unpredictably. It is a higher-order cognitive ability, because it concerns controlled changes in cognitive activity over time, problems, or tasks. Cognitive flexibility is required for everyday language processing, because most of us do not inhabit fully predictable and familiar linguistic environments, or use only learned scripts and sequences to produce and understand words, utterances, and discourse. A generalized description of cognitive flexibility is the metaphorical Multi-Aspectual Representational Medium, wherein activation of different aspects of representations (e.g., of a physical array, sequence of events, or mental state) dynamically shifts in response to varied, changing task-relevant input forces. This input is often in the medium of natural language.

In understanding the development of cognitive flexibility as reflected in, and influenced by, language use, a persistent challenge is that age-related changes in flexibility coincide with multiple changes in brain, cognitive, and

language development. Nevertheless, some interim conclusions can be drawn. From 2 to 6 years, and even from 3 to 5 years, there is substantial increase in ability to adapt descriptive locutions to changing (linguistic) task cues, and ability to adapt to changing meanings of successive verbal messages. This applies to a variety of speech acts (e.g., declarative utterances in narrative, instructions or rules, descriptive sentences, questions), and to practical problems of following adults' instructions, and inferring the meanings of ambiguous words or the referents of complex locutions. There is no evidence that this developmental change is the direct result of maturation of a central, executive capacity to inhibit active responses, whereby activation grows over repeated responses and decays over time or intervening activity. Young children are *not* mechanically unable to inhibit prior responses (Deák, 2000b, Experiment 3; Perner & Lang, 2001), nor are they unable to switch labels, on short order, for a given referent (e.g., Deák & Maratsos, 1998). Of course, inhibitory ability might contribute to the development of flexibility, but this hypothesis has little support. In contrast, there is recent evidence that children's awareness of changing verbal information (e.g., predicates), and ability to selectively map alternative locutions to different predicates or questions, is a factor in the development of flexible language use. A more speculative hypothesis is that sensitivity to indeterminacy of messages (e.g., questions; unfamiliar words) contributes to flexibility in language processing. These speculations are rich grounds for future research efforts.

Finally, it is worth noting that available evidence explores flexibility in three age groups: 2- to 6-year-olds, young adults, and elderly adults. Although there is some evidence pertaining to cognitive flexibility in older children (Ceci & Howe, 1978), such evidence is so scant that few inferences can be drawn about development in the vast gulf between kindergarten and college. We are therefore far from being able to describe and explain typical and atypical life-span changes in flexible linguistic and nonlinguistic cognitive processing. Investigating this will, in part, depend on methods and tests that can compare cognitive flexibility across wide age ranges.

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