

第7回 京都大学大学院教育学研究科 国際シンポジウム

心の高次制御機能に関する国際シンポジウム

**International Symposium on
Executive Function in the Mind**

&

**International Seminar for Young Psychologists on
Cognitive and Developmental Sciences**

Kyoto University, Kyoto, Japan

December 5 & 6, 2007

京都大学大学院教育学研究科

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京都大学グローバルCOEプログラム
「心が生きる教育のための国際的拠点」

Symposium Program

<December 5>

14:50-15:00 Opening remark: Naoyuki Osaka (Kyoto University, Japan)

Executive Function and Action Control (Chair: Satoru Saito)

15:00-15:40: Explorations of task-set control through experiments on task-switching
Stephen Monsell (University of Exeter, UK)

15:40-16:20: Exploring the role of verbal short-term memory in task-switching and action control

Satoru Saito (Kyoto University, Japan)

16:20-16:30: Coffee Break

16:30-17:10: Control dilemmas and the dynamic regulation of complementary executive control processes

Thomas Goschke (Dresden University of Technology, Germany)

17:10-17:50: Thinking is for doing: Individual differences in working memory, inattention, and goal-neglect errors

Michael J. Kane (University of North Carolina at Greensboro, USA)

17:50-18:00: Commentary and Discussions

Naoyuki Osaka (Kyoto University, Japan)

18:30- Reception

<December 6>

Executive Function and Theory of Mind (Chair: Shoji Itakura)

10:00-10:40: Is there a place for emotion in the relation between executive function and theory of mind?

Louis J. Moses (University of Oregon, USA)

10:40-11:20: Executive function & social understanding from 2 to 6: Which way the links?

Claire Hughes (University of Cambridge, UK)

11:20-11:30: Tea Break

11:30-12:10: Lying, theory of mind, and executive function: A developmental perspective

Kang Lee (University of Toronto, Canada)

12:10-12:50: Toward a unified theory of young children's development of understanding others' mind

Masuo Koyasu (Kyoto University, Japan)

12:50-13:00: Commentary and Discussions

Shintaro Funahashi (Kyoto University, Japan)

Executive Function in Context (Chair: Masuo Koyasu)

14:30-15:10: Understanding others: Challenge from the developmental cybernetics

Shoji Itakura (Kyoto University, Japan)

15:10-15:50: Culture, interaction and the development of social and executive skills

Charlie Lewis (Lancaster University, UK)

15:50-16:00: Coffee Break

16:00-16:40: Experience and executive functions: Evidence from training, schooling, and culture

Priti Shah (University of Michigan, USA)

16:40-17:20: The unity and diversity of executive functions: Individual differences and behavioral genetic analyses

Akira Miyake (University of Colorado at Boulder, USA)

17:20-17:30: Commentary and Discussions

Jun Saiki (Kyoto University, Japan)

17:30- Closing remark: Masuo Koyasu (Kyoto University, Japan)

Abstracts

International Symposium on Executive Function in the Mind:
Kyoto, 5-6 December 2007

Explorations of task-set control through experiments on task-switching.

Stephen Monsell, School of Psychology, University of Exeter, UK

A major constituent of executive function is the ability to get the mind into such a state that we perform one cognitive task rather than one of the many others that may be afforded by the current input and contents of memory. “Task-set” simply labels the complex of settings that comprise such a state (orientation of attention, activation/inhibition of responses, of S-R rules, of inter-domain links, etc.). If we practice a task, the task-set becomes readily retrievable from memory as a package. Our task-set state at any moment reflects a complex interaction between “endogenous” (top-down, intentional) control — reflecting goals, intentions, motivation — and exogenous (bottom-up, stimulus-driven) activation of responses and stored task-sets by the stimulus, modulated by the frequency with which task-sets have been exercised and the recency with which they have been active.

The properties of task-set control mechanisms are most likely to be revealed in behavioural or brain activation measures at points where we must change tasks or anticipate changing tasks. This is the rationale for task-switching experiments. Subjects respond on each trial to a stimulus with a discrete response, according to a task-rule (usually some sort of classification, or identification, of one attribute of the stimulus, such as its colour, shape, or value). Usually only two or three tasks are “in play” through the experiment. The task required on each trial is indicated by task-cues, a prespecified task sequence, or both. Performance is generally worse in sequences of trials in which there are task switches compared to sequences in which there are not (“mixture costs”). In the mixed-task blocks continuing activation of currently irrelevant task-sets is indicated by elevated Stroop-like response-conflict effects. On a trial where the task changes there is marked slowing of the response (a “task switch cost”), and conflict effects may also be magnified. The switch cost is typically reduced by allowing half a second or so to prepare for a change of tasks, but is rarely eliminated – there is usually an asymptotic “residual” cost even with several seconds allowed for preparation. (See Monsell, 2003, for review).

Early hopes that switch costs might measure endogenous control processes or exogenous influences in a relatively direct way have given way over the last decade to the realisation that their causation is complex. This of course has implications for attempts to study the development of executive function using switching paradigms. I will address some recent controversies, illustrated by data from our lab.

The ability to reduce switch costs through advance preparation has been taken to isolate the contribution of endogenous (“executive”) control processes to switch costs. But how control is reflected in behavioural measures, and whether we can detect neural correlates of this preparation process, remain problematic issues. It has even been argued that the

reduction in switch costs through preparation in task-cuing experiments can be explained entirely in terms of simple associative processes, without appeal to endogenous control. I will briefly review the current state of play.

Another controversial issue concerns the contribution to switch costs of competition due to carry-over of task-set states from previous trials. One theory is that task-set states simply persist transiently (“task-set inertia”), causing competition on the first trial (or so) following activation of a different task-set, then being suppressed by actual performance of the different task (but not by mere preparation for it). Another theory is that through associative learning, stimuli activate task-sets with which they have recently or frequently been associated, and this has more impact on switch trials (perhaps because of instability due to task-set inertia). I will present some recent data from our lab where we find strong effects of recent stimulus-task associations, but they do not modulate switch costs.

Because the majority of task-switching experiments have used stimuli that afford responses in more than one of the tasks in play, it is sometimes thought that task switch costs arise chiefly as a result of having to cope with response conflict. I’ll show that substantial costs are observed even when the currently irrelevant stimulus attribute is never associated with a response. Also, contrasts between such single-affordance stimuli and congruent stimuli (i.e. mapped to the same response in both tasks) can reveal conflict at the level of task-sets.

Monsell S, (2003) Task switching. *Trends in Cognitive Sciences*, 7 (3), 134-140.

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The role of verbal short-term memory in task-switching and action control

Satoru Saito, Graduate School of Education, Kyoto University, Japan

Flexibility in human behaviour is secured by executive control, which enables us to regulate our mental activities endogenously against prepotent responses or habit. In this talk, I will first provide evidence for the involvement of verbal short-term memory in executive control that emerges through task-switching paradigms. A typical switching paradigm requires participants to repeat the same task or to switch between two tasks in separate blocks or in the same block. The cost of switching—the difference in performance (response times and errors) between the repeated and switched trials—is arguably thought to reflect executive demands required in preparation for task switching.

A seminal study by Goschke (2000) suggested that the preparation for task switching is supported by the retrieval of a verbal-task representation. He found that the switch costs in response times were greater under conditions in which participants were required to say a task-irrelevant word once during a long response-stimulus interval (*i.e.*, 1500 ms) than under conditions in which participants were required to say the next task name once. Since articulation of a task-irrelevant word (called *articulatory suppression*) seemed to prevent participants from retrieving or retaining verbal representations of task information, Goschke (2000) suggested that an important component of preparing for task switching was the use of task representations that could be in verbal format, such as self instruction.

Subsequent studies examined the cost of switching in a variety of task-switching paradigms systematically, using an articulatory suppression technique, in order to clarify the roles of verbal short-term memory and inner speech in task switching, and to explore the nature of verbal executive control (Baddeley, Chincotta, and Adlam, 2001; Emerson & Miyake, 2003; Miyake, Emerson, Padilla, & Ahn, 2004; Saeki & Saito, 2004a, 2004b; Bryck, & Mayr, 2005; Saeki, Saito, & Kawaguchi, 2006). Based on this, the literature suggests two possible roles for verbal short-term memory in task-switching paradigms, or more generally, roles for verbal short-term memory in action control: Miyake et al. (2004) proposed that task set retrieval is an important function of verbal short-term memory (inner speech in their paper) using the random cueing paradigm. Saeki and Saito (2004b) and Bryck and Mayr (2005) suggested that serial order control is a crucial function of verbal short-term memory in action control, through the alternating runs paradigm introduced by Rogers and Monsell (1995). We assume that task set retrieval requires reconstruction of *task set binding*, which includes the binding of task components (*e.g.*, stimulus-response mapping is a type of bound information), and that serial order control includes the retention of task order and the resolution of order conflict between two tasks.

Based on this theoretical framework, which consists of the concepts task-set binding and serial order control, we are now examining the role of verbal short-term memory in motor action control, using an action slip induction technique (Mattson & Baars, 1992). The slip technique produced many action spoonerisms and other types of action slip, and

the former increased dramatically when either articulatory suppression or body movement suppression was performed concurrently, while other slips increased only in the movement suppression condition. Articulatory suppression seems to be able to induce action slips by either weakening action binding or interfering with serial order control for action sequences, but not by disrupting the memory of the action components. The results suggest a direction for research on verbal-regulation mechanisms in a variety of human behaviours, through which we can integrate studies on working memory, task-switching, and executive control.

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**Control dilemmas and the dynamic regulation of complementary executive control
processes**

Thomas Goschke, Dresden University of Technology, Germany

Agents pursuing goal-directed action in a changing environment face a number of antagonistic challenges, for instance, to maintain goals on the one hand vs. to flexibly switch between goals in response to significant changes on the other (stability-flexibility-dilemma); to select task-relevant and inhibit distracting information vs. to monitor the environment for potentially significant stimuli (selection-monitoring-dilemma); to exploit learnt reward contingencies vs. to explore novel actions which eventually gain even larger reward (exploitation-exploration-dilemma). Such control dilemmas raise the neglected question of how organisms regulate dynamically the balance between complementary control processes (e.g., goal shielding vs. goal shifting). I propose that the way control dilemmas are solved depends on a set of meta-control parameters (e.g., learning rate; noise level; degree of goal shielding), which are modulated both by situational variables (in particular, response conflicts and emotions) as well as dispositional variables (e.g., genetic variety related to specific neuromodulatory systems). I will present experimental studies in which we show that the balance between goal shielding and goal switching is modulated by phasic emotions. Specifically, we obtained evidence that positive affect reduces perseveration and goal shielding, but at the same time increases distractibility; conversely, we negative affect and response conflicts appear to increase goal shielding. Moreover, I will present initial findings suggesting that the balance between goal switching (cognitive flexibility) and goal shielding (cognitive stability) is moderated by individual differences and genetic polymorphisms related to the modulatory effects of dopaminergic systems on prefrontal control functions.

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**Thinking is for Doing:
Individual Differences in Working Memory, Inattention, and Goal-Neglect Errors**

Michael J. Kane, University of North Carolina at Greensboro, USA

What is conscious thought for? Some theorists argue that it is merely epiphenomenal, providing an after-the-fact explanation of our unconsciously controlled behavior to ourselves (e.g., Pinker, 1997). Indeed, unconscious processes can be complex and goal-directed (e.g., Bargh & Ferguson, 2000), and people sometimes experience illusions of volition and control (e.g., Ono, 1987). Our daily subjective experiences nonetheless suggest that conscious thought allows for deliberation and reflection and, therefore, free will. Is this illusory? Perhaps not, as other theorists argue that thoughts matter: Conscious states allow widespread access to otherwise encapsulated information in the processing system; by broadcasting such information, conscious thoughts sustain goal-directed behavior and resolve conflict among competing action plans (e.g., Morsella, 2005).

Nowhere is the apparent causal link between thought and action more compelling than in the study of human error and executive control. Diary studies of everyday cognitive failures, as well as case studies of industrial accidents, make clear that errors often occur when people engage in routine actions while distracted or preoccupied (e.g., Reason, 1990). In the laboratory, failures of executive control often take the form of “goal neglect,” where subjects momentarily fail to act according to task goals, even though they can articulate them when queried (Duncan, 1995); subjects seem to simply stop thinking about what they’re doing and revert to habitual but inappropriate behaviors. Goal neglect has become a useful construct in research on cognitive development, neuropsychology, and individual differences, as preschoolers (Towse, Lewis, & Knowles, 2007), older adults (De Jong, 2001), frontal-lobe patients (Duncan et al., 1996), lower-intelligence adults (Duncan et al., in press), and people with reduced working memory capacity (WMC) all show heightened vulnerability to goal-neglect errors.

For example, Kane & Engle (2003) investigated whether WMC variation, as measured by complex span tasks (such as Reading Span), predicted attention-task performance due to variation in goal neglect. A Stroop task presented either many or few congruent trials (with color-word match; “RED” in red) and few or many incongruent trials (with color-word mismatch; “BLUE” in red). With few congruent and many incongruent trials, the context reinforced the color-naming goal because most trials presented word-color conflict. Active goal maintenance was thus “outsourced” to the environment. In contrast, with many congruent and few incongruent trials, goals were *not* reinforced. Word reading produced correct responses on most trials, so subjects had to actively maintain access to the color-naming goal for appropriate responding to rare incongruent trials. WMC-related differences were strongest in high-congruent conditions: Lower WMC subjects committed 50 – 100% more errors than higher WMC subjects on

incongruent trials, mostly by reading words aloud. Lower WMC subjects thus maintained less suitable access to goal-relevant information under conflict and interference.

My talk will present findings from both laboratory and daily-life experience-sampling studies that assessed subjects' thought content as they performed ongoing tasks and everyday activities. These findings suggest that goal-neglect errors, and WMC-related differences, are linked to thought content: they arise, in part, through an attentional lapse away from task goals and toward another object of thought. Thus, WMC predicts attention-task performance because it predicts people's ability to simply keep their thoughts on whatever it is they are doing and to prevent their minds from wandering.

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Is there a Place for Emotion in the Relation between Executive Function and Theory of Mind?

Louis J. Moses, Department of Psychology, University of Oregon

Strong relations exist between executive functions (EF) and theory of mind (ToM) during the preschool years. These relations have been found in many different laboratories and in a number of different cultures (Carlson & Moses, 2001; Hughes, 1998; Oh & Lewis, in press; Sabbagh, Xu, Carlson, Moses, & Lee, 2006). Moreover, they persist when a variety of different confounding factors are held constant. However, very little is known about the role emotion understanding and emotion regulation might play in this relationship. In this paper I will describe some recent research from our lab examining this issue.

Our research aims to address four questions. First, executive functioning involves not only regulation of cognition (“cool” EF) but also regulation of emotion (“hot” EF). Are these facets of executive function related or are they quite distinct systems? Second, cool EF appears to be implicated in the “cool” or cognitive aspect of ToM (e.g., belief understanding). Is it also implicated in the “hot” or emotional aspect of ToM (emotion understanding)? Just as belief understanding requires holding two perspectives in mind (working memory) while suppressing one of them (inhibition), emotion understanding requires holding in mind the different feelings people may have about a situation, and suppressing one’s own emotional perspectives. Third, is hot EF related to ToM and, if so, is it related more strongly to hot ToM than to cool ToM. It may be that emotion regulation is especially critical for determining the emotional perspective of others because of the particular salience of one’s own emotional perspective. Finally, does hot EF predict ToM over and above cold EF? Alternatively, is it the case that emotion regulation relates to ToM only in virtue of the fact that it is dependent on more basic executive functions such as working memory and inhibition?

To begin to answer these questions Seraphine Miller and I have collected data from 80 preschool children (3 to 5 years of age) and their mothers in the Pacific Northwest. Belief understanding was measured with five different false belief tasks. Emotion understanding was measured with affective perspective-taking tasks, emotion recognition tasks, and emotion change tasks. Children’s cool executive functioning was measured with the Card Sort Task (DCCS), the Bear/Dragon task, and by parent report on children’s executive abilities (the attention shifting, attention focusing, inhibitory control, and impulsivity scales of the Children’s Behavior Questionnaire). Hot EF was measured by assessing children’s persistence at two highly frustrating tasks (an impossible puzzle task and an impossible circle drawing task), and by parent report on children’s emotional lability.

Preliminary analyses suggest that hot EF and cool EF are quite strongly related. In addition, cool EF predicts belief understanding and emotion understanding equally well. Similarly, hot EF predicts both belief and emotion understanding, and does so to roughly the same degree. Finally, cool EF predicts both aspects of ToM over and above hot EF whereas only limited evidence has emerged that hot EF predicts ToM over and above cool EF. I will attempt to integrate these findings in a broader account of the role of executive function in the development of children's theories of mind.

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Executive Function & Social Understanding From 2 to 6: Which Way the Links?

Claire Hélène Hughes, Social & Political Sciences Faculty, University of Cambridge, UK

Recent years have seen impressive advances in research on two key aspects of cognitive development, namely ‘theory of mind’ (ToM - the ability to attribute inner states to oneself and others, and to understand the influence of inner states on human behaviour - Wellman, Phillips, & Rodriguez, 2000) and ‘executive functions’ (EF –the higher-order cognitive functions that underpin flexible goal-directed behaviour; e.g., inhibitory control, working memory, attentional flexibility). From these definitions the constructs of ToM and EF appear quite distinct. Indeed, ToM development is widely thought to depend upon a modular social-information processing system. In contrast, EF is generally regarded as non-social and domain-general, overlapping with other cognitive constructs, such as attention and memory. Despite these contrasts, a close and intriguing relationship between ToM and EF is highlighted by the findings from several studies of preschoolers (SM Carlson & Moses, 2001; S Carlson, Moses, & Breton, 2002; Frye, Zelazo, & Palfai, 1995; Hala, Hug, & Henderson, 2003; Hala & Russell, 2001; Hughes, 1998a, 1998b; Perner & Lang, 2000).

That said, conclusions from the above studies are limited by three methodological weaknesses: (i) a restricted focus on preschoolers; (ii) reliance on cross-sectional data, or on data from longitudinal studies with a relatively short temporal span; and (iii) a lack of diversity in participants’ general ability levels and socio-economic backgrounds. The present study capitalised on the availability of data on ToM and EF performance in a socially diverse sample of 125 children seen at ages 2, 3, 4 and 6-years. These data enabled us to expand the scope of existing research, by addressing several new questions. For example, to what extent do individual differences in ToM and in EF show continuity vs. change across this extended developmental period? Are the associations between family characteristics (e.g., socio-economic status) and individual differences in ToM and EF similar across time-points? Or do children from disadvantaged families an initial delay in mastering ToM and EF skills but later catch up with their peers, such that this relationship becomes attenuated over time? Likewise, do associations with individual differences in verbal ability also weaken over time; in accord with Karmiloff-Smith’s (1992) hypothesised the progressive modularisation of cognitive skills? Alternatively, are there developmentally stable predictive relations between ToM and EF? If so, are these relations reciprocal or asymmetric? Specifically, does initial ToM independently predict later EF and improvements in EF? Or is it the other way around, such that initial EF independently predicts later ToM and improvements in ToM? Age-6 data-collection is nearly complete, and should be ready for analysis in time for the Kyoto meeting. Our findings from the three earlier time-points are currently in press (Hughes & Ensor, in press) and support the following conclusions: (i) for both ToM and EF, task scores improve with age and show stable individual differences; (ii) verbal ability and social disadvantage independently predict changes in EF (but not ToM); predictive relations between ToM and EF are asymmetric, providing partial support for

the view that ToM is a pre-requisite for EF but stronger support for the proposal that EF facilitates children's performance on ToM tasks.

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Lying, Theory of Mind, and Executive Function: A Developmental Perspective

Kang Lee, Institute of Child Study, University of Toronto, Canada

Lying, or verbal deception, refers a speaker making an untruthful statement with an intent to instill false beliefs into the mind of the listener. This widely accepted definition has led to developmental researchers to focus on the issue of the relation between the development of verbal deception and that of theory of mind understanding (e.g., Chandler, Fritz, & Hala, 1989). Indeed, existing evidence suggests that children's false belief understanding predicts their tendency to lie (Polak & Harris, 1999). However, the role of executive function has been largely ignored (see Carlson, Moses, & Hix, 1998 for an exception). In this talk, I will present a recent series of studies in our lab that examined the development of lying from 3 to 16 years of age. We used a temptation resistance paradigm (Lewis, Stanger, & Sullivan, 1989; Talwar & Lee, 2002; Talwar, Gordon, & Lee, 2007; Talwar & Lee, in press) in which children were asked to participate in a game. To succeed in the game, they must provide correct answers to various test questions that were difficult to answer. Many children resorted to peeking at the answers. When the experimenter returned, children were asked whether they had peeked at the answers, what the correct answers were, and if they gave correct answers, we also asked how they came to know the answers. We found that children begin to tell lies around 3 years of age and the tendency to lie increases significantly with age. Also, with increased age, children increasingly feign ignorance or give plausible explanations about why they have come to know the answers.

We also ran a battery of social and cognitive measures along with the temptation paradigm (e.g., theory of mind tasks, moral judgment tasks). We found children's moral and conceptual understanding of lying to be unrelated to their lying behavior. However, the first order theory of mind understanding indeed predicts children's tendency to lie and the second order theory of mind predicts how successful their lies are at deceiving others. More important, we also found that at the younger ages (3-8 years), children's tendency to lie and their ability to feign ignorance significantly correlated with their performance in the Stroop task, a task specifically requiring inhibiting a prepotent response and replacing it with an alternative response. Other executive function tasks were however not significantly correlated. For older children (9 years and above), children's tendency to lie predicted their ability to complete the Tower of London (ToL) task, a task assessing planning. Specifically, children who completed the ToL within the standard amount of time were more likely to tell lies, while those children who took longer to complete the task were less likely to tell lies. In addition, children's ability to maintain their lies during follow-up questioning was related to their inhibitory control skills, planning ability and working memory. Those children who performed better on the executive functioning tasks (Stroop, ToL, and digit span backwards) were better at concealing their lies during follow-up questioning.

These findings along with results of additional studies suggest that children's theory of mind understanding and executive functioning ability both play an important role in children's decision to lie and their ability to lie successfully. More specifically, we propose that children's theory of mind understanding plays a motivational role that enables them to make decisions about whether to lie and what to lie. In contrast, children's executive functioning abilities serves a maintenance function that ensures them to plan, execute, and sustain their lies successfully. Thus, the development of lying reflects the successful integration of children's executive functioning ability and theory of mind understanding.

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**Toward a unified theory of young children's
development of understanding others' mind**

Masuo Koyasu, Kyoto University, Japan

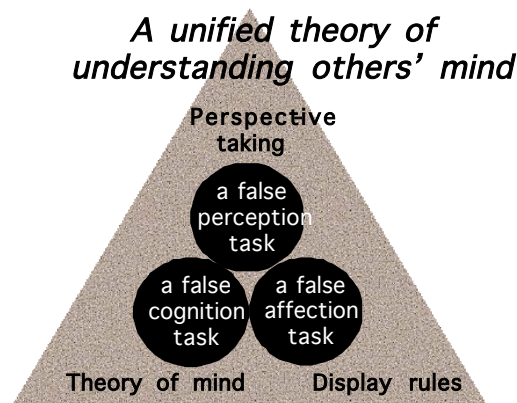
In this paper I will talk on a unified theory of the mind in young children including perspective-taking abilities, theory of mind, and display rules. Research on young children's perspective-taking abilities began with Piaget's "three mountains task." Although this method has a productive power, I have pointed out that there is a serious limitation in the paradigm. In the "three mountains task," even if children cannot directly guess the viewpoint of a person in another position, they can solve the problem by conducting *mental simulation* or *mental rotation*. The false belief task by Wimmer and Perner (1983) gave us a more robust measure of understanding others' mind. It has been pointed out that there are at least three types of perspective-taking abilities: to infer what other people see (perceptual), to infer what other people feel (affective), and to infer what other people think (cognitive). These three types of perspective-taking abilities should be integrated into a unified theory of understanding others' mind. To achieve this goal, it is essential to use tasks which include misrepresentation of the protagonist: a false *perception* task, a false *cognition* task, and a false *affection* task (see Figure 1).

Mizokawa & Koyasu's (2007) study demonstrated an example of the false *affection* task. Gross & Harris (1988) showed that 6-year-olds can understand that one can simulate an emotion while feeling another, and that such a display can mislead others. However, there are few studies that have examined children's ability to distinguish apparent crying from reality. Mizokawa & Koyasu's (2007) study examined young children's understanding of apparent crying and its misleading consequences. They evaluated the relationship between children's performance of two false belief tasks (Wimmer & Perner, 1983; Perner & Wimmer, 1985) and children's understanding of apparent crying, as well as the relationship between children's performance in the false belief tasks and its misleading consequences. Participants were sixteen 4-year-olds, twenty 5-year-olds, and twenty five 6-year-olds, all assessed individually. Materials were three "crying tasks" (two apparent crying tasks and one real crying task) and two "theory of mind" tasks (a standard false belief task and a second-order false belief task). In each "crying task", the protagonist looked as if he or she was crying. After being shown each story using a computer, participants were asked to judge whether the protagonist was really crying, and whether the other character believed that the protagonist was crying. It was found from this experiment that:

- (1) Understanding of apparent crying develops between the ages of 4 to 6;
- (2) Even for 6-year-olds, it is hard to understand misleading consequences of another's apparent crying; and
- (3) Only understanding of apparent crying relates to the child's performance in the standard and second-order false belief tasks.

In Mizokawa & Koyasu (submitted), 525 Japanese children, aged 6 to 12, were administered a questionnaire, which is composed of three "crying tasks" and one "second-order false belief task." Results showed that children can understand false belief about apparent crying around the age of nine, and there is a relationship

between their understanding of such false belief and their performance in the second-order false belief task.



**Figure 1 A unified theory of
understanding others' mind**

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International Symposium on Executive Function in the Mind:
Kyoto, 5-6 December 2007

Understanding Others: Challenge from the Developmental Cybernetics

Shoji Itakura, Kyoto University, Japan

For the human infants, agents-other humans are the fundamental units of their social world. Agents are very special stimuli to the infants. Quite many researchers who study object-person differentiation have derived a set of rules that they postulate infants use when they react to objects as opposed to people in the world. Premack & Premack (1995) proposed that infants perceive people as perceptual events that are self-propelled and goal-directed objects. In such case, we adults also perceive the agent has intention. Spelke, Phillips, and Woodward (1995) described the concept of human in infants as follows: "Three aspects of human interactions that are accessible in principle to young infants are contingency (humans react to one another), reciprocity (humans respond in kind to one to another's actions), and communication (humans supply one another with information)." Spelke et al. showed the evidence that infants object movement using three principles, including the "Principle of Contact". To explain the contact principle, they used habituation procedure to show that infants expect an object that moves to have been set in motion by another object (or person) pushing it. On the other hand people did not need an external force to be applied for them to begin moving. They demonstrated that this kind of perception of agency is appeared by 7-month-old. Agents are not simply physical objects with new properties added to them. They are entities of an animate that move on their own, breath, eat, drink, look, and engage in actions with objects or interact with other agents (Gomez, 2004).

From the view point of social cognitive development, there are two questions as follows pointed at by Johnson (Johnson, 2003): 1) when do children first attribute mental state to others, and 2) when they do so, whom do they attribute mental state to?

In my presentation, we will review a line of research conducted to investigate how children understand and detect agents not only humans but also nonhuman agents. We start with the first cue for agents as a social partner for infants. That is an ability to detect whether caretakers and social partners are attentive and responsive to their own behavior in social exchanges. We call this social contingency. In second part, we introduce our study concerns to the relationship between understanding of other's mental state and inhibitory control in infants by using card sorting tasks. In third part, we review the several studies investigated the infant's interpretations of nonhuman agents from the action. Especially, we will review the studies of Csibra and his colleagues. Recently, they claimed that there are two fundamentally different ways to attribute intentional mental states to others upon observing their actions, those are teleological understanding and referential understanding. We will focus on teleological stance in this section. Finally, we will propose the new idea of research domain called "*Developmental Cybernetics*" and introduce some of our studies. Developmental cybernetics is a study of interaction and integration between children and robots (Kojima, 2005). Futurists and technologists have

long predicted that the 21st century will see a wide application of robotics technology in common households where robots will be as ubiquitous as refrigerators and dishwashers (Asada & Kuniyoshi, 2006; Ishiguro, 2005).

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Culture, interaction and the development of social and executive skills

Charlie Lewis, Department of Psychology, Lancaster University, U.K.

This paper explores the conjunction between two key issues in the study of executive function in the mind: [1] the development of executive skills and their relation to our understanding of mental states ('executive function in the mind'); [2] the tendency to depict executive skills as fixed capacities rather than dynamic processes. I will argue that we need to take a more grounded approach to the nature and development of these skills. The talk will divide into three parts.

The first section considers the nature of the executive processes, in an analysis of the role of cultural processes in the development of executive and social skills. A few studies have suggested that patterns of executive functions show only minor variations across varied cultures (Chasiotis, Kiessling, Winter & Hofer, 2006) and relate to 'theory of mind' performance (Carlson & Moses, 2001). Given the emphasis placed on the control of action and filial interdependence in oriental cultures, a number of recent studies have examined whether children in these cultures show the same relationships as those in Western and Southern cultures. While research on Chinese children shows advanced executive skills without similar precocious 'theory of mind' skills, these tend still to find a link between these areas of psychological functioning (Sabbagh, Xu, Carlson, Moses & Lee, 2006; but see Lewis, Huang and Rooksby, 2006, for an exception). We have conducted three studies that do not show such clear associations in Japan (Lewis, Koyasu, Ogawa & Short, in progress) and Korea (Oh & Lewis, in press). I will present the data from two studies in Korea to suggest that in this culture executive skills appear almost two years ahead of those of their English counterparts, without showing a clear relation to false belief skills. I will argue that these data raise key questions not only about the nature and development of the executive system but also its relation to social understanding.

The following two sections of the paper examine how such processes might influence the executive system. The second part explores a series of experiments in which a brief social cue is given before the child performs a task designed to tap executive skills (Lewis, Warburton, Harrison & Maridaki-Kassotaki, in progress). These show that levels of children's performance on tasks of set shifting and inhibitory control are influenced by a prompt which is focused upon the particular skill under investigation more than a prompt which relates to her or his social skills. These results suggest that the dynamics of experimenter-child social interaction exert clear influences upon performance and raise questions about the influences upon such performance. In a related paper at this conference Ivonne Solis-Trapala will present some of our work examining the dynamic effects of cognitive and social factors on preschoolers' performance in test batteries.

The final section of the paper considers the dynamics of children's executive performance as they perform individual tasks. It draws upon our recent analysis of goal maintenance and neglect in preschoolers (Towse, Lewis & Knowles, 2007). This work is based upon our Selective Image Naming Task (SINT) which we developed for administration to preschool children in order to assess their ability to achieve two goals within the flow of activity – following a first instruction to name the objects

appearing in one location, while paying attention to another goal of a cue to switch the task to name items in another location. I will briefly report data from this task in relation to performance on two more standard executive measures of set shifting and conflict inhibition. The propensity to neglect initial task cues on the SINT was linked to inhibition performance, while neglect of a later cue to shift the goal was linked to the Dimension Change Card Sort. Thus, data from the SINT task underscore the importance of, and place constraints on, current theories of information-regulation. The paper concludes with a reflection upon the factors that executive function must be considered within the dynamics of everyday activities and that these are constrained, at least in part, by social and cultural processes.

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International Symposium on Executive Function in the Mind:
Kyoto, 5-6 December 2007

**Experience and Executive Functions: Evidence from Training, Schooling, and
Culture**

Priti Shah, Department of Psychology, University of Michigan

Can executive functions be modified by experience? In this talk I will describe data suggesting three different kinds of experiences affect executive functions: direct training (Minear & Shah, under review; Minear, Shah, & Park, in preparation; White & Shah, 2006;), schooling (Burrage et al., in press), and culture (Lan, Boduorglu, & Shah, in preparation).

The training studies I will describe focus on the training of task-switching. In the typical task-switching paradigm, a participant is required to switch between two simple tasks such as judging whether a letter is a consonant or vowel on one trial and judging whether a number of odd or even on the next. When required to alternate between two tasks, participants' reaction times are slower than when performing one task alone. A number of studies have demonstrated practice-related improvements in switching performance, but there has been no direct test of whether the better performance seen constitutes a transferable improvement in the ability to switch tasks more efficiently or simply an improvement in the specific tasks practiced. In the studies I will present, we investigated the extent to which improved task-switching performance with practice can transfer to a new task-switching situation. We employed a pre-test/post-test design in which participants were measured on their ability to switch between two tasks both before and after practice on other switching tasks. I will describe results from studies that demonstrate transferable improvements in task-switching as measured by mixing costs (time to perform a non-switch trial in a switching block minus the time to perform a non-switch trial in a pure block). Specifically, I will present data suggesting that improvements occur for predictable switching and random switching even when cues are different from those used during training (Minear & Shah, under review). I will also present data demonstrating improvements in task-switching for older adults (Minear, Shah, & Park, in preparation) and individuals with ADHD (White and Shah, 2006).

In the second part of my talk, I will briefly present new data from our laboratory in which we examine the possibility that everyday experiences may also have an impact on executive functions. I will present the results of one study in which we exploited the fact that school cutoff dates result in children of approximately the same age attending school or not yet attending school. We compared children of the same age attending kindergarten and pre-kindergarten to children not in school to separate the effects of maturation and schooling on the development of working memory and response inhibition. We found that working memory and response inhibition are affected not only by age but also by schooling (Burrage et al., 2007). Finally, I will present the results of a study that shows Chinese-American differences in performance of response inhibition

tasks but not interference resolution tasks as predicted by theories of East-West cultural differences (Lan et al., in preparation).

Together, the studies I will present suggest that that direct intervention, schooling, and culture may have an influence on executive functions.

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International Symposium on Executive Function in the Mind:
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**The Unity and Diversity of Executive Functions: Individual Differences
and Behavioral Genetic Analyses**

Akira Miyake, University of Colorado at Boulder, U.S.A.

Executive functions — a set of control processes that regulate one's thought and action — have become a popular topic in many subfields of psychology (including cognitive psychology/neuroscience and developmental psychology). Specifying their cognitive and biological underpinnings has been a major challenge, however. In this presentation, I will provide an overview of executive function research that my colleagues and I have been conducting from the perspectives of individual differences (Friedman et al., 2006, 2007; Friedman & Miyake, 2004; Miyake, Friedman, Emerson, Witzki, Howeter, & Wager, 2000) and, more recently, behavioral genetics (Friedman et al., in press). By focusing on interindividual differences that naturally exist among normal young adults, our research has tried to specify (1) the extent to which different types of executive functions identified in the literature are separable, (2) the extent to which lab-based simple executive function tasks can tap socially or clinically important problems in the real world (e.g., attention/conduct problems in school, substance use), and (3) the sources (genetic vs. environmental) of individual differences in executive function abilities.

Although executive functions are often treated as a unitary ability that can be reliably measured with prevalently used complex neuropsychological tests (such as the Wisconsin Card Sorting Test and the Tower of Hanoi task), this typical approach is problematic for several reasons, perhaps the most significant of which is the so-called task impurity problem. Because executive control abilities, by definition, must be assessed in the context of other cognitive processes, a large portion of variance in any one executive function task may not necessarily be measuring the putative executive control ability (see Friedman & Miyake, 2004, and Miyake et al., 2000, for more discussion). To alleviate this problem, we have adopted a latent variable approach, which involves operationally defining the constructs of interest, selecting and administering multiple measures tapping each defined construct, statistically extracting the common variance across these measures, and using those “purer” latent variables as the dependent measures for analysis.

Using this latent variable approach, we have demonstrated that, at least among young normal adults, three frequently postulated executive functions — inhibiting prepotent or dominant responses (Inhibiting), continuously monitoring and updating working memory representations (Updating), and flexibly shifting between task sets (Shifting) — are moderately correlated with each other, but show clear separability (Miyake et al., 2000), a pattern sometimes referred to as the “unity” and “diversity” of executive functions (see Friedman et al., 2006, in press, for more recent replications of this pattern). Moreover, these executive functions are differentially related to other complex cognitive and neuropsychological measures of executive control abilities (Friedman et al., 2006; Miyake et al., 2000), such as the Wisconsin Card Sorting Test (most closely related to Shifting), the Tower of Hanoi task (Inhibiting), and crystallized

and fluid intelligence (Updating), further suggesting that a completely unitary view of executive control abilities is not tenable.

Our more recent research extends this initial work by examining the degree to which the three target executive functions (Inhibiting, Updating, and Shifting), all assessed with fairly simple lab-based cognitive tasks, are related to more socially and clinically relevant variables. Although Updating seems the most important when it comes to general cognitive abilities (Friedman et al., 2006), it is Inhibiting that appears to have the greatest predictive power when it comes to socially and clinically important (as opposed to purely cognitive) variables. For example, our work has shown that the severity of attentional problems exhibited in classrooms during childhood (e.g., inattentiveness, poor concentration, distractability, impulsivity) is highly predictive of individual differences in the Inhibiting ability measured during late adolescence (Friedman et al., 2007). Inhibiting also seems to be more strongly related than Updating and Shifting to depressive symptoms (Sabella, Miyake, Friedman, Young, & Hewitt, under review) and to externalizing behaviors such as drug use and conduct disorder (Young et al., under review) among late adolescents. Thus, even though the measures used to assess the executive functions consist of simple, lab-based tasks, they share a substantial amount of variance with various socially and clinically important variables and hence hold great promise for helping us better understand the potential role of executive functions in various forms of self-regulation in everyday situations (e.g., failing to control the amount of food to eat while on a diet, resisting the temptation to try drugs or engage in risky sex).

Finally, we have recently started to address an important yet so far neglected question in the studies of individual differences in executive functions: Why do people differ in their executive control abilities? To address this question, we examined the extent to which individual differences in executive functions are attributable to genetic versus environmental factors by using a genetically informative sample, monozygotic (identical) and dizygotic (fraternal) twins (Friedman et al., in press). Our results indicate that, though the level of genetic influences on performances on individual executive function tasks are at best moderate, executive control abilities, measured as latent variables, show surprisingly high heritability. In particular, our analyses suggest that the genetic influences on individual differences in executive functions occur at multiple levels — at the level of “unity” (i.e., what is common across the three target executive functions, Inhibiting, Updating, and Shifting) as well as at the level of “diversity” (i.e., what is unique to each executive function), suggesting that both the unity and diversity of executive functions are substantially genetic in origin. Moreover, such genetic contributions to executive functions go beyond those that affect general intelligence (e.g., IQ) or processing speed. These results suggest that individual differences in executive functions, measured as latent variables, have strong genetic bases and highlight the potential of genetic approaches for uncovering the biological underpinnings of executive control abilities. More generally, our work shows that studying executive functions from the perspective of individual differences and behavioral genetics is a fruitful approach and can greatly help us understand the cognitive, neural, and genetic bases of executive functions and their relevance to various socially and clinically relevant issues.

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International Seminar for Young Psychologists on Cognitive and Developmental Sciences

Seminar Program

09:30 - 09:35 Opening Remark

09:35 - 10:50 Session 1: Working Memory and Executive Control (Chair: Yusuke Moriguchi)

Taiji Ueno (Graduate School of Education, Kyoto University)
When binding of two features falls into apart

Azumi Tanabe (Graduate School of Letters, Kyoto University)
Inhibition in visual working memory of scene images

Yukio Maehara (Graduate School of Education, Kyoto University)
The workings of working memory in a theory-of-mind task for adults

Ivonne Solis-Trapala (Department of Psychology & School of Medicine, Lancaster University)
Statistical models of executive function test performance in children

10:50 - 11:00 Coffee Break

11:00 - 12:15 Session 2: Development of Executive Function in Young Children (Chair: Yukio Maehara)

Macarena Silva Trujillo (Department of Psychology & School of Medicine, Lancaster University)
Narrative development: Moving from questions to independent narrative

Ayako Ogawa (Graduate School of Education, Kyoto University)
The role of executive function in Japanese preschooler's explanation of other person's wrong action

Tomohiro Nabeta (Graduate School of Education, Kyoto University)
Can young children reduce false recognition?

Yusuke Moriguchi (Graduate School of Letters, Kyoto University)
Executive function and socio-cognitive development: Evidence from human children and chimpanzee

12:15 - 12:30 General Discussion and Closing Remark

Abstracts

When binding of two features falls into apart

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The fact that we can consciously be aware of our own experience and reflect upon it implies working memory has to convey not only the constituents but also the labels, which tell which element belongs to which coherent representation. Researchers in the working memory field have clarified the characteristics of the labels and the role of working memory in binding, by identifying when binding memory (e.g., memory of color & shape), but not simple feature memory (e.g., memory of color or of shape), is selectively impaired (e.g., attentional-based account, for Wheeler & Treisman, 2002; similarity-based account, for Allen, Baddeley, & Hitch, 2006). Allen et al. demonstrated the lower recognition accuracy of binding memory condition with sequential presentation than with simultaneous presentation. Based on this result, they offered the similarity-based account and argued that bound representations were fragile and easily overwritten by similar items presented later. The present study extended the validity of this similarity-based account, using suffix paradigms. A suffix involving different feature combinations on each trial (e.g., circle was yellow at one time, and blue at another time), as the to-be-remembered items were involving, had a larger effect than one involving the same combinations (e.g., circle was always blue).

References

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Inhibition in visual working memory of scene images

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The working memory system is assumed to operate with domain-specific (verbal and visuospatial) resources that support cognitive activities. However, in research on visuospatial working memory, differences in relationships to cognitive activities between working memory tasks and simple storage tasks remain unclear. In this research, a novel task is developed, the picture span test, PST, which addresses this problem. PST requires memorizing the parts of scene images while comprehending various scene situations. Results validated that PST performance correlated with performance in visuospatial cognitive tasks whereas performance in a simple visual storage task did not. Furthermore, two kinds of errors in PST were analyzed. One is the intrusion error, which is defined as false recognition of information presented concurrently with target, and another is the token error, which is defined as false recognition of novel information belonging to the same category as target. By significant correlation between intrusion errors and task performance, the result indicated that inhibition of task-irrelevant information is important for visuospatial working memory. These results suggest that PST is appropriate for measuring the visual working memory capacity and can elucidate its relationship to higher cognition.

The workings of working memory in a theory-of-mind task for adults

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Quite a few researchers have insisted that some difficulties in the inference of a more naive perspective (i.e., naive other's belief) in adults are based on a tendency to be biased by one's current knowledge; this is sometimes called the "curse of knowledge" (for a review, see Birch & Bloom, 2004). However, the cognitive foundations of the curse of knowledge are unknown. In this study, I propose working memory as a possible factor that mediates the curse of knowledge in the mental-state reasoning of adults. I developed a theory-of-mind task for adults in which participants were asked to estimate probabilities to possible choices for a story character's behavior while remembering a meaningless two-letter or seven-letter word. The results showed that the participants under a heavy memory load (seven-letter word) estimated a higher probability to the choice indicating that the story character would behave based on the fact that they knew but that she did not know; however, the participants under a light memory load (two-letter word) estimated a fair probability to the choice. Nevertheless, participants in both groups could answer that she did not know the fact. This indicates that participants who overloaded their working memory could not activate the knowledge that the story character was ignorant of a certain piece of information while they were reasoning her mental state.

Reference

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Statistical models of executive function test performance in children

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Research into executive functions (EF) has increasingly adopted a multivariate approach in which groups of tests are administered to adults (e.g., Miyake et al., 2000) or children (e.g. Huizinga, Dolan, & van der Molen, 2006) in order to assess the structure of these processes. Within such tasks participants perform multiple trials to assess each component EF skill. Most studies simply aggregate scores to identify the underlying construct. My approach is to analyse performance using random effects models on successive trials of a task, both with and across time points. This enables me to examine the dynamics of performance and influence of extraneous processes like test order on the development of these skills. I examine a study in which 89 children were administered a battery of EF and social understanding at three time intervals, six months apart. The analyses reveal that children's success on individual tasks is strongly influenced by their previous performance on test trials and the order in which tasks were administered. At the very least such findings raise questions about the validity of research in which large numbers of tests are administered to children within a battery. I suggest that executive task performance must be cast within a theoretical framework constructed as a dynamic relation between the participant, the test and the experimenter.

References

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Narrative development: Moving from questions to independent narrative

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The current study examines if the concepts of sociocultural theory can be used to explain narrative coherence development in preschoolers. It explores specifically, if questions, viewed as an interaction device (De Rivera, Girolametto, Greenberg, & Weitzman, 2005; Pontecorvo, 1993), can promote an internalisation process of narrative coherence. Sixty Chilean children in kindergarten were recruited; thirty of them first completed an individual narrative task and then a set of questions; the other thirty children completed the two tasks in reverse order.

Both tasks, individual narrative and questions, were based in the wordless book “A boy, a frog and a dog” (Mayer, 1967) Three main elements of narrative coherence were assessed: initiating event/problem; mental states; resolution. Those aspects were evaluated in terms of their appearance and the extent of the relation between each of them and story events.

The results show that there was better performance when the individual task is completed after the questions, but questions do not show any effect as a consequence of order, indicating that “narrative first” condition does not aid narrative coherence performance in answering questions. On the other hand, questions can be labeled as a mediator that improves performance in a narrative task. This process can be seen as an illustration of the role that social activities, like questions, may play in developing skills.

References

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The role of executive function in Japanese preschooler's explanation of other person's wrong action

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Recent studies on children's theory of mind has identified that development of executive function (EF) is an essential factor which contributes to children's developing understanding of false-belief. Perner et al. (2002) showed that performance on the EF tasks was correlated with not only performance on the false-belief prediction task but also performance on the false-belief explanation task. Recent study revealed that Japanese children show a delay in false-belief prediction and the cultural difference in explanation of human action as attributing it to behavioral and situational cues, rather than to individuals' mental states (Naito & Koyama, 2006). Although a large number of studies were conducted in Western countries and some Asian countries, few studies have shown relationship between false-belief understanding and EF in Japan. The purpose of the present study was to investigate the relationship between Japanese preschoolers' ability to explain the other person's wrong action in the standard unexpected transfer task and their performance on the EF tasks. Sixty children, aged 3 to 5, were given the false-belief prediction and explanation task, a receptive vocabulary task, and EF tasks.

References

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Can young children reduce false recognition?

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Presentation of a list of items that are related to an item (lure) semantically elicits recognition of the lure. The recognition of the lure is called false recognition because the lure is not presented. Although many studies have shown that a pictorial study reduces false recognition more than word study, relatively few studies have examined this phenomenon in young children. Therefore, this study examined whether the reduction due to a pictorial study occurs in young children and, if so, how a pictorial study reduces false recognition. After studying lists of pictorial items or word items that were related to lures semantically, young children took a recognition test that had pictorial test trials and word test trials. The main results were as follows: 1) the pictorial study reduced false recognition; and 2) the pictorial reduction was greater in the pictorial test trial than in the word test trial. The results indicate not only that the young children encoded pictorial features but also that they used the pictorial cues that were encoded during the pictorial study to reduce the false recognition of lures.

Executive function and socio-cognitive development: Evidence from human children and chimpanzee

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Socio-cognitive development might play an important role in human evolution. Indeed, human develops socio-cognitive abilities, such as theory of mind and communication, more significantly than other species. Recent studies have shown that executive function might contribute to socio-cognitive development, such as theory of mind, emotion regulation, and communication. Given the developmental evidence, it appeared that executive function might contribute to the socio-cognitive evolution. However, the evolutionary trajectory of executive function is still unclear. To understand the trajectory and evolutionary relation between executive function and socio-cognitive ability, our research group examined the executive function in chimpanzee, and compared the performances with those in young children. Specifically, we examined inhibition skills in both participants. As an index of inhibition skills, we used a non-verbal Dimensional Change Card Sort task (DCCS). Participants (both chimpanzees and 5-year-old children) were presented targets (e.g., a small circle and a small triangle) and a sorting card (e.g., a big triangle) on a screen and required to sort the card according to one dimension (e.g., shape). After five consecutive correct trials, participants were required to sort the cards according to the other dimension (e.g., size). The results suggested that chimpanzee's inhibition skills might be less developed than 5-year-old children's. We proposed that executive function might play a significant role in socio-cognitive evolution.