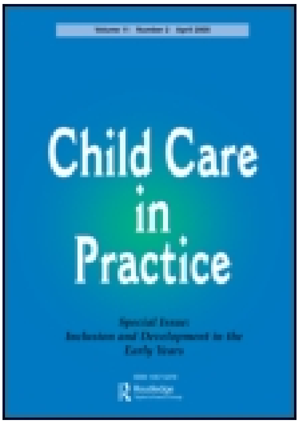

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Understanding Cognitive Development: Automaticity and the Early Years Child

Colette Gray

In recent years a growing body of evidence has implicated deficits in the automaticity of fundamental facts such as word and number recognition in a range of disorders: including attention deficit hyperactivity disorder, dyslexia, apraxia and autism. Variously described as habits, fluency, chunking and over learning, automatic processes are best understood in terms of their distinctive properties. While typically identified as fast, parallel, attention-free processes, a commonly agreed definition of automaticity continues to elude theorists investigating this concept. Most theorists would, however, agree that since attentional resources are finite, automaticity of basic facts serves to free sufficient mental resources for a learner to focus their attention on the novel or more complex aspects of a task. Yet despite the importance of automaticity to the learner, the term remains largely unfamiliar to most educationalists and early years practitioners. In order to address this issue, the present paper seeks to review several influential theories of automaticity, to describe the problems associated with defining a process as automatic and to draw from relevant research to demonstrate how the early years environment can be organised to promote automaticity in the young learner.

Introduction

Throughout the past decade a growing body of research has investigated the relationship between automaticity and a wide range of learning disabilities including attention deficit hyperactivity disorder, dysgraphia, and dyscalculia (AASU, 2001; Warshaw, 2002). Evidence from these studies suggests an association between deficits in automaticity and difficulties in reading, reading comprehension, reading fluency, writing, numeracy, spelling, memory, speed, hearing, vision and balance (Gray, 1999; Nicolson & Fawcett, 1999). Similarly, deficits in automatic word recognition have been shown to underpin dyslexia, while other research suggests that children with

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apraxia of speech (a difficulty in sequencing the motor movements necessary for volitional speech) have failed to automatise the basic components of speech (Vellerman, 2001).

Automaticity and Learning

Among the earliest studies of automaticity was Huey's research into alphabet learning in young children. From this Huey (1908) concluded that practice and familiarity are essential for children to develop automaticity when learning the letters of the alphabet, new words and new word sequences. Support for this view comes from more recent research into the relationship between automaticity and higher order thinking. Gray (1999), for example, used a computer program to measure individual levels of automaticity for addition facts in a large sample of children ($n = 410$) aged between 6 and 11 years of age. Her results offered empirical support for the commonly held view that children with high levels of automaticity for addition facts have correspondingly high scores on tests of mathematical ability. Gray concluded that in reducing the demands placed on limited mental resources, automaticity of simple arithmetic facts enabled children to focus their attention on the novel or more complex aspects of problem-solving. Similar results were obtained from studies of preschool children who showed automaticity for paired addition problems such as $1 + 1$ and $2 + 2$ (Lemaire, Barrett, Fayol, & Abdi, 1994), and from a range of other studies investigating links between automaticity and second language learning (Perfetti, 1996), writing (Hayes & Flowers, 1980), reading (Hook & Jones, 2002), and spelling (Mulhern, Wiley, & Sawey, 1997).

Non-academic examples of automaticity include walking, riding a bicycle, dancing, driving and ice-skating. For example, a child's first faltering steps generally require intense concentration. On hearing their name the child may stop, turn towards the speaker, lose concentration, totter and fall. With sufficient practice the child may walk while talking and listening at the same time.

Another more commonly cited example of automaticity involves driving. Initially, each of the subskills required to get the car in motion demands a considerable amount of attention. However, with practice these skills become automatic to the extent that the driver may listen to the radio, talk to a passenger or check for road signs while driving. Implicit in these examples is the notion that automaticity develops through practice, that it is transferable, effortless and that it enables individuals to divide their attention between several tasks (i.e. to multi-task).

Defining Automaticity

Yet despite the evidence already presented, a commonly agreed definition of automaticity continues to elude theorists. For that reason many prefer to focus on the processes involved in automaticity. For example, Schneider and Schiffrin (1977) and Schiffrin and Schneider (1977), who provided the first and most influential account of automaticity, described learning as a two-stage process, with controlled or serial processing at one end and automatic or parallel processing at the other. They also claimed that automatic processes (those that are well learned) were inflexible and impervious to change. Cheng (1985) was critical of this account and disputed the notion of automaticity. She claimed that changes attributed by Schneider and Schiffrin to automaticity were the result of information restructuring or chunking. According to this theory, a young child who frequently visits a hospital may develop an elaborate "hospital schema" that might include information about uniforms worn, job titles and the roles performed by individuals including doctors, nurses and patients. They are therefore less fazed when a doctor appears in green scrubs or a suit than a child who associates doctors with white coats.

Despite the popularity of schema theories, other evidence indicates that similarly related information is not always recalled with equal speed, suggesting that it might not be stored collectively, as suggested by Cheng (Eysenck & Keane, 1996). In attempting to account for differences in speed of recall, Flor and Dooley (1998) suggested that more than one schema could develop at a time with processing time slowed due to competition between similar schemas. According to Flor and Dooley, over time a single schema would emerge to become dominant. This view is similar to a previous theory posited by McKay (1982) who argued that practice under consistent conditions leads to an increase in neural firing between the nodes in an existing neural network. Therefore, modification in the network is not necessary to explain gains in speed and accuracy. This is the worn-path view, where connections are strengthened, or made easier to follow, due to repetition. While this may offer one explanation for gains in processing speed, it seems probable that there exist limits in reaction times due to limitations in the neurological and electric-chemical reaction speeds.

Consistent with this theory, Logan's (1988) Instance Theory of Automization describes the development of automaticity in terms of a progression from a search algorithm schema to a direct retrieval schema. In the early stages of this model, a child or an adult might progressively work through a problem using a simple step-by-step problem-solving approach. Each time the performance was repeated an instance (i.e. a memory trace) would be laid down. With repetition and practice, the number of steps required to solve the problem would reduce until eventually the solution would be recalled directly from memory. As new pathways were strengthened, other less frequently used routes would be forgotten.

Automaticity Deficits

Although initially controversial, in recent years a number of theorists have argued a biological basis for automaticity deficits. Frith (1995), for example, was among the first to associate abnormalities in cerebral functioning with dyslexia. Support for this view was provided by Nicolson and Fawcett (1990/1999) who undertook a series of experiments with preschool children spanning a 10-year period. Their initial work involving tests of balance and time estimation was based on the premise that automatic processes are fast and require little conscious effort. According to this theory, performance will degrade when dual-task conditions necessitate conscious effort. In order to test this hypothesis, Nicolson and Fawcett (1990) examined the performance of 23 13-year-old dyslexic children on a test of motor balance, and compared it with that of same-age controls. To test the "conscious compensation hypothesis" they introduced a secondary task to divert attention away from the primary task. They employed two groups, a control group who performed a single motor balance task and an experimental group who performed the motor balance task and a concurrent secondary task, designed to take up "conscious processing capacity". Their findings indicated that children with dyslexia performed at a lower rate and had significantly more impairment problems than non-dyslexic children. Based on this evidence and the results of behavioural and anatomical studies and brain imaging research, Nicolson, Fawcett, and Dean (2001) concluded that cerebellar problems present at birth lead to problems in the development of skill (including articulation), fluency and automaticity.

Automaticity and Learning

While automaticity has a pejorative ring for those who associate it with mindless rote learning, it can also imply as is intended here an opportunity for young children to gain familiarity with the basic concepts that form the building blocks of higher order thinking and learning. A number of interesting methods have been suggested to aid the early development of automaticity. For example, Kelly and Johnson (2001) argued that screening in the preschool years would enable practitioners to identify children at risk of automaticity deficits. Although initially confined to children with a history of dyslexia in the family, screening would ensure that, from their earliest years, those vulnerable to similar developmental difficulties were offered intensive training in word recognition to facilitate the development of automaticity. Despite their good intent, caution is required with programmes that may be interpreted as labelling children as failures, most especially when they occur in the early years of a child's education. The long-term consequences of labelling are well documented and have been found to negatively impact on the developing child's self-efficacy, self-esteem and self-worth.

Allied with early identification, other theorists have argued that motor skill intervention can help learning disabled children achieve automaticity (Farnham-Diggory, 1992). Although these studies indicate a significant improvement in motor tasks (for example, Cammisa, 1994), there is little evidence of skill transfer to academic and social domains. Further criticism of these intervention programmes comes from research by Bluechardt and Shepard (1995), who found a significant improvement in the performance of both the control and experimental group members, which they attributed to the Hawthorne effect. Consequently, educators have been slow to adopt these methods.

Less controversially, perhaps, Koda (1996) suggested that classroom environments should be structured to reinforce learning and the development of automaticity through the use of visual displays and pictures associated with a learning task.

Koda was also concerned that learning should not be viewed as domain specific and argued that teachers were responsible for ensuring that children understood how knowledge learnt in one context might be applied in another. Consistent with this view, Dewey (1998) claimed that the classroom environment should assist children in grasping the essential similarities between tasks. Dorn and Soffos (2001) went further when they argued that teacher's should create the conditions necessary to promote the transfer of information across contexts. They also considered varied and repeated practice in a structured and supportive environment essential for the development of automaticity. Using basic numeracy as an example they offered the following set of guidelines, which they proposed could be adapted to a range of activities and modified to suit the needs of all children, irrespective of ability:

- the task must promote problem-solving strategies based on what the child already knows;
- initially the task should be introduced with guidance and coaching from the teacher;
- the teacher should ensure the child understands the goal of the task and the specific instructions for carrying it out;
- tasks should develop along a continuum from basic introductory units to the more challenging and complex aspects that involve higher order thinking; and
- the skill should enable the child to track their own performance through journals and logs (Dorn & Soffos, 2001, p. 74).

Within this framework, teachers are encouraged to design a classroom programme that reflects the expressed needs and interests of the child. For example, an environment that promotes practice with numbers in a variety of settings can be used to encourage the development of basic numeracy skills, without the need for mindless repetition and rote. The illustrations in Figure 1 indicate some of methods available to Early Years professionals.

By acknowledging that many children come into early years settings having picked up some numeracy skills at home, teachers can initiate developmentally appropriate experiences in the classroom that build on the child's existing knowledge base and ultimately serve to develop automaticity.

The benefits of guided learning were summed up by Collins, Brown, and Newman (1991, p. 38), who described them as "the interplay between observation, scaffolding, and increasingly independent practice aids, apprenticeship both in developing self-monitoring and correction skills, and in integrating the skills and conceptual knowledge needed to advance towards expertise". From a developmental perspective, the establishment of a system that emphasises skills such as planning and monitoring in the development of automaticity must play a central role in cognitive growth (English, 1992). Of equal importance is the flexibility of the programme, which can be tailored to suit the ability level of the most or least able pupil. However, a

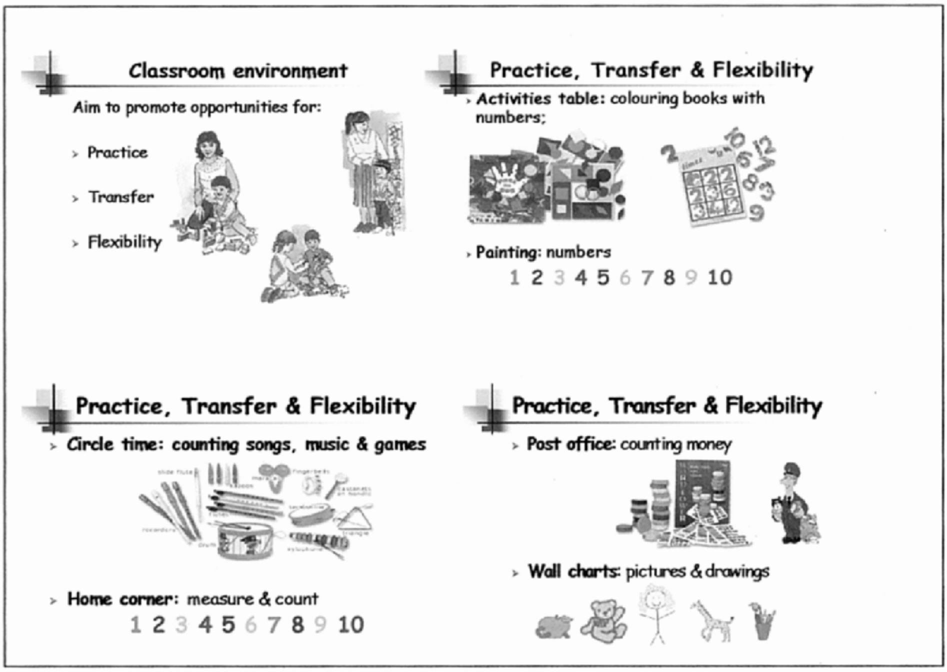

Figure 1. Methods Available to Early Years Professionals.

cautionary note was provided by Perfetti (1996), who argued that it would be unrealistic to expect high levels of automaticity to develop in the short time available to early years practitioners. Nevertheless, he claimed that even in 1 year practitioners should expect some dramatic increases in processing efficiency. Perfetti (1996, p. 16) offered teachers the following advise: "lots of practice makes perfect, less practice makes less perfect, but when time is limited you do what you can".

Summary and Conclusion

While a growing body of evidence implicates deficits in automaticity in a range of learning disabilities, theorists have failed to agree a common definition of automaticity. Most would, however, agree that automaticity is fast, that it involves parallel processing and that it reduces the demands placed on limited cognitive resources. Although it was beyond the scope of this paper to examine the extant literature in detail, theories pertinent to this discussion were briefly reviewed. Their findings suggest that automaticity of basic facts is fundamental to the acquisition of more complex skills and for the development of higher order thinking and learning. An important and recurring theme of this paper was the role of practice in the development of automaticity. As was pointed out, practice should not be interpreted as rote learning or as meaningless repetition; rather it should be innovative, varied, interesting and appropriate to the developmental needs of the individual child. While it might be argued that the evidence presented here is not new, in drawing on research from a number of previously disparate areas it may serve to highlight the role that an early years practitioners can play in the development of automaticity.

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