CURRENT TOPIC

Learning in preschool children with neurological disability

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Infants and children learn through the interaction of their nervous systems with their physical, social, and cultural environments, helped by their peers, parents, and teachers. The failure of such learning to progress normally in preschool children delays their acquisition of developmental skills and may lead to the identification of the child as being "developmentally delayed".

There is increasing understanding of processes underlying learning at different levels of complexity: from changes in synaptic function, through the identification of specific neuronal systems, to the cognitive and perceptual faculties which such systems may support,¹ and extending to the logical structures required to represent what is learnt and to guide further learning.² This has a counterpart in the considerable literature on how a child's learning may be influenced by social and cultural environments,^{3,4} by the attitude and responses of parents and carers, and by the child's ability to interact with them.

It is important clinically that we are able to identify impediments to learning in individual children, at such different levels, so that we can assess their effects and develop strategies to optimise subsequent learning for that child. We do not know how to influence damaged brain systems directly, but may be able to reduce the effects of neurological damage on subsequent learning and skill acquisition, which may in turn improve impaired perceptual or memory abilities. How can the child with neurological impairment be enabled to perceive, understand, respond to and explore their environment?

Active learning

Infants and children learn through "active engagement", doing things together with a parent or carer, who enables and mediates the child's further exploration and understanding of the environment.³ We wish to provide examples to describe some of the neurological processes which may underlie such "active learning", and how it might be disrupted when they are impaired.

Perception

A perceptual bias to faces, voices, and moving objects ensures that a newborn infant's attention is directed to those aspects of his or her

world which contain the most relevant information.² Access to such information may be affected directly by visual or auditory impairment or as a result of the lack of attention to faces and speech in infants later shown to have an autistic spectrum disorder.

Damage to sensory tracts in the form of periventricular leucomalacia, with impairment of subsequent myelination, is a recognised sequel of preterm delivery and intrauterine growth retardation. This may degrade the quality of individual sensory signals, particularly those dependent on the accurate registration of short time differences.⁵ It might also affect the synchronisation of activity between cortical neurones, which is thought to underlie the "binding" of separate attributes pertaining to one object, and the more widespread "dynamic selection" and "binding of responses" throughout the forebrain.⁶

To provide information for a response, percepts must be "encoded". Such "encoding" depends on both "bottom up" and "top down" processing, when low level sensory signals (bottom) are recognised and categorised on the basis of prior expectation or existing knowledge (top). If a perceptual system is damaged, then items of "weak perceptual salience" are less likely to be attended to and encoded correctly, unless they are specifically anticipated, and such encoding may be slower, resulting in a loss of information before a task is complete. Such impairment can be partly compensated for by ensuring that relevant features are made most salient, that the infant's or child's expectations are directed towards those features, and that they are assimilated before other demands are imposed.⁷ In general, an enhanced knowledge base or appropriately directed expectation may compensate for degraded sensory signals.⁷

Auditory signals which contain very rapidly changing characteristics and transients, such as are produced by consonants in speech, require encoding by specialised cortical systems, which appear to be specifically impaired in some children with language impairment.^{7,8} This deficit may extend to the encoding of rapidly changing visual signals, but may possibly be ameliorated by extending stimulus duration.⁸

Disordered sensory signalling might also be expected to affect the integration of sensory information across modalities. Imitational abilities for mouth and tongue movements are

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present neonatally, and imply a direct link between visual and motor percepts which may extend to a perception of affect.² The integration of sensory signals across modalities is demonstrable from 2–3 months.⁹ The ability thus to link different aspects of an object or event is also likely to be important in the perception of temporal contingencies, and the perception of wider cues to the understanding of a situation.¹ Developmental coordination disorder is frequently associated with white matter damage following preterm birth. Cross modal sensory integration is impaired in children with developmental coordination disorder.¹⁰

Learning and recognition

Infants and young children depend on a high degree of contextual and task similarity to recall, or perform, what has previously been learnt. In early infancy, recall may even require testing in the room in which the task was learnt. Infants are more able to encode new information when presented in a familiar context, and by a familiar person. The duration of task recall after one training session depends on age and on subsequent reinforcement. It is reduced if the infant is upset or crying during the session.¹¹ This dependence on the particular learning context is seen in individuals with learning disability, and with autism. In the former group and in young infants, it can be reduced by incorporating novel contexts in the original training.^{11–12} Autistic children may be particularly sensitive to minimal changes in context. There is evidence that similarities and differences, between tasks or stimuli, are processed differently in the brain,¹ and that autistic individuals are less able than others to process similarities, but more able to respond to differences.¹³

Contingency and interaction

Infants are particularly responsive to events occurring within 3–5 seconds of an action, particularly if they are of a kind to confirm or negate their expectations.¹⁴ Such temporal contingency can be disturbed by their actions lacking wanted or reliable effects, as in infants with cerebral palsy, or where the contingent responses of carers are lacking, as in maternal depression.¹⁵ Contingency might also be affected when the infant's response is so delayed as to escape notice, or by subclinical seizure activity.¹⁶

With adult cueing, indication of relevance and encouragement, or “scaffolding”, an infant is able to perform at a higher level than alone. This precedes the independent practice of that skill.⁴ Such reciprocity requires both child and adult to monitor each others' responses, and to determine what is mutually understood at any time. This monitoring will be more difficult with sensory impairment or inattention as described above, or in those with deficient “joint attention”.

Adaptation and interpretation

The ability of a child to modify their approach to a task requires the inhibition of an automatic

response, and the selection of a suitable approach from a range of competing possibilities.¹⁷ The inhibition of “automatic” responses and the delaying of responses may depend on prefrontal lobe maturation.¹ Both may be impaired in children with attention deficit disorder, in whom there may be a critical balance between the rewards and delays associated with a task.¹⁸ The “meaning” of the task for the child and parent, and its social context, will also influence how a task is approached.

“Inflexible” approaches are seen in children with learning disabilities, due both to failure to modify existing knowledge, and difficulty in adapting a skill to a new setting without specific instruction.¹² “Trial and error” learning may be important in permitting the modification of existing procedural memories,¹⁹ which may be inflexible and tied to “surface characteristics” of situations,¹ and whose persistence may otherwise prevent adaptation.¹⁹ Frontal lobe damage may impair “trial and error” learning, while still permitting procedural learning in an “errorless” paradigm.

Anticipation of, and appropriate responses to, events in specific situations are seen early in infancy, and may develop into complex routines.² The ability to understand that the significance of an event may vary according to its context requires a different form of logical representation in the brain. Such “metarepresentations” allow objects, words or gestures to be recognised in their own right, but also to be interpreted according to context, and thus to be used as symbols.²⁰ Children with features of an autistic spectrum disorder have particular difficulties with metarepresentation and the flexible interpretation of social and language information.

Motivation

Imitation and exploration are required for the child to develop behavioural repertoires, and to test inferences about the results of their actions on objects and people.² An inability to achieve reliable and successful results, whether it be because of sensory or motor impairment, difficulty in linking the sensory and motor aspects of the required movement, or inappropriate responses from carers, may discourage the child from active involvement and may eventually demotivate carers,²¹ further reducing the sensitivity of their responses.

Any notable neurological disability will affect a child's ability to respond to and influence their environment appropriately. The more severe the disability, the more the child may be a passive spectator of events and environmental features, rather than a purposeful and successful protagonist. Parents may spontaneously modify the environment and their responses to encourage the child and promote learning. For example, deaf children of deaf parents may develop communication skills more easily than deaf children of hearing parents. This is because deaf parents will be more attuned to non-auditory cues from the child and thus are able to respond more easily in the most appropriate manner, as well as being more adept at

alternative methods of communication. Otherwise, an assessment programme may enable parents and carers to develop observation skills and lead to different responses to cues from their disabled child.

Assessment

Standardised instruments are used increasingly in the diagnosis of autistic spectrum disorders, in the quantification of ability in motor disorders, and in the recording of impairment in cerebral palsy. Such instruments are of great value for purposes of audit, epidemiological investigation, and comparison of populations across centres. They are of less value in identifying approaches for individual intervention, particularly in those children with mixed or partial disorders, who may be placed in the "comorbid" or "not otherwise specified" categories.

The World Health Organisation terminology separates "impairment" and "disability". The aim of any developmental intervention must be to reduce the level of disability arising from a given impairment. The circumstances in which the impairment has arisen and the meaning of the disability for the family will influence their perception of, and response to, the child's difficulties. The effect of a neurological impairment on skill acquisition may thus be compounded by the family's inability to adapt their responses and the child's environment appropriately. The purpose of an assessment is to identify both these obstacles to learning, and the strengths of the child and family which can form the basis for intervention.²² Elucidation of the underlying impairments would be helpful; however, most developmental and ability scales only measure disability. Such elucidation thus relies on inference guided by the currently adopted approach to the child's motor and cognitive development. The evaluation of parental understanding, strengths, and needs may be similarly imprecise and fragmented. Parents and carers will usually know most about the child and will be the most sensitive to his or her responses and activities; assessment needs to be undertaken in partnership with them.²²⁻²³ An assessment must obtain information that is valid for different settings and different times. Observation and discussion of the child's interaction with carers and their responses are of vital importance. Ideally a child should be seen at home with other family members, in a nursery setting with other children where applicable, and in a controlled environment such as an assessment centre. Where only the last is practicable, video records of the child in other settings, which can be discussed with parents and carers, may be valuable. For some children, where initial consultation suggests that learning is slow in all areas in the absence of more specific difficulties, an "assessed intervention" with an early learning programme, such as Portage, may be appropriate. More detailed assessment can then be undertaken should progress be slower than expected.

We suggest that the concept of disturbances of "active learning", as discussed above, may form a useful framework within which to con-

duct assessments and plan interventions with parents and carers. The key aspects, such as changes in attention, contingent responses, adaptation, and motivation are directly observable and accessible to families and therapists.

Intervention

The purpose of a developmental intervention from the viewpoint of the child is to ensure that he or she can perceive and assimilate relevant features of his or her environment, that salient events and carers' responses are contingent, predictable, and rewarding, that exploration is possible, and that tasks are structured to enable success. From the carers' viewpoint, professional intervention should be such that they are enabled to understand and respond contingently to the child's efforts, and to synchronise their activities with his or her arousal and attention,²⁴⁻²⁵ rather than the child's activities being seen as inappropriate or incomprehensible. Highly prescribed activities may be damaging to such a process if parents or carers are made to feel deskilled, but may be helpful in some families, particularly initially when introduced within a model of partnership. "Hands on" therapeutic techniques are of value when used to demonstrate skills to parents and carers. They may be discouraging when viewed as being restricted to "therapy sessions", rather than adapted to form an integral part of families' activities with their children.²²⁻²⁶⁻²⁷ Continuing negotiation with, and listening to, parents and carers is crucial in ensuring that professional approaches are adapted to the changing requirements of the child and family.²⁸ Overburdening parents with responsibility for deciding on activities, or conversely, treating them as passive recipients of expert advice and assistance, are both to be avoided. Intervention programmes should have clear, relevant, attainable, and measurable goals.

Activities designed to promote specific skills or prevent deformity should be part of an integrated approach to the child's difficulties. Systems of reward to encourage attention and to further exploration need to be combined with manipulation of the task environment to minimise failure and maximise motivation. For infants and children with motor impairments, supportive technology such as specialised seating or body/limb supports to assist postural control, and switch accessed computers, may allow successful exploration and interaction. Pool activities and riding may provide highly motivating settings to develop postural control skills. Similarly music may provide a focus for reward and interaction in children with verbal inattention,²⁹ as may singing in those children who also lack facial attention. Visual cueing and instruction by demonstration may assist such children in group activities. Self paced computer activities with immediate rewards can be used to develop memory and attention skills in children with attention deficits, and to develop language and interactional skills in children with autistic spectrum disorders, taking advantage of their predisposition to computers.³⁰ Activities can be presented in short steps to coincide with a reduced attention

span or to maximise success in an errorless learning paradigm. A guided "trial and error" approach may be suitable at other times. Developmental programmes need careful and continuing review in light of the responses of the child and family. Where several workers and agencies are involved, coordination and willingness to allow the child's overall interests to take precedence over issues of professional and agency demarcation are vital to avoid parent and child confusion and to maintain engagement.

Conclusion

Assessments of preschool children with suspected neurological disability have traditionally relied on catalogues of levels of achievement and disability in different areas of professional interest, drawn up following attendance at a child development centre, with interventions designed to promote separate skills identified as deficient. We suggest that the emphasis should be on ascertaining how a child's learning is impaired, through assessment in a variety of settings, and how "active learning" can then be supported in ways directly accessible to the family.

- 1 Mesulam MM. From sensation to cognition. *Brain* 1998;121:1013-52.
- 2 Gopnick A, Meltzoff AN. *Words, thoughts and theories*. Cambridge, Massachusetts: MIT Press, 1996.
- 3 Bronfenbrenner U. *The ecology of human development*. Cambridge, Massachusetts: Harvard University Press, 1979.
- 4 Vygotsky LS. Discussed in Meadows S. *The child as a thinker*. London: Routledge, 1993.
- 5 Stanley OH, Fleming PJ, Morgan MH. Signal transmission in sensory systems following intra-uterine growth retardation. In: Jones CT, ed. *Fetal and perinatal development, research in perinatal medicine (VII)*. New York: Perinatal Press, 1988;7:250-3.
- 6 Singer W. A new job for the thalamus. *Nature* 1994;369:444-5.
- 7 Bishop DV. *Uncommon understanding*. Hove, West Sussex: Psychology Press, 1997.
- 8 Tallal P, Sainburg RL, Jernigan T. The neuropathology of developmental dysphasias: behavioural, morphological and physiological evidence for a pervasive temporal processing disorder. *Reading and Writing* 1991;3:363-77.
- 9 Streri A. Tactile discrimination of shape and intermodal transfer in 2 to 3 month old infants. *British Journal of Developmental Psychology*. 1978;5:213-22.
- 10 Hulme C, Biggerstaff A, Moran G, McKinlay I. Visual, kinaesthetic and cross-modal judgements of length by normal and clumsy children. *Dev Med Child Neurol* 1982;24:461-71.
- 11 Rovee-Collier S, Gerhardstein P. The development of infant memory. In: Cowan N, ed. *The development of memory in childhood*. Hove, West Sussex: Psychology Press, 1997.
- 12 Brown AL, Campione JC. Training for transfer. Guidelines for promoting flexible use of trained skills. In: Wade MG, ed. *Motor skill acquisition of the mentally handicapped: issues in research and training*. Amsterdam: Elsevier Science Publishers, 1986.
- 13 Plaisted K, O'Riordan M, Baron-Cohen S. Enhanced discrimination of novel, highly similar stimuli by adults with autism during a perceptual learning task. *J Child Psychol Psychiatry* 1998;39:765-75.
- 14 Watson JS. Memory and "contingency analysis". In: *Infant learning*. Detroit: The Merrill Palmer Institute. 1967;13:55-76.
- 15 Puckering C. Maternal depression. *J Child Psychol Psychiatry* 1989;30:807-17.
- 16 Marston D, Besag F, Binnie CD, Fowler M. Effects of transitory cognitive impairment on psychosocial functioning of children with epilepsy: a therapeutic trial. *Dev Med Child Neurol* 1993;35:574-81.
- 17 Thornton S. *Children solving problems*. Cambridge, Massachusetts: Harvard University Press, 1995.
- 18 Sonuga-Barke EJS, Taylor E, Sembi S, Smith J. Hyperactivity and delay aversion: the effects of delay on choice. *J Child Psychol Psychiatry* 1992;33:387-98.
- 19 Baddeley A, Wilson BA. When implicit learning fails: amnesia and the problem of error elimination. *Neuropsychologia* 1994;32:53-68.
- 20 DeLoache J. Shrinking trolls and expanding minds: how very young children learn to understand and use symbols. *Zero to three*. Richmond, Virginia: National Centre for Infants, Toddlers and Families. 1996/1997;17:10-16.
- 21 Wasserman GA, Allen R. Maternal withdrawal from handicapped toddlers. *J Child Psychol Psychiatry* 1985;26:381-7.
- 22 Dale N. *Working with families of children with special needs: partnership and practice*. London: Routledge, 1996.
- 23 Cunningham C, Davis H. *Working with parents: frameworks for collaboration*. Milton Keynes: Open University Press, 1988.
- 24 Beckwith L. Adaptive and maladaptive parenting: implications for intervention. In: Meisels SJ, Shonkoff JP, eds. *Handbook of early childhood intervention*. New York: Cambridge University Press, 1990.
- 25 Barnard KE, Kelly JF. Assessment of parent-child interaction. In: Meisels SJ, Shonkoff JP, eds. *Handbook of early childhood intervention*. New York: Cambridge University Press, 1990.
- 26 Israel C, Dolby S. *Parent-baby interaction programme*. Windsor: NFER-Nelson, 1997.
- 27 Davis H, Rushton R. Counselling and supporting parents of children with developmental delay: a research evaluation. *Journal of Mental Deficiency Research* 1991;35:89-112.
- 28 Cameron SJ. A parents' view. In: Dessent T, ed. *What is important about Portage?* Windsor: NFER-Nelson, 1984.
- 29 Bunt L. *Music therapy: an art beyond word*. London: Routledge, 1994.
- 30 Light P. Computers for learning: psychological perspectives. *J Psychol Psychiatry* 1997;38:497-504.