A Blue Kangaroo in the Brain Lab

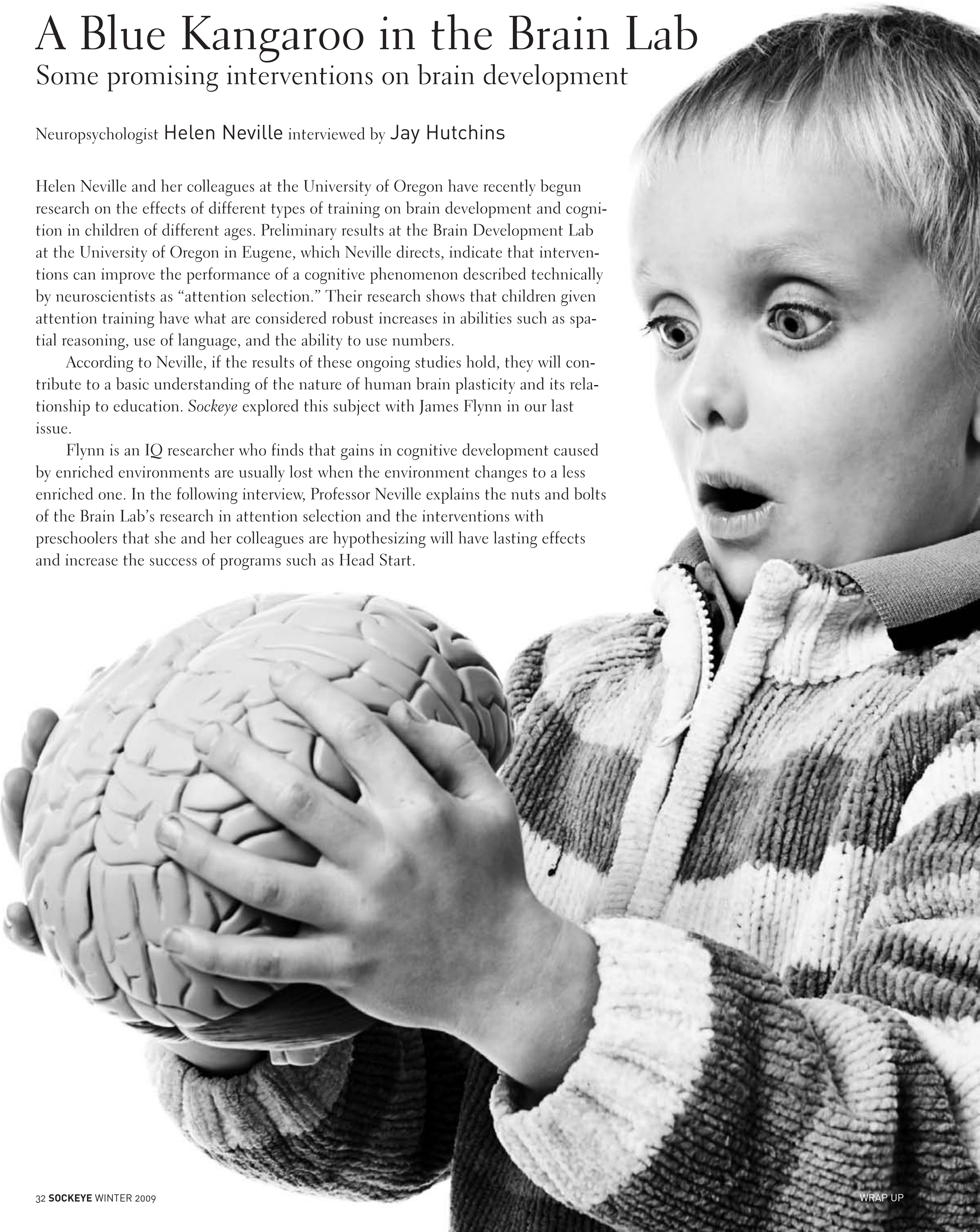
Some promising interventions on brain development

Neuropsychologist Helen Neville interviewed by Jay Hutchins

Helen Neville and her colleagues at the University of Oregon have recently begun research on the effects of different types of training on brain development and cognition in children of different ages. Preliminary results at the Brain Development Lab at the University of Oregon in Eugene, which Neville directs, indicate that interventions can improve the performance of a cognitive phenomenon described technically by neuroscientists as "attention selection." Their research shows that children given attention training have what are considered robust increases in abilities such as spatial reasoning, use of language, and the ability to use numbers.

According to Neville, if the results of these ongoing studies hold, they will contribute to a basic understanding of the nature of human brain plasticity and its relationship to education. *Sockeye* explored this subject with James Flynn in our last issue.

Flynn is an IQ researcher who finds that gains in cognitive development caused by enriched environments are usually lost when the environment changes to a less enriched one. In the following interview, Professor Neville explains the nuts and bolts of the Brain Lab's research in attention selection and the interventions with preschoolers that she and her colleagues are hypothesizing will have lasting effects and increase the success of programs such as Head Start.



Sockeye: Professor Neville, please tell me how you chose this line of study.

Neville: Our research began with a basic interest in the changeability of the human brain, what neuroscientists refer to as neuroplasticity. Neuroplasticity refers to the way that experiences modify the brain's functional specialization. Initially, this work focused on adults with unusual early experience, including those born deaf or born blind. We observed very different organization in the visual and auditory areas of their brains. Different neural subsystems displayed markedly different profiles of neuroplasticity, meaning that the architecture of the brain is highly specialized and complex.

Sockeye: People often project an awful lot onto what research such as yours might mean. Can you give some concrete examples of the ways the brain is plastic and the limits of this plasticity?

Neville: Vision is a system. Within the system there's a specific crucial period in babies for removing cataracts. If you don't get them out within five weeks, a child will never have normal visual acuity. But there's a different critical period for surgically aligning the two eyes. The cutoff for depth perception is at about a year. Every aspect of vision is quite different, and these are examples of two of its subsystems. Others subsystems are highly modifiable by experience.

Attention selection, the subject of our research, is one of those cognitive systems that is very changeable. Like other brain systems that are modifiable, it takes longer to develop. We also know that this aspect of attention has a long developmental time course; it continues to develop at least through 10 years of age. And it is vulnerable to deficit and capable of enhancement.

Sockeye: What is attention selection? I assume it is different than just paying attention.

Neville: Yes, technically it is very different. Attention selection is a fundamental cognitive process that takes place in the brain very early on in the processing of any sensory input from the environment. While you are listening to my voice, you are suppressing irrelevant information. That is attention selection.

Sockeye: By early, you mean the effect happens early in the process of directing your attention, whether you are an adult or a toddler?

Neville: That's right. And attention selection changes sensory processing. Studies on this effect have been around for 20 to 30 years and very well controlled. We know the physiology, the anatomy, the genetic basis, and the chemistry. We can manipulate an attention effect with drugs. We neuroscientists believe we know exactly how attention selection works.

Attention selection is created when the brain amplifies the neural response to whatever is the focus of attention relative to whatever is ignored. In your visual or auditory world you might be attending to one out of 100 or 1,000 different objects or events. If a child in school (or an adult, for that matter) doesn't have the capability of effectively selecting one out of six possible events in the world, basically, their brain is overwhelmed and they're not able to do very much at all. A selective attention problem negatively affects learning and it makes sense that it can affect social skills. A small attention effect explains why children with Attention Deficit Disorder, ADD, have trouble in school.

Sockeye: What factors influence attention selection?

Neville: The whole process is mediated by dopamine. In our research, some people have more of an attention selection effect than others, depending on the distribution of dopamine and serotonin that they have.

What caught our attention in earlier research was that in deaf people, the attention selection effect neuroscientists measured was twice as large as it was in hearing people. In blind people, it was twice as large as in sighted people. In these populations, we saw that the effect was modifiable by experience or training. And we have recently found attention selection effects are modifiable by experience in vulnerable children from lower socioeconomic backgrounds.

Sockeye: What do you mean when you say the effect was twice as large?

Neville: It is twice as large in terms of the amplitude in microvolts, which is how we measure these effects. So, it is the magnitude of the effect that is twice as large. The technical name for what we measure is the event-related potential (ERP), which is the electrical potential we measure with probes placed on the scalp.

Sockeye: How do you measure the attention selection effect in young children?

Neville: We start by having them fixate on crosshairs (we call this a fixation cross) displayed on a monitor. At the same time, two stories are presented from two speakers, positioned at the left and the right of the monitor. One story is about a blue kangaroo and the other is about Harry the dog.

And we have pictures on the monitor that go along with the story: a picture of a blue kangaroo and a picture of Harry the dog. We tell the child to keep their eyes straight ahead on the crosshairs and pay attention to the blue kangaroo.

Then we look at the brain's electrical response in physical probes, measuring the effect in the part of the brain where attention selection takes place. When the attention is directed to the blue kangaroo, there is no physical change, such as shifting the eyes or increased arousal stimulated by a change in the picture. The only change is a mental shift in attention.

We have now measured attention selection in kids as young as 3. What we have seen are 3-year-old kids' brains displaying an electrical force that "multiplies attention," as measured by an increase in electric potential, within a tenth of a second, a hundred milliseconds.

Sockeye: So the stronger the effect, measured by the ERP, the more ably the individual can focus on one thing at the exclusion of other stimuli?

Neville: That is right. The first two studies we published showed that 3-year-old brains can display these effects within a tenth of second. But they were both done with kids from the university community.

Sockeye: Does using kids from the university population skew your results?

Neville: Yes, it does. Many studies done with a middle class population have given biased results, so, we have also looked at kids in the Head Start Program. Some of these kids don't have any effect at all, most commonly low socioeconomic status (SES) kids. These are children enrolled in Head Start programs that serve children living below the federal poverty line, which is about $20,600 for a family of four.

Sockeye: They don't have a strong reaction within a tenth of a second?

Neville: Not within the first half second, which for cognitive processing is a long time. Given the evidence for the ability of experience to enhance neural systems, we have begun to develop attention-training interventions to target these vulnerable systems in typically developing children of lower socioeconomic status.

Sockeye: How scientific are the intervention studies?

Neville: Low SES families who choose to participate in the interventions are randomly assigned to different interventions. The effects of the interventions are assessed by looking at changes in several outcome measures compared to a group of "matched" children whose parents are randomly assigned not to receive the intervention. All testers are blind to the child's intervention status.

Sockeye: Are you raising the awareness in preschoolers of what it feels like to pay attention?

Neville: In what we call "attention training" we teach preschoolers to concentrate on three focal points—eyes, body, and brain—and to use these focal points to regulate their level of attention during various activities. These include physical activities in which the children practice body control, balance, and focus, for example by walking on a balance beam or simply by increasing the time they can remain quiet and still.

The activities also include more mental activities in which the children talk about what it means to pay attention and to deal with distraction. Then we begin to build a common language and set of experiences that all of the children become familiar within their bodies, their emotions, and their thinking.

In some activities the children take turns trying to distract each other while doing a task which requires focus. The kids love to play both roles and effectively build a strong understanding of what it means to pay attention, what it means to be distracted, and even what it means to be distracting to others.

Over the course of the eight-week intervention, they eventually gain the skills to independently use these attention and self-regulation strategies in different environments, including small groups, the classroom, the playground, and at home.

Sockeye: Who are their parents?

Neville: Many of the parents have multiple jobs, are in counseling, and a few have been incarcerated. Some of their households are very chaotic.

Sockeye: I understand you pay them.

Neville: That's right. We pay them $180 to help them find the time to participate. We also give them the full profile of their kids' strengths and weaknesses, and for the most part they find it very interesting.

Sockeye: You have tried a number of different interventions?

Neville: That's right, and the most promising intervention actively involves low SES parents of typically developing low SES preschool children. Across eight weekly, small-group sessions, parents learn evidence-based strategies to improve communication with their children, who are taking the attention training. These communication skills promote children's critical thinking skills, and decrease family stress.

Sockeye: How big are these intervention groups?

Neville: So far, we have data from 14 children in each group. Even with these small numbers, the training that also involves the parents appears very promising. Relative to the control group, parents in the intervention group show a larger decrease in self-reported stress levels. And when interacting with their children, they allow more opportunities for the child to talk and to guide the interaction.

Sockeye: What about the attention selection effect, the ERP, you measure in the kids?

Neville: It goes up two or threefold. The effect is small at first, then increases. In the intervention which also involved the parents, we found larger increases in standardized measures of language, IQ, memory, and attention compared to children whose parents are randomly assigned not to receive the intervention.

Sockeye: So, when both the parents and the kids were involved in the training the effects were stronger?

Neville: The kids' IQ scores went up 14 points. In an intervention where we only trained the parents, we still got an increase of five IQ points from the kids. These are dramatic results, but it's very important to recognize that the results of our interventions need to be replicated.

Sockeye: The gains in IQ must be controversial.

Neville: Yes they are, because everyone assumes IQ is always highly heritable, even immutable. Even the Head Start people were shocked by our results. But in a low SES environment, the heritability of IQ appears to be very low. Eric Turkheimer at the University of Virginia finds that it may be as low as .2 when he looks at studies that include subjects adopted into low SES environments. As you know, most studies that show IQ is highly heritable, about .7, using identical twins from optimized middle-class environments that are similar to our university community.

> The kids love to play both roles and effectively build a strong understanding of what it means to pay attention, what it means to be distracted and even what it means to be distracting to others.

Sockeye: Heritability of .2 would mean that only 20 percent of measured IQ could be attributed to genes in these kids?

Neville: That's right.

Sockeye: Are there other ways you assess your Head Start kids?

Neville: Oh yes. We use standardized tests for receptive language, expressive language, executive functions, and math. All these measures show increases in the intervention groups.

Sockeye: But you have not replicated these results or proven that any of these effects are long-lasting.

Neville: That is correct. We are continuing to assess the parent-training program. We are looking at the effects of the attention training on children's brain organization using the methods I described as well as a functional MRI.

Sockeye: I understand you now have a grant to expand the project.

Neville: Up to now we have been using funds from other projects, but we are fortunate to have this next stage of research funded. In the next three years, during every quarter, we will run the intervention study in which we will counsel both the parent and the kids. We hope to get 100 kids in both the intervention group and the control group—those that attend just Head Start. We are following children longitudinally to see whether improvements persist and generalize to the school environment.

The goal of this research is to contribute information of practical significance in the design and implementation of educational programs such as Head Start. We'll see if our findings are upheld. If they are, we will be proactive in letting policymakers know what we have found.