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EDUCATION AND THE SOCIAL BRAIN: LINKING LANGUAGE, THINKING, TEACHING AND LEARNING

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Several fields of investigation, including developmental psychology, evolutionary psychology, educational research and neuroscience have begun to recognize the essentially social quality of human cognition, as represented by the concept of the 'social brain'. In this article, I discuss this concept, its value for psychological studies of teaching and learning, and how it can be related to a sociocultural theory of education and cognitive development. This involves a consideration of the relationship between individual and collective thinking, and between spoken language use and cognitive development. Some implications for understanding and promoting the educational functions of talk in the classroom are discussed.

INTRODUCTION

The concept of the 'social brain' was introduced by the evolutionary anthropologist Dunbar (1998). Essentially, it represents the view that human intelligence is intrinsically social: that evolution has given us the capacity to operate effectively in complex social networks. Such a social perspective on cognition has relevance for the study of the nature and functions of classroom education, as I will explain. However, I will also argue that some of the most interesting and important implications for understanding how people think, and learn to do so, have not been fully recognized by those who have developed the concept. In particular, I suggest that more account should be taken of the functional connections between collective and individual thinking activities, and of the role of language in those activities. I will present the findings of empirical and theoretical research in support of this argument.

THE INDIVIDUAL AND COLLECTIVE IN HUMAN THINKING

Cognitive psychology has generally upheld the common-sense view that thinking just goes on in individual minds. For many years, the study of how people solve problems or develop new understandings together has typically been seen by cognitive psychologists as a topic within the 'softer' domain of social psychology. Collective thinking has even been judged as unworthy of the attention of 'scientific' psychologists. I recall at one British Psychological Society conference in the 1990s hearing an eminent cognitive colleague dismissing the study of collective remembering as 'just research on chat'. The relatively new field of evolutionary psychology has likewise seemed based upon a strongly individualistic notion of human evolution, of the kind promoted by Dawkin's (1976) book *The Selfish Gene*. On the other hand, social psychologists who have investigated collective thinking have sometimes used their understanding of it to question the validity of experimental cognitive research, not only criticizing the quantitative methods associated with it but the study of individual cognition itself (e.g. Edwards, 1997). Studies of how people think alone and how they think together seemed destined to be kept apart.

Recently, however, these barriers have begun to break down. Across what have been separate fields of investigation, there has been some convergence between researchers about how the individual/social cognition issue should be defined, and its significance for understanding learning and development. In accord with recent criticisms of highly individualistic, 'selfish' interpretations of Darwinism (Midgeley, 2010), within evolutionary psychology and neuroscience some researchers have begun to describe cognition as both an individual and a social phenomenon and to emphasise the intrinsically social nature of human intelligence. In educational research, the development of sociocultural theory has been accompanied by a heightened awareness of the potential importance of collaborative learning and classroom dialogue for children's learning and the development of their understanding. And within developmental psychology, research has demonstrated the importance of self-regulation and metacognition for problem-solving and learning, and has highlighted the role of social interaction with adults for developing children's metacognitive and self-regulatory skills. I will discuss these matters in more detail below.

NEUROSCIENCE, EVOLUTIONARY PSYCHOLOGY AND THE SOCIAL BRAIN

Dunbar (*op. cit.*) comments that the conventional wisdom over the past 160 years in cognitive psychology and neuroscience has been that the human brain has evolved as a means for individuals to process factual information about the world. Investigations in these fields have thus focused on individual sensory and information-processing abilities. It is only relatively recently that it has been suggested that the nature and size of the human brain might also reflect the survival advantages of being able to handle complex social relationships (e.g. Brothers, 1990, cited by Dunbar, *op. cit.*). This has encouraged an interest in how we are able to sense and respond to the subtle social signals of the other people we are interacting with, whether or not we are aware of doing so. Social psychologists observed some years ago that when people interact, they tend to reflect each other's gestures and postures (e.g. Chartrand & Bargh, 1999) and strive to infer each other's emotions and intentions (Fiedler &

Bless, 2001). Such findings can now be linked to neuroscience research which has found that 'mirror neurons' become active when a primate (key research has involved monkeys) observes a community member carrying out an action which involves those same neurons. Commenting on this, Frith and Singer (2008, p. 3875) say: "Through the automatic activation of mirror systems when observing the movements of others, we tend to become aligned with them in terms of goals and actions." This suggests that our evolutionary success, as a species, was strongly assisted by the emergence of abilities not only to coordinate our actions with others (as many other animals can also do, *par excellence*), but to infer their mental states and intentions (based on an intuitive 'theory of mind': Premack & Woodruff, 1978). In combination, such findings support claims for the inherently and distinctively social nature of human intelligence. We are creatures evolutionarily designed for life in a complex society. As Grist (2009, p. 44) explains:

> "We become aware of others because our brains can apply 'theory of mind' – this is the cognitive endeavour of attributing thoughts to others. Part of theory of mind consists in thinking about what other people are thinking about other people – 'what does Jane think about Tom's behaviour towards Pablo, given that Pablo is upset about his father's illness?' This is a very complicated kind of cognition and is, as far as we know, unique to humans. The social brain hypothesis in evolutionary anthropology contends that human brains have evolved to be as big as they are so that we can think about and manage our relationships with other people."

The social brain hypothesis entails a significantly different conception of human intelligence from that which has usually been adopted in mainstream psychology. However, there is a danger that this perspective merely employs the concept of the social brain to generate a new style of individualistic explanation for how people are able to negotiate the social world, and why some of our individual ancestors managed to 'survive' in that world better than others. That is, it is still associated with an inherently individualistic conception of human cognition. Thus evolutionary psychologists tend to argue for the value of intermental sensitivities for promoting individual success in competition and combat (e.g. Harcourt, 1989, cited in Dunbar). Taking a similar perspective, the linguistic philosophers Mercier and Sperber (2011) have even argued that the human capacity for reasoning should primarily be understood as a social, argumentative mechanism, whereby we each strive to persuade others to comply with our preferred courses of action. I think that this misses one of the most important functions of our social-cognitive capabilities, which is that we are able to engage collectively in purposeful, reflective endeavours. Moreover, we learn and develop our understanding of the world through social interaction which is commonly mediated by language. On the one hand, people are able to think collectively; and on the other, engagement in such collective activities enables the development of individuals' thinking. The concept of the social brain should encourage us to investigate cooperative intellectual activity and explore its relationship to the development of individual cognition.

To engage in such investigations, we need to expand the concept of the social brain. Sensitivity to the emotions and intentions of others do not only help us to pursue our individual agendas: they also enable us to create and pursue joint agendas. In ways that are just not possible for other species, we can jointly activate the practical cycles of planning, acting, reflecting and re-planning by which we solve problems, share knowledge, construct new joint understandings. Through becoming sensitive to the limits of each other's levels of understanding, we are also able to take part in interactions whereby one person helps another to learn. This ability to do more than just interact, but rather to 'interthink' (Mercer, 2000; Littleton & Mercer, 2013) is a key characteristic of the social brain. Humans can link their individual brains to create a mega-brain, a collective problem-solving tool, and it is this, rather than individualized competition, which has ensured the dominance of our species. The term 'social brain' should thus carry a double meaning: on the one hand, to refer to the special social capabilities of the organ we each possess; and on the other to refer to the uniquely human capacity to think collectively.

In conversations, we do not only make inferences about the mental states of other speakers, we also make crucial judgements about their knowledge, such as how explicitly we need to reference relevant information about matters under discussion. Such judgements are particularly important in educational

settings when one knowledgeable person is trying to help another who is less knowledgeable to advance their understanding. Language is the prime means at our disposal for making a dynamic assessment of shared understanding, and so has a central, integrated position in enabling human cognition to be both individual and social. As Vygotsky (1962) originally argued, language is both a cultural tool and a psychological tool, linking the 'intermental' and the 'intramental'. He also argued that it is inextricably bound up with the development of more advanced forms of reasoning. As Vass and Littleton put it, "interpsychological thinking is a prerequisite for intrapsychological thinking: it is through speech and action with others that we learn to reason and gain individual consciousness" (2010, p. 107). This view is of course at odds with some other influential views on language and cognition, notably of those who remain committed to a view of language as a discrete cognitive 'module' or capacity, designed for a transmissional kind of communication (e.g. Pinker, 1994, 2007). But emerging findings from contemporary neuroscience research support the more integrated view, as they suggest that mental abilities associated with some non-linguistic skills, such as the appreciation of rhythmic patterns and structures in music, are also involved in language abilities. Thus Goswami (2009, p. 182), a neuroscientist who has studied both literacy and music, comments:

> "If the hypothesis that the dyslexic brain is inefficient in phase locking to rhythmic information in speech is supported by further studies, we can begin to think about how to facilitate children's ability to phase lock to any kind of rhythmic information. For example, rhythm is usually more overt in music than in speech. So perhaps the neuroscience-enriched educator would begin with tapping or dancing in time with music."

THE EDUCATIONAL FUNCTIONS OF LANGUAGE

A model of the social brain in which language is a fully integrated component is compatible with a sociocultural theory of education and cognitive development derived from Vygotsky's work (as described for example by Daniels, 2001, 2008; it is also known as 'cultural-historical activity theory': van Oers, Wardekker, Elbers & van der Veer, 2008). While this theory has some variants, at its basis are the premisses that human intelligence is essentially social and cultural; and that the relationship between social and psychological activity underpins cognitive development. As Vygotsky (1978, p. 88) himself put it:

> "Human learning presupposes a specific social nature and a process by which children grow into the intellectual life of those around them."

It has inspired empirical examinations of how social interaction influences individual learning, problem solving and representations of knowledge. It may well be that, as one socio-cultural researcher suggests "all too often the focus of sociocultural research has been on *intermental* (social, interactional) processes *per see*, to the neglect of explanations of how these intermental processes forge the *intramental* processes that sit at the heart of cognitive development" (Rojas-Drummond, 2009, p. 241). Nevertheless, the potential of sociocultural theory for making the link between social processes and individual learning outcomes is there to be exploited. It not only links the social and the psychological in an account of cognitive development, but also provides a theoretical basis for the primacy of language as a cultural and cognitive – and hence educational – tool (Mercer & Howe, 2012).

Theoretically, the case for the prime role of language in cognitive development and learning has several strands. The first strand concerns the collective process of constructing educational knowledge (whether amongst students or between teacher and students). This process must, by its nature, involve induction into reasoned argument. Although much education focuses on the transmission and acquisition of knowledge and skills, it would be surprising to find many teachers who did not think that their students should be learning how to construct arguments to support any claims that the opinions, analyses, solutions, or conclusions that they present are correct (and that alternative claims are not). While arguments can sometimes be presented through other communicative modes (such as the use of mathematical notation, and by physical demonstration in science or music), language is essentially involved in all subjects. Moreover, achieving competence in specific subjects involves learning to use the specialized discourses

of subject communities; and those discourses are not mere jargon, but tools designed for pursuing scholarship and enquiry. They are functional language varieties, or genres (Kress, 1987; Swales, 1990). Such genres represent ways that individual thinking is made accountable to the normative rules of specific communities of thinkers; and fluency in the appropriate genres is a requisite for full admission to those communities. As Lemke (1990) has put it, a student of science needs to become a fluent speaker of science. The same applies to any other subject, and to a great many non-academic activities also (such as those of the computer and financial industries: see Goodman, 1996). If children's access to these genres is not ensured, their access to wider educational opportunities will necessarily be limited (Rochex & Crinon, 2011). The situated learning which enables people to join communities of practice almost always has a linguistic dimension, even if this is not highlighted by studies of such processes (Lave & Wenger, 1992).

The second strand is an elaboration of Vygotsky's proposed link between the intramental and the intramental. If learning a subject like science involves learning to 'speak' it, then learning to think like a scientist must involve learning to think in a way that corresponds to the ways that other scientists think. Thus the genres of various discourse communities provide resources for organizing the process of thinking alone. The strength of Vygotsky's model is that he envisaged this psychological-social relationship as reciprocal: shared social representations shape individual cognition, and individual insights and arguments can, through the use of language and other modes of communication, populate the social world. Newton's ideas about gravity did not constitute a scientific theory until he succeeded in communicating his thoughts to other people. Shakespeare's plays were not art until they had been shared and performed. Both then became resources for the induction of future generations into science and the arts. Even in the visual arts, styles of painting are distinguished not just through the use of specialized vocabulary, but through the linguistic invocation of the body of common knowledge that underpins critical analysis and the instruction of novices. It is through using specialized language genres that subjects, disciplines, trades, and other fields of human endeavour persist and grow, within and across generations.

The third strand is based on an analysis of the teacher-student relationship. The process whereby an expert guides a novice is one of the basic, key features of human society; it is a manifestation of the social brain. It depends on the establishment and maintenance of a relationship which is normally mediated through language. Talk and writing are the main tools of a teacher's trade, even in settings where the acquisition of some specific skill is assisted by demonstration as well as instruction. Instructing a learner, or providing useful feedback on their efforts, is very difficult without some kind of spoken or written dialogue. As mentioned above, a student's induction by a teacher into the specialized language genres of subject is a very important aspect of education.

The fourth strand of the argument concerns the importance of talk for more symmetrical, collaborative types of learning and problem solving. I will deal with this strand later, under the heading of 'collaborative learning'.

DIALOGUE, METACOGNITION, SELF-REGULATION

The idea might be Vygotsky's, but we have Wertsch (1979) to thank for first illustrating with examples the ways that adult-child communication can promote children's learning and psychological development. He offered an original model of the intellectual interaction between an adult 'teacher' and a child working together on a task, based on the level of intersubjectivity attained by the participants. This helped to clarify Vygotsky's position on egocentric speech, as distinct from Piaget's – that it should be understood in temporal context, as both as product of a child's experience of social speech and a precursor of the 'silent speech' or 'inner speech' of individual cognition (Perret-Clermont, 1980). Egocentric speech therefore represents a developmental stage in the movement from 'other-regulation' to 'self-regulation'. As I have argued elsewhere (Mercer, 2008), this set a new agenda for the study of how the dialogue of social interaction shapes the development of self-regulation, which is such an important aspect of individual thinking and learning.

Olson (1988) was one of the first to suggest links between between parent-child talk about mental states and the development of 'theory of mind'. As

mentioned above, 'theory of mind' is a capacity which has been proposed by evolutionary psychologists and neuroscientists as central to the functioning of the social brain. It is also associated with the broader ability to think about thinking – metacognition. Research on the development of children's metacognitive skills has shown that this is linked to their ability to self-regulate while problem-solving, and contributes significantly to their effectiveness as a learner (Veenman & Spaans, 2005; Whitebread & Pino Pasternak, 2010). This research has not typically been concerned with the role of spoken language use in cognitive development, but some links have been made. One involves a consideration of how social language use can provide a template for the production of 'inner speech', which acts as a self-regulating mechanism:

> "When the child, confronted by a tricky challenge, is 'talked through' the problem by a more experienced agent, the child can often succeed at tasks which would otherwise prove impossible (think of learning to tie your shoelaces). Later on, when the adult is absent, the child can conduct a similar dialogue, but this time with herself." (Clark, 1998, p. 66)

Reviews of research by Whitebread and Pino Pasternak (2010) and Dignath, Buettner and Langfeldt (2008) have shown that many interventional studies based on the principles of making metacognitive and learning strategies explicit and encouraging participants to reflect and talk about their learning have obtained significant effects. Examples include Forman and Cazden's (1985) co-operative group work study; Siegler's (2002) intervention that required children to describe scientific phenomena and then explain their understanding; and Black and Wiliam's (1998) research in which children were encouraged to reflect upon and assess their own learning. The important role of classroom talk for enabling the development of children's metacognition and reflection is now becoming more widely recognized (Whitebread, Mercer, Howe & Tolmie, 2013).

THE EMPIRICAL EVIDENCE: THE EFFECTS OF DIALOGUE ON LEARNING AND DEVELOPMENT

In studies of classroom interaction, the term 'dialogue' has in recent years tended to become more common than the earlier term 'discourse'. They are not, though, synonymous. 'Discourse' can be used to mean any kind of verbal interaction, even of an abstract kind – and indeed that has become one of the problems of using it to convey a more specific meaning. 'Dialogue', on the other hand, has usually been employed to describe a particular quality of interaction. As Skidmore (2006, p. 203) comments, various classroom researchers have independently argued that teacher-student talk should become more 'dialogic', introducing such notions such as:

> "*dialogic instruction*, characterized, by the teacher's uptake of student ideas, authentic questions and the opportunity for students to modify the topic (Nystrand, 1997); *dialogic inquiry*, which stresses the potential of collaborative group work and peer assistance to promote mutually responsive learning in the zone of proximal development (Wells, 1999); *dialogical pedagogy*, in which students are invited to retell stories in their own words, using paraphrase, speculation and counter-fictional utterances (Skidmore, 2000); and *dialogic teachin*g, which is collective, reciprocal, supportive, cumulative and purposeful" (Alexander, 2004).

To those one might add Wegerif's (2010) advocacy of *dialogic education* (in which dialogue seen as both the medium of education and its goal) and Scott's (2008) of *interactive/dialogic* talk (which allows for the exposition of students' naïve ideas as well as those of more authoritative accounts in classroom discussions of scientific phenomena). Some initially distinct, separate lines of pedagogic research have begun to converge around such ideas (as represented by the various authors' contributions to Mercer & Hodgkinson, 2008). Specific teaching techniques have been developed which promote the use of language for collective reasoning, such as Dawes' (2012) 'Talking Points' whereby children are asked to discuss a series of statements related to a topic of study and provide reasons on whether they are true or false; 'Concept Cartoons' (Keogh & Naylor, 1999), whereby children are offered alternative accounts of natural phenomena by cartoon characters and have to decide which is correct; and Stein, Engle, Smith & Hughes' (2008) "five practices for helping teachers move beyond show and tell" in mathematics classrooms. But to what extent is such advocacy of dialogue justified? We need to know if research evidence shows that

the quality of spoken dialogue affects the quality of educational outcomes. A useful, if crude, distinction can be made between two types of talk in educational settings: between teachers and students, and between students working collaboratively without the teacher. I will deal with each in turn.

Teacher-student interaction

Some researchers have made direct links between the patterns of parent-child interactions described by Wertsch (*op. cit.*) and interactions between teachers and students in terms of their effects on the development of children's skills in remembering (Reese, Haden & Fivushm, 1993). Ornstein, Grammer and Coffman, (2010) offer results of a study of primary/elementary school teachers who used a 'high mnemonic style' of dialogue with students, with those with a 'low' style. Those with a 'high' style used what the authors call more 'memory-relevant language', meaning that they proposed methods or procedures for remembering to children and asked them to explain their own strategies. They assessed the impact of variations in style by comparing children's scores on two memorizing tasks over the course of a school year. Children taught by 'high mnemonic' teachers became significantly better at these tasks. However, drawing also on other research, Ornstein *et al.* comment that the natural incidence of such explicitly mnemonic language by teachers is very low.

Low natural incidence is not an issue when it comes to a different feature of teachers' talk – questions, which have been observed to occur frequently in classroom talk the world over. There has been much debate amongst educational researchers over the years about the functions and value of teachers' questions to students (see for example Norman, 1992; Wells, 1999). In this debate, it was at one time very common to find researchers criticising teachers for using questions so much. It was claimed, for example by Dillon (1988) and Wood (1992), that because most teachers' questions are invariably designed to elicit just one brief 'right answer' (which often amounts to a reiteration of information provided earlier by the teacher) this unduly limits and suppresses students' contributions to the dialogic process of teaching-and-learning. Observational evidence shows that it is indeed common practice (at least in those countries where observational research has been carried out) for teachers to use such 'closed' questions very frequently. Thus in a study in English primary schools, Smith, Hardman, Wall & Mroz, (2004, p. 410) reported that "In the whole class sections of literacy and numeracy lessons… most of the questions asked were of a low cognitive level designed to funnel pupils' responses towards a required answer." There is also evidence that reducing the number of questions increases the length of children's contributions to dialogue (Wood, *op. cit.*). Not surprisingly, then, Wood and others have argued that teachers' frequent use of questions should be discouraged.

However, most classroom researchers now avoid simplistic judgements about the problematic nature of teachers' questions. As Wells (1999) and others have clearly shown, teachers' questions can have a range of different communicative functions. For example, they can be used to test children's factual knowledge or understanding ("What is the nearest planet to the sun?"), to manage classroom behaviour ("Could we have all eyes to the board please?") and – less obviously – as a way of finding out more about what pupils are thinking ("Why did you decide to have just three characters in your play?"). In a systematic review of research on talk in mathematics classrooms, Kyriacou and Issitt (2008) found an association with good learning outcomes when teachers make regular use of interactional strategies other than the usual closed-question exchanges. Reviewing a range of studies related to the development of reading comprehension, Wolf, Crosson and Resnick, (2006) concluded that questions about literary texts that encourage students to put the main idea in their own words, and press them for elaboration of their ideas (for example by asking "How did you know that?," "Why?") help to promote students' high-level comprehension skills. On the other hand, Wolf *et al.* also conclude that it is *not* helpful if teachers merely check students' comprehension by seeking yes-no answers, leave little room for students to make sense of the text and select appropriate evidence to back up their thoughts, or frame the question in such a way that the students only have to complete the teachers' incomplete sentence. As Dawes (2008) and others have suggested, teachers can – and should – use questions to serve many pedagogic functions, including the following:

(a) encourage children to make explicit their thoughts, reasons and knowledge and share them with the class;
(b) 'model' useful ways of using language that children can appropriate for use themselves, in peer group discussions and other settings (such as asking for relevant information possessed only by others, or asking 'why' questions to elicit reasons);
(c) provide opportunities for children to make longer contributions in which they express their current state of understanding, articulate ideas and reveal problems they are encountering;
(d) ask not just one, but several students for their initial ideas before going into a topic (but not evaluating their responses);
(e) ask students to comment on each other's views.

These functions of can be related to practical theories of didactics in the European tradition. Thus in describing a study of what makes teaching effective in primary school education, Sensevy (2014, p. 602), suggests that teachers need to help their students understand that "when the students articulate reasons in order to justify their epistemic beliefs, they have to do so through the knowledge language-games that they must master." Using dialogue, teachers are able to help develop their students' understanding in ways that would not be possible if classroom talk was limited to the more usual, closed question 'recitation script'. They can enable students to reflect more carefully on what they themselves do or do not know. They can allow students to practice speaking the expert genres of a subject. They can model ways of regulating learning and problem solving that students can internalise. And the benefits are reciprocal. From hearing their students explain their understanding (or misunderstanding), teachers can gain a better understanding of what students do know, or do not know, and so adjust their 'scaffolding' and instructional teaching accordingly (Soong & Mercer, 2011).

Questions are of course just one common feature of teacher talk. Our study of teachers in Mexican classrooms (Rojas-Drummond & Mercer, 2004) found that those who achieved the best learning outcomes organized more interchanges of ideas and mutual support amongst pupils and generally encouraged pupils to take a more active, vocal role in classroom events than the less effective teachers. In general terms, a teacher's commitment to the use of such strategies reflected their conception of learning as a social, communicative process. That is, they enacted a sociocultural model of education even though they did not necessarily know it as such.

Scott (*op. cit.*) and Alexander (2008) have independently argued that teachers should strive for a better balance in whole-class sessions between 'authoritative', teacher-led talk (which predominates in classrooms the world over) and more genuine dialogue in which students have opportunities to express their understandings and misunderstanding, think aloud, ask questions and explore ideas without being immediately evaluated as 'wrong' or 'right' by the teacher. The evidence for the effects of different styles of teacher-talk on students' motivation, learning and conceptual development is not very precise and lacks much quantitative content, but it has encouraged quite a strong consensus amongst researchers about what is functionally valuable.

Collaborative learning

Research on collaborative learning and problem solving has been an active field since the middle of the last century. Research has been both observational and interventional. Interventional methods have commonly been to try to improve social relations or communications amongst students and see if this improves the quality of collaborative learning, and hence learning outcomes. When such research achieves positive results, as it often has, it offers support for the 'social brain' hypothesis, and for the special importance of language. As Jones (2008, p. 81) puts it, 'the coordination of collective activity through language presupposes individuals who are capable of using language as a means of organising and controlling their own actions and behaviour within the communal task.'

Some carefully designed research studies have provided intriguing results. For example, Howe (2010) describes a series of related studies on collaborative work by 8-15 year olds. Most of these studies concerned children's understanding of science, and involved children being given specially designed practical tasks in which they typically had to predict the outcomes of the relevant events. For example, 8 year olds were asked to predict whether an empty metal box, or a solid rubber ring, would float

in a tank of water. Having agreed on a prediction, they would then test this out using real objects. The children were pre- and post-tested (using either their oral responses or written answers to tests) about their understanding of the relevant phenomena. In this way, Howe and her colleagues established that significantly better results on post-tests of learning and understanding were obtained when (a) groups of children were asked to seek agreement on their predictions before testing them (even if they did not achieve agreement); (b) children worked in a group in which contrasting opinions were expressed. Moreover, it did not seem to matter whether agreement was actually reached, or if contrasting views were reconciled. What was important was that these were features of the discussions.

In explaining these results, Howe suggests that (a) having to seek agreement encourages children to pursue their discussions in more depth and to more certain conclusions and (b) unresolved contradiction during conversation particularly primes children's metacognition – with the result that they subsequently reflect more on what they think about the phenomenon, and on the significance of their observations. She comments that this research "does not merely confirm that sociocognitive conflict, transactive dialogue, exploratory talk, or whatever can precipitate growth; it also shows that these forms of social interaction are so powerful that they can sustain cognitive activity over many weeks when, as often seems to happen with children, differences are not immediately resolved." (Howe, *op .cit.*, p. 80). The studies of collaborative learning in the classroom described by Howe and others such as Slavin (2009) and Roseth, Johnson and Johnson (2008) have provided convincing evidence for the educational value of providing structured opportunities for collective thinking. Group-based activities have been found to assist the study of mathematics (Sfard, 2001; Mercer and Sams, 2006; Slavin, Groff and Lake, 2009) and science (Howe, *op. cit.*, Mercer, Dawes, Wegerif, and Sams, 2004). Most research has involved children, but some studies have been carried out with adults. These have found, for example, that experience of group-based reasoning activities improves subsequent individual performance of reasoning on a task (e.g. Augustinova, 2008; Maciejovsky & Budescu, 2007, cited in Mercier & Sperber, *op. cit*).

Observational research has suggested that for dialogue in groups to be productive (in terms of assisting problem-solving, learning and the development of understanding), it should have the characteristics of what has been called Exploratory Talk (a term originally used by Barnes, 1976). Exploratory Talk "represents a joint, coordinated form of co-reasoning, with speakers sharing knowledge, challenging ideas, evaluating evidence and considering options in a reasoned, equitable way." (Mercer & Littleton, 2007, p. 62). Others have used the terms 'transactive dialogue' (Berkowitz, Gibbs & Broughton, 1980) and 'accountable talk' (Resnick, 1999; Keefer, Zeitz & Resnick, 2000) to describe similar ways of using talk as an effective tool for collective reasoning. A recent review of research on collective problem solving activity across a range of settings – including workplaces as well as classrooms – suggests that Exploratory Talk is essentially the kind of communication which engenders successful 'interthinking' (Littleton & Mercer, 2013). As a speech genre, it represents one of the most important tools in our cultural toolkit. However, research also shows that Exploratory Talk is quite rare in classrooms, in comparison with less analytic and less collaborative types of interaction. This helps explain the apparent paradox of some research on group work indicating that on the one hand it is commonly badly organised and of little educational value (Bennett & Cass, 1989; Galton, Hargreaves, Comber, Wall, & Pell, 1999; Blatchford & Kutnick, 2003; Wegerif & Scrimshaw, 1997) and on the other (as in the research described above) a distinctive and valuable mode of learning. To make the most of opportunities for applying the affordances of the social brain during group work, it is necessary to maximise the use of Exploratory Talk. This encourages us to relate the quality of the dialogue which takes place in groups and the quality of talk that goes on in teacher-led whole-class sessions.

USING TEACHER-STUDENT TALK TO IMPROVE COLLABORATIVE LEARNING IN GROUPS

"By listening carefully to what others say, by giving emphasis to reasoned understanding rather than to formulaic answers, and by trying to help the class to arrive at consensus in a shared understanding rather than by imposing a conclusion arbitrarily, a teacher can make whole-class dialogue a model for pupils' group

> discussions. In both contexts, pupils are experiencing engagement in reasoned discourse" (Black, 2009, p. 4.).

Black's comments, based on his own work in science education, have wider empirical support. For example, Webb, Nemer and Ing (2009) report that differences between teachers in which they asked students to elaborate their problem-solving strategies corresponded strongly to the extent to which students did so during group discussions. Their general conclusion is that one of the main influences on children's talk in groups is the kind of talk that their teacher uses in interactions with them; but that teachers do not commonly model effective discussion in whole class sessions. Many, perhaps most, children do not have many opportunities to learn how to conduct reasoned discussions in their out-of-school lives, or do not realize that they should conduct them on these occasions. If school does not provide that guidance, they are less likely to do so. It is not so surprising, then, that in peer group discussions the talk is often unproductive.

Some interventional research has trained teachers to lead small groups of students in a 'dialogic' manner. Anderson and colleagues have carried out several studies of the effects of teachers using the approach they call 'collaborative reasoning' to lead students in discussions of literary texts. Retznitkaya and Anderson's (2001) study involved 115 fifth grade (i.e. 10-11 years old) students from 3 classrooms, who participated in collaborative reasoning discussions for a period of 5 weeks. These students and students from three comparable classrooms who had not engaged in collaborative reasoning, were asked to write persuasive essays. The essays of the intervention class students were found to contain a significantly greater number of relevant arguments, counter-arguments, rebuttals, formal argument devices, and uses of text information. Through analyzing the talk during such interventions, in which a teacher modelled and guided discussions of that kind about literary texts, Chinn, Anderson and Wagner observed:

> "Four cognitive processes integral to good thinking and greater learning were found more frequently in Collaborative Reasoning discussions than in Recitations [i.e those based on the traditional 'closed question' type of interaction]. In comparison with students in Recitations, students in Collaborative Reasoning discussions (a) made many more elaborations, (b) made many more predictions, (c) provided evidence at a rate nearly 10 times higher than in Recitations, and (d) were much more likely to articulate alternative perspectives." (Chinn, Anderson & Waggoner, 2001, p. 398)

Other researchers have tried to ensure that group work (not involving the teacher) is more effective by encouraging teachers to use whole class sessions to guide and model the effective use of language for reasoning. The Thinking Together intervention studies carried out by myself and colleagues have so far involved more than 700 children, aged 6-14. They represent a continuing attempt to link small group activity and whole-class interactions through the implementation of the kind of pedagogy which Alexander (2008) calls 'dialogic teaching', embodying a sociocultural theory and pedagogy based on language as the prime cultural and psychological tool. These studies have been described in detail elsewhere (for example, Mercer & Littleton, 2007), so I will summarise here only those aspects relevant to my argument. The typical form of each of the studies has been as follows. Teachers of intervention classes are introduced to the concept of Exploratory Talk, and offered ways of developing their students' awareness of this genre of language use as a basis for working together effectively. Essentially, each class agrees to follow a set of 'ground rules' for talking together in groups, which early studies showed help to generate Exploratory Talk. Students are encouraged to apply these rules during all curriculum-related group work, and the teacher uses whole-class sessions to model Exploratory Talk and encourage children's meta-awareness of the ways they use language for reasoning. Compared with control classes following their normal course of study, results have shown that children who follow the intervention programme begin to use much more Exploratory Talk, pursue group activities more cooperatively and become better at solving problems together than those in control classes. Moreover – and crucially for the case I am making here – they also become better at reasoning and solving problems *alone*. So in one study (Mercer, Dawes, Wegerif & Sams, 2004) involving an intervention of 10 weeks, we found that one set of Year 5 children (aged 10-11) improved both their collective and their individual performances on the Raven's Progressive Matrices test of non-verbal reasoning significantly more than did children in

control classes (Raven, Court & Raven, 1995). They also gained significantly better scores in national tests of science and maths; but let us stay with their improved reasoning. Their enhanced performance was achieved through a programme which specifically targeted the spoken language use of the teachers and children: they were not given additional practice in doing non-verbal reasoning. Instead, the teachers used dialogic methods to raise children's metacognitive awareness of how they talked together, and establish common 'ground rules' for how they would talk and work together in groups. The prime goal was for the children to master the genre of Exploratory Talk as a cultural tool. They then applied this to their curriculum-related work. That this would improve the quality of their group work is not surprising, given the findings of research on effective collaborative learning (as reviewed above). It is also in accord with the results of some studies involving adult participants, which found that the generation of debate was a requirement for group activities to lead to improved performance on reasoning tasks: see for example Schulz-Hardt, Brodbeck, Mojzisch, Kerschreiter and Frey (2006). But the effect of this on their *individual* reasoning scores is more surprising. However, it is relevant to note that both sets of groups (control and experimental) were given two opportunities to do the Raven's test in groups, as well as (using a different version of the test) on their own, before the intervention and after it. The intervention children obtained better group *and* individual scores on the post-intervention collaborative application of the test than the control children. The intervention class children would therefore have been able to apply their improved skills in Exploratory Talk to this post-intervention group task, while the control children would not (we observed little change in their discussion skills over the intervention period).

There are thus three possible explanations for the greater individual improvements in reasoning of the intervention class children, which might be called *appropriation*, *co-construction* and *transformation*:[1]

(a) *Appropriation*: Children can learn successful problem-solving strategies and explanatory accounts from each other during group work. Because of their greater use of Exploratory Talk, the experimental children would be more likely to share relevant knowledge effectively as they carried out the Raven's test together, as they would explain and justify their strategies to each other. They would thus be more likely to acquire new, successful reasoning strategies from each other and go on to apply them;

(b) *Co-construction*: By using Exploratory Talk to coordinate their mental efforts, the intervention children would use debate to jointly construct new, robust, generalizable strategies and/or explanations together for completing the Raven's test. This is sometimes called the 'assembly bonus effect', whereby the performance of the group is better than that of its best member (Laughlin, Hatch, Silver & Boh, 2006). The children could then each, individually, go on to on to use these effective strategies and solutions when faced with new, similar problems;

(c) *Transformation*: The intervention children's dialogic training and practice in the use of Exploratory Talk would develop their abilities to reason collectively. By requiring their reasoning to be made explicit, it would also promote their metacognitive awareness of how they reasoned. They would thus become more able than the control class children to examine possible problem-solving strategies in a critical way and regulate their own problem solving when doing a task like the Raven's test. That is, Exploratory Talk provided a dialogic model for the development of individual reasoning.

All three explanations are compatible with sociocultural theory. All three acknowledge, in different ways, the case for the special significance of language use in the development of reasoning, and of the social brain. All three could probably be used to explain the positive results of other studies of collaborative learning. They are not mutually exclusive. But while the 'appropriation' and 'co-construction' explanations are relatively prosaic, the 'transformation' explanation is not. It is a reformulation of Vygotsky's (1978) claims about the transformative effects not only of social experience on psychological development, but of the key role of language in shaping individual cognition. It suggests that even non-verbal reasoning has a language base. This is compatible with claims made by Wegerif (2010) and Mercier and Sperber (2011) that human reasoning is essentially dialogic, and so functions best when set in argumentative contexts.

CONCLUSIONS

In summary, I have argued that the concept of the 'social brain' can help us recognize cognition as both an individual and a social phenomenon, in its practice and in its development. It can also help to bring together some separate areas of research, particularly those on neuroscience, metacognition, linguistics, self-regulation, collaborative learning and pedagogy. To be useful in this way, however, it must carry more than the limited meaning it has commonly been given in evolutionary psychology, anthropology and neuroscience, that we are each naturally equipped to be sensitive to the emotional states of other people and are able to enact a 'theory of mind' about their intentions in order to pursue our individualistic needs. It needs to be set in the context of a sociocultural theory in which thinking is recognized as a collective as well as an individual activity, and which recognizes the distinctive human capability for combining the power of individual brains so that we are able to achieve more collectively than we can do alone. This theory also highlights the reciprocal developmental relationship between individual and collective thinking: we learn to reason as individuals by taking part in collective reasoning, but we also influence collective reasoning (and its knowledge outputs) through our individual contributions to communal activities. The term 'social brain' should thus imply the fundamental link between collective cognition and individual cognition.

This sociocultural conception of the social brain gives language a prime role in enabling collective cognition and in structuring the processes of individual thinking. This is not to deny that non-linguistic modes of representation and communication are important in our intellectual and social endeavours; but research evidence indicates that our evolutionary history has integrated language, in a special way, into both our social/cultural activities and our higher cognitive functions. Research has also shown that language use is involved in the development of metacognition and reasoning, and that is why the quality of children's experience of language use, in and out of school, can affect the course of that development. Given the demonstrated impact of children's pre-school experience on their academic achievements, and the variety of that experience amongst children, the relationship between language and the social brain achieves a special significance in the classroom. The role of classroom talk for promoting the development of children's skills in reasoning collectively and reasoning alone thus needs to be recognized as extremely important and be better understood. For some children, classroom dialogue may offer crucial opportunities for learning that could transform their social destinies.

NOTES

1. I discuss these three explanations in more detail in Mercer (2013).

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