Article for The Psychologist

Doherty-Sneddon, G., Bonner, L., Longbotham, S., Phelps, F., & Warnock, H.

Don't look now I'm trying to think: children's eye gaze and cues to comprehension

During difficult cognitive activity, for example remembering information, thinking of an answer to a question, planning what we are going to say, and speaking, we often close our eyes, look up at the sky, or look away from the person we are in conversation with. Adults are very good at switching off from environmental stimulation (both live faces and other sorts of visual displays) in order to concentrate better. Until recently we knew very little about whether children use gaze aversion in a similar way. This is a potentially important omission since the efficiency with which children process information influences many aspects of their development, including school progress. In this article I'll describe what our research team at Stirling have been doing to investigate children's gaze aversion, including past and current work. These investigations have been funded through 3 ESRC grants. Children's patterns of gaze promise to yield important cues to their thinking, concentration and mental processing that will be useful to parents, teachers, psychologists and anyone engaged in assessing children's knowledge and development.

Visual Communication Signals and Cognitive Effort

Considerable research effort has been expended on examining the role played by visual communication signals in human interaction. There is much evidence that visual communication signals (such as eye gaze, gesture and facial expression) are often important sources of information. Indeed many researchers propose that such signals play a facilitatory role in human communication (for example, Clark & Brennan, 1991; Goldin-Meadow, Wein, & Chang, 1992; McNeill, 1985). However, the fact that such signals are informative means that they carry a cognitive load. The processing costs of visual signals are documented. For example if you are forced to look constantly at your listener while speaking, your speech will become less fluent and contain more "erms" and "uhms" (Beattie, 1981). In addition, adults avert their gaze from other people's faces more when they're dealing with difficult questions and this typically improves accuracy of response (Glenberg, Schroeder, & Robertson, 1998). These sorts of findings have motivated what has been called the 'cognitive load hypothesis' of gaze aversion. In other words we avert our gaze at critical points within a task or interaction to avoid processing of unnecessary, distracting or arousing visual cues from our environment.

Switching off from environmental stimulation (sometimes other people's faces) is documented in real world situations. Feyereisen and Lignian (1981) investigated gaze behaviour in normal and aphasic speakers. They found evidence that gaze avoidance reflects difficulty with verbal encoding. Difficult memory questions produce more frequent eye movements than questions involving less extensive memory search (De Gennaro & Violani 1988). Similarly, the perceived importance of gaze aversion for accurate memory recall is exemplified in Fisher and Geiselman's (1992) recommendation that a witnesses' eyes should be closed as part of cognitive interviews used for eye witness testimony.

Not everyone agrees with a direct 'cognitive interference' hypothesis of gaze aversion. Beattie (1981) suggests that the cognitive load hypothesis is difficult to reconcile with the fact that adults are very good at dual-tasks and selectively attending to relevant stimuli. As an alternative, he suggests that too much gaze between adults can interfere with task accomplishment because it produces increased physiological arousal which in turn influences cognitive processing. In other words, we gaze away from interlocutors' faces when doing demanding tasks, not because information from faces produces an increased cognitive load, but because mutual gaze between people results in physiological changes that can influence cognitive functioning negatively.

Children's Strategies

So gaze aversion is reported occurring in adult interactions as a strategy for avoiding cognitive overload. However until recently no-one had investigated this phenomenon in children. Is disengaging from environmental stimulation a skill that is learned? Children are especially dependent on non-verbal signals in both their comprehension and production of communicative messages. My own research has shown that young children rely on visual communication to support their relatively poor language (Doherty-Sneddon & Kent, 1996). An extract from a dialogue between two 6-year-olds doing a map task illustrates just how

much young children sometimes struggle with verbal expression of difficult information and how often they fall back on non-verbal strategies. One child, the instruction giver, is explaining a route on a map to another child, the instruction follower, who has to draw this route on their own copy of the map (figure 1 shows examples of instruction giver and follower maps). The underlined words represent speech that was accompanied by communicative hand gestures that the children purposefully expressed to one another. Indeed being able to see one another's gestures allow young children to perform significantly better on this task.

Instruction Giver: Ehm, now do three straight lines.

Instruction Follower: Straight?

Instruction Giver: Uh huh.

Instruction Follower: Like this?

Instruction Giver: No.

Instruction Follower: Like this, like this?

Instruction Giver: No "dunk" "dunk" straight down the way.

Instruction Follower: Down? Then do do do .

Instruction Giver: No just three lines straight down the way just three.

Because children use visual non-verbal cues so often, might they look more at their interlocutors? Furthermore will this influence their ability to process information when visual cues distract rather than facilitate the task in hand?

In a recent study we investigated children's communication abilities in face-to-face and audio-only interaction using a communication task called the shape description task (Doherty-Sneddon et al., 2000). In the shape description task children attempted to describe and to understand descriptions of complex, abstract shapes (see figure 3 for one set of shapes used). Such a task required that the information sender scrutinise the shapes for distinctive visual properties, and the information receiver built a visual representation of the described shape over time, sufficient to select the correct target shape from distractors[1]. In contrast to all our previous comparisons of face-to-face and audio-only interaction the children performed less well when they could see one another than when they could not. This supported the argument that, in certain tasks, visual communication signals might interfere with task demands. Indeed when they couldn't see one another both senders and receivers focused more on verbal strategies which helped them establish understanding. In later work (Doherty-Sneddon et al 2001) we found that 'forcing' children to look at a sender's face while listening to descriptions of abstract shapes interfered with their abilities to understand these descriptions. In addition children are less able to retain visuospatial information when they have to monitor a face during retention than if they are allowed to look away.

We can look at gaze aversion as an overt strategy for shifting one's attention from environmental stimulation (such as faces). A vast literature has shown that older children are better than younger children in tasks that require the ignoring of irrelevant information. For example, age-related improvements occur in primary school-aged children in the visual domain (e.g., Enns & Girgus, 1985). We therefore expected that gaze aversion, as a strategy to shift attention, would develop with increasing age.

[1] The children were given no instructions regarding their gesturing behaviour. In fact, in contrast to earlier work, they used very little gesture that could have been of benefit to their partners during the task.

Development of gaze aversion

Our first studies of children's gaze aversion looked at different age groups of children answering questions of varying difficulty while face-to-face with an adult who was asking the questions. We predicted that the younger children would not adjust their gaze aversion in response to the cognitive difficulty of questions asked of them. In addition to the face-to-face interference we had found and what we know about the development of attention shifting abilities, children's social understanding of gaze develops throughout early and middle childhood. For example a child typically won't interpret high amounts of mutual gaze between two people to indicate liking and attraction (in the way that adults do) until he is around 6 years old. However certain gaze aversion behaviours develop from a very early age. Aversion behaviour in response to social stimuli is reported in infants who often break mutual gaze with their caregivers during interaction (Bruner, 1977). It has been suggested that this relates to arousal control- mutual gaze produces increased physiological arousal in infants and they break mutual gaze in order to reduce the level of arousal once it reaches a certain point (Stern, 1977). These findings suggest that from an early age gaze aversion is a mechanism with which children control their own internal states. We were interested in finding at what age children use gaze aversion to control their mental load.

In one study, in which we compared 5- and 8-year olds, we found that children of 8 years of age averted their gaze from a questioner's face more when thinking about and making their response to harder questions compared with easier ones (as expected children seldom looked away from their questioner when listening to the question, presumably because of the usefulness of visual cues such as lip configuration in speech perception). This was found with both verbal reasoning and arithmetic questions. We concluded that children of this age use gaze aversion to control their cognitive load in a similar way to adults. This is potentially important for the way children are seen to engage in learning situations. There is a tendency in many cultures to encourage children to "look at me while I'm speaking to you", and to interpret looking away as a sign of disinterest or disengagement. What our research clearly showed was that primary school aged children used gaze aversion to help them concentrate on difficult material. Therefore, provided the aversion is appropriately timed within the interaction (i.e. especially during thinking and to a lesser extent during speaking), it is something to be encouraged rather than discouraged. In contrast 5-year-old children only looked away more when answering difficult verbal questions, not arithmetic. These younger children only sometimes used gaze aversion when they had to concentrate hard. So gaze aversion in response to difficult questions is a skill that develops with age, rather than being an innate behavioural response to questions. Furthermore the younger children generally looked at the questioner more. This suggests a higher reliance on visual cues at lower ages and perhaps attempts to elicit help from the adult rather than work things out themselves (Doherty-Sneddon, Bruce, Bonner, Longbotham & Doyle 2002).

Preliminary work from another study suggests that gaze aversion by 6-year-olds can be used as a cue to whether they are in their zone of proximal development (Vygotsky, 1934). In this study the children worked through a series of arithmetic problems with a 'teacher'. Each child progressed through different stages of competence from being consistently incorrect, to giving partially correct responses, to consistently correct responses. Gaze aversion peaked for each child when they were working on sums that they gave partially correct responses to. We suggest that high amounts of gaze aversion reflect that the child is on task but is having to try very hard to work out the problem (Doherty-Sneddon et al 2002). Gaze aversion may therefore be a useful cue that teachers and parents can use to judge children's 'readiness to learn'. These patterns of gaze promise to be an important cues helping adults decide when to provide or withdraw additional help to a child they are teaching.

This research adds to what we know about how visual communication signals function in children's cognition. Visual communication cues provide a rich source of information to adults and children alike and often produce significant communication benefits. We now know the importance of considering the processing *consequences* of this information. What our research to date has not ascertained is whether looking away as part of a question-answer sequence helps children answer more accurately. We know that older children look away more when they're trying hard to concentrate, but does this actually help?

New Research

The first goal of our new ESRC project is to explore whether (and why) looking away from a questioner during difficult mental activity helps children's performance. If gaze aversion does have a functional benefit this has important educational implications. It may be that encouraging young children to look away from their teacher when thinking (although not listening), helps them learn more effectively. We are

in the process of finishing two studies relating to this. In these studies we have looked at 5-year-olds, since they typically avert their gaze, from the face of an adult asking them questions, far less than older children. We have investigated the efficacy of encouraging these young children to look away more while thinking about arithmetic and verbal reasoning questions. Although very much a work in progress, so far we have found that children of this age are amenable to such 'training' and readily take gaze aversion on as a 'thinking strategy'. Furthermore looking away while thinking seems to result in more accurate responses to moderately difficult questions. For now 'watch this space'!

Our second goal is to examine whether the source of any such benefit is social and/or cognitive. In other words does looking away help because children feel embarrassed or self-conscious when they find questions difficult? Alternatively does gaze aversion work because the child reduces the amount of complex visual information they are processing when they look away? Perhaps both explanations play a part. To address this question we will look at children's aversion behaviours when questioned face-to-face compared with across live video links - live video links reduce the social impact of visual cues (Doherty-Sneddon & McAuley 2000).

Our earlier work shows that gaze cues promise to be useful external indicators of thinking and concentration. For example children's levels of gaze aversion are much higher when they are just about to understand something compared both with when they fully understand, and when they don't understand at all. Our final goal is to establish the extent to which teachers use patterns of gaze as cues within learning contexts in order to, for example, time the offering or withdrawal of instruction. The project will provide information relating to the use of non-verbal cues to promote learning. We are using a variety of methods to measure teacher responsiveness to pupil gaze, ranging from questionnaires to detailed video analyses of one-to-one teacher-pupil interactions. Teachers and primary school pupils from Stirling, Clackmannanshire and Glasgow are taking part in the studies.

We are only just beginning to understand the link between children's patterns of eye gaze and their cognition, there are many questions still to be addressed. If we look long enough into space perhaps we will fathom at least some of these.

References

Beattie, G. W. (1981). A further investigation of the cognitive interference hypothesis of gaze patterns during conversation. *British Journal of Social Psychology*, *20*, 243-248.

Bruner, J.S. (1977). Early social interaction and language acquisition. In H. R. Schaffer (Ed.), *Studies in mother-infant interaction* (pp.271-289). London: Academic Press.

Clark, H. H., & Brennan, S. E. (1991). *Grounding in communication*. In L. B. Resnick, J. Levine, & S. D. Teasley (Eds.), *Perspectives on socially shared cognition* (pp.127-149).Washington, DC.: American Psychological Association.

De Gennaro, L., & Violani, C. (1988). Reflective lateral eye movements: Individual styles, cognitive and lateralization effects. *Neuropsychologia*, *26*, 727-736.

Doherty-Sneddon, G., Bruce, V. Bonner, L., Longbotham, S. & Doyle, C. (2002). Development of Gaze Aversion as Disengagement from Visual Information. *Developmental Psychology*, 38, 438-445.

Doherty-Sneddon, G., Bonner, L., & Bruce, V. (2001). Cognitive demands of face monitoring: Evidence for visuospatial overload. *Memory and Cognition*, *29*, 909-919.

Doherty-Sneddon, G., & McAuley, S. (2000). Influence of video mediation on adult-child interviews: implications for the use of the live link with child witnesses. *Applied Cognitive Psychology*, 14, 379-392.

Doherty-Sneddon, G**.,** McAuley, S., Bruce, V., Langton, S., Blokland, A., & Anderson, A. H. (2000). Visual signals and children's communication: negative effects on task outcome. *British Journal of Developmental Psychology*, *18*, 595-608.

Doherty-Sneddon, G., & Kent, G. (1996). Visual signals and the communication abilities of children. *Journal of Child Psychology and Psychiatry*, *37*, 949-959.

Enns, J. T., & Girgus, J. S. (1985). Developmental changes in selective and integrative visual attention. *Journal of Experimental Child Psychology*, *40*, 319-337.

Feyereisen, P.,Lignian, A. (1981). Gaze direction in aphasics during speaking: a pilot study. *Current Psychology of Cognition*, 1, 287-298.

Fisher, R. P., & Geiselman, R. E. (1992). *Memory enhancing techniques for investigative interviewing:*

the cognitive interview. Springfield IL: C.C. Thomas.
Glenberg, A. M. (1997). What memory is for. *Behavioural and brain Sciences*, *20*, 1-19.
Glenberg, , A. M., Schroeder, J. L, & Robertson, D. A. (1998). Averting the gaze disengages the environment and facilitates remembering. *Memory and Cognition*, *26*, 651-658.
Goldin-Meadow, S., Wein, D., & Chang, C. (1992). Assessing knowledge through gesture: Using children's hands to read their minds. *Cognition & Instruction*, *9*, 201-219.
McNeill, D. (1985). So You Think Gestures are Nonverbal? Psychological Review, 92, 350-371.
Stern, D. (1977). *The first relationship: Infant and mother*. London: Fontana/Open Books.
Vygotsky, L. (1934,62). *Thought and language*. Cambridge Mass.:MIT Press,1962. (Originally Published, 1934).