

Teachers' responses to children's eye gaze

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Abstract

When asked questions, children often avert their gaze. Furthermore the frequency of such gaze aversion (GA) is related to the difficulty of cognitive processing (Doherty-Sneddon, Bruce, Bonner, Longbotham & Doyle 2002), suggesting that GA is a good indicator of children's thinking and comprehension. However, little is known about how teachers detect and interpret such gaze signals. In Study 1 teaching interactions were analysed to determine teachers' responses to different patterns of children's eye gaze. In Study 2 a different group of teachers completed a questionnaire assessing teachers' awareness of GA in determining children's thinking, understanding and interest. Results showed that teachers did not typically respond to children's GA in predicted ways and did not associate GA with children's thinking. However when asked explicitly about GA cues they made predictions relating to question difficulty and children's thinking in line with empirical work (Doherty-Sneddon et al., 2002). We conclude that whilst teachers have an implicit understanding of GA cues, they typically do not make full use of such cues during classroom teaching.

During difficult cognitive activity (e.g., remembering information, thinking of an answer to a question, speech-planning, speaking) we often close our eyes, look up at the sky, or look away from the person we are in conversation with (Glenberg, 1997; Glenberg et al., 1998). A number of studies report ways in which adults switch off from environmental stimulation (both live faces and other sorts of visual displays) in order to concentrate on cognitive tasks (e.g. Beattie, 1981; Day, 1964; Glenberg et al., 1998).

Considerable research effort has been expended on examining the role played by visual communication signals in human interaction (e.g. eye gaze, gesture and facial expression). There is much evidence that these cues are often important sources of information, and many researchers propose they play a facilitatory role in human communication (e.g. Clark & Brennan, 1991; Goldin-Meadow, Wein, & Change, 1992; McNeill, 1985). However, the fact that such signals are informative means that they carry a cognitive load. Indeed, the processing costs of visual signals are documented. Excessive eye gaze between speakers is associated with increased cognitive load, evidenced by, for example, less fluent speech (Beattie, 1981). In addition, the cognitive difficulty of a task relates to the likelihood that people will avert their gaze from other people's faces (Doherty-Sneddon et al., 2002; Doherty-Sneddon & Phelps, in press; Ellyson, Dovidio, & Corson, 1981; Glenberg et al, 1998; Phelps, Doherty-Sneddon & Wanock, in press). So one explanation of the link between cognitive difficulty and gaze aversion (GA) is that the interlocutor's face, an information-rich aspect of the environment, requires cognitive resources to monitor (Glenberg, 1997; Glenberg et al, 1998). When people avert their gaze they can deploy additional cognitive resources to the task in hand and hence improve their performance - the 'cognitive load hypothesis' (cf. Glenberg, 1997).

Other work has shown that older children (8-year-olds), like adults (Glenberg et al., 1998) also look away more when answering difficult questions compared with easy ones when questioned face-to-face (Doherty-Sneddon et al., 2002; Doherty-Sneddon & Phelps, in press; Phelps et al., in press). GA is therefore a potentially useful cue during pedagogical interactions since it gives a non-verbal indication of a child's level of understanding and concentration (see Doherty-Sneddon et al., 2002). GA from the face of a questioner has been shown to peak while children of all ages are thinking of responses to questions compared to speaking

their responses and listening to questions (Doherty-Sneddon et al., 2002; Doherty-Sneddon & Phelps, in press). Indeed, it has been shown that relatively high amounts of GA (for the child) are typically indicative of a child who almost understands something but requires more help (Longbotham, 2001). However younger children (5-years and younger) have been shown to be inconsistent in their use of GA as a response to cognitive difficulty. So, for example, instead of consistently averting their gaze when experiencing cognitive difficulty, they would also often revert to 'staring the adult out' under such circumstances (e.g., Doherty-Sneddon, 2004; Doherty-Sneddon et al., 2002). Other work (Doherty-Sneddon, Phelps, & Clarke, under review) has also shown that young children often maintain face-gaze with a questioner when they are 'stuck' and are unlikely to respond. Similarly Day (1964) proposes that GA is an indicator of active (rather than passive) coping in response to a problem. It appears therefore that patterns of gaze can be indicative of a child's current cognitive strategies, and in particular, periods of thought.

The importance of recognising 'thinking time' is illustrated well by the results of Davenport (2003). She suggests that during preschool assessments children often require extended thinking/processing time to allow them to completely demonstrate their knowledge or understanding of a question. It is therefore important that teachers can judge when a child has finished with a question and is ready to move on to the next, and GA promises to be a reliable cue that enables differentiation between a child who is engaged in thought and one who has 'given up'. Rowe (2003) illustrates that without training teachers typically employ very short wait times when questioning their pupils. She showed that after a teacher asks a question pupils must begin a response within around one second otherwise the teacher interrupts by repeating the question, asks a different question or calls on another pupil. Rowe found that mean wait-times of three to five seconds can be achieved through training. Furthermore this had positive effects on students, for example increasing the length of responses to questions increases and reducing failures to respond. In addition the number of speculative responses increases. These are likely to contain valuable information about a student's transitional understanding of material being discussed. Rowe proposes that teacher interruptions typically prevent completion of pupil thought. Other researchers also point to the importance of sufficient wait times in fostering a learning environment conducive to active student participation (e.g. Hyman & Whitford, 1990; Swift & Gooding, 1984). In addition it is likely that teacher expectations of pupils' abilities will influence the way that they give feedback and the opportunities for responding given to individual children- which in turn

influence learning outcomes (Harris & Rosenthal, 1986). GA is therefore a potentially useful cue in contributing to a positive learning environment.

Some research has documented how children's non-verbal behaviour changes in relation to how well they understand referential messages. Four-, 6- and 8 year olds shifted their posture more and used more hand movements when listening to uninformative referential messages compared to informative messages (Patterson, Cosgrove & O'Brien, 1980). In addition, Machida (1986) found that first graders reduced eye contact, did more head-tilting, and used excessive hand and body movements when listening to difficult versus easy lessons. These studies have looked at the general amount of these sorts of behaviours occurring under different conditions. One aspect of the current studies is to take a micro-level approach and look at children's patterns of GA within question-answer interactions, relating gaze and GA to episodes of listening, thinking and responding.

Some research suggests that even experienced teachers are little better than novices at detecting whether children had understood something or not based on non-verbal cues (Jecker, Maccoby & Breitrose, 1964). On the other hand teachers and also untrained adults are reasonably good at picking up the informational content of certain visual communication signals, such as hand gestures (Goldin-Meadow, Wein & Chang, 1992). While this is true, it is likely that there are considerable individual differences between adults in terms of whether they explicitly notice these sorts of signals (Alibali, Flavours. & Goldin-Meadow, 1997). The literature on teacher awareness in the classroom shows that without specific training teachers are sometimes unaware of important aspects of their interactions with pupils (e.g. Martin & Keller, 1976).

Given the potential utility of GA as an educational tool, coupled with the discrepancies in the literature regarding adults' ability to detect non-verbal cues, in the current studies we investigate whether teachers detect and use gaze and GA as cues to children's thinking and understanding. In Study 1 we video-recorded teacher-pupil interactions and looked at whether teachers detect gaze cues, and also whether they respond differently to children dependent on their patterns of gaze and GA. If teachers have either an implicit or explicit awareness of the signal value of children's gaze behaviour, then different contingent responses should be made to different patterns of gaze; in particular to extended face-gaze versus GA. In study 2 we

asked a different sample of teachers about their explicit understanding of children's patterns of gaze using a questionnaire methodology.

Study 1. Gaze aversion in teacher-pupil interactions

In Study 1 we investigated whether teachers use GA as a cue to children's levels of comprehension. Each of 12 teachers was recorded interacting with 3 different pupils (36 unique interactions in total) as part of normal day-to-day classroom activity. These recordings were then transcribed and the transcripts coded for the children's gaze behaviour to see whether gazing at the teacher versus GA predicted different teacher contributions. In Study 1a, we looked at whether teachers' responses to children were contingent upon the child's gaze behaviours. In Study 1b, we asked the same teachers to offer retrospective commentaries on their own teacher-pupil interactions. Teachers were thereby given opportunity to describe their own motivations for different behavioural responses to children on the basis of their pupils' (verbal and non-verbal) behaviours.

Study 1a. Teachers' behavioural response to different patterns of gaze.

Method

Participants. Twelve primary school teachers (10 female, 2 male) were sampled from 8 different participating Stirlingshire schools. Their mean age was 45 years (range = 29 years to 60 years), and the mean duration for which they had been teaching was 20 years (range = 5 years to 35 years). At the time of recording 1 teacher exclusively taught children aged 7-8 years; 2 exclusively taught children aged 8-9 years; 2 exclusively taught children aged 9-10 years; 3 exclusively taught children aged 10-11 years; 4 exclusively taught children aged 11-12 years. During their working career, all had previously taught children of a different age to those currently taught. Whilst teachers were aware that they were participating in a study about cues to children's comprehension, none were aware of the explicit hypothesis under investigation- that GA is a cue that a child is still thinking, and will therefore influence whether teachers interrupt a child while they are preparing a response. None had previously participated in related experiments.

Thirty-six primary school children (14 male, 22 female), aged 7 years upwards, also participated.

Participating children were randomly selected and parental consent obtained. Whilst children were aware that they were being filmed during classroom activities, none were aware that their gaze direction was of specific interest. None had previously participated in related experiments.

Procedure. Each teacher was observed interacting with three pupils during naturally-occurring one-to-one or small group teaching sessions, with the restriction that the content of the sessions be mental arithmetic or a verbal discussion of, for example, class reading materials. During testing the experimenter stood behind or to the side of the teacher and focussed a hand-held digital camera on the face of the particular child of interest. This enabled a visual recording of the child's gaze behaviour and an auditory recording of both the child's and the teacher's input. Filming took place for the duration of an entire teaching session, which could last anywhere between 5-30 minutes.

Analyses and Design. For each teacher-pupil interaction, every question-answer episode was noted, and coded for whether or not teachers interrupted the child during their thinking time, giving us a behavioural measure of the teachers' response to the child. In addition each child's pattern of gaze behaviour was noted for the thinking stage of each question-answer episode. Thinking stage was defined as the period of time from when the teacher finished saying the question until the child began speaking their response. From these data we first measured the absolute duration of each thinking occurrence across all children ($n = 1106$) and then calculated the percentage of time spent averting gaze for each of these thinking occurrences, giving us thinking time GA values ranging from 0% through to 100%. Interjudge reliability as to whether GA had occurred was calculated for a random sample of 10% of the thinking occurrences ($n = 111$) by two judges, for which there was 97% interjudge agreement.

To establish whether different levels of GA are acted upon and interpreted differently by teachers, we categorised each occurrence of GA behaviour as: low, medium or high. These categories were obtained by splitting the full range of potential GA values into thirds, such that those thinking

episodes for which there was 0-33% GA were categorised as ‘low use of GA’, those for which there was 33.1-67% GA were categorised as ‘medium use of GA’, and those for which there was 67.1-100% GA were categorised as ‘high use of GA’. These categorical divisions fit well with previous research suggests that during pedagogical interactions relatively high levels of GA ($M_s > 66\%$) are indeed indicative of a child who is engaged in thought (see Doherty-Sneddon *et al.*, 2002). In contrast, it has been shown that relatively low levels of GA and medium levels of GA are indicative of a child who is not thinking, but instead a child who is either listening to a question being asked ($M_s < 30\%$), or a child who is speaking their answer to a question ($M_s 13-68\%$) (see Doherty-Sneddon *et al.*, 2002).

To establish whether duration of the thinking period influenced teachers’ tendency to interrupt a child, irrespective of whether GA had occurred, we looked at teachers’ responses to children across time at one-second time intervals. Whilst blocking time into shorter durations could potentially prove a more sensitive analysis, statistical constraints regarding number of responses in each cell precluded this option. Furthermore this level of time analysis reflects earlier work in the area of ‘wait time’ (e.g. Rowe, 2003). Six different categories of thinking latencies were therefore established: 0-1s, 1.1-2s, 2.1-3s, 3.1-4s, 4.1-5s, or 5.1+s. All thinking durations over 5s in duration were included in the final category because children were far more likely to respond before 5s ($n=1029$) than after 5s ($n=77$). Categorisation of thinking time into these time intervals therefore allowed us to establish within a 1s time frame whether teachers alter their behaviour towards children. Is there is a time-contingent stage at which teachers alter the way in which they respond to children engaged in thought?

Results

Interruption rate and percentage time spent gaze averting

First we looked at whether teachers were more likely to interrupt a child as the proportion of thinking time spent in GA increased. As can be seen in Table 1, overall teachers were more likely to avoid interrupting a

child whilst he or she was thinking than to interrupt him or her (teaching exchanges: 61% = no interruption, 39% = interruption) indicating that teachers do recognize ‘thinking time’. Further, children were most likely to use high levels of aversion during thought, followed by low levels of aversion (GA at each level: high = 78%, low = 18%, medium = 4%), as would be expected based on previous research (Doherty-Sneddon et al., 2002; Doherty-Sneddon, 2004). Previous findings suggests that high levels of GA indicates that the child finds the task challenging but is attempting to work it out, whereas low levels of GA can indicate that the child has given up (Doherty-Sneddon et al., 2002). However there was no association between proportion of time spent in GA whilst thinking (high, medium, low) and the teachers’ response to the child (interruption, no interruption), Pearson’s chi-square = 0.13, $df = 2$, $p = .94$, suggesting that teachers do not employ children’s use of GA during ‘thinking time’ as a sign of the children’s need for assistance.

Table 1

Interruption rate and thinking time duration.

We then looked at whether teachers were more likely to interrupt a child as the time the child takes to answer increases. We had 6 time intervals: 0-1s; 1.1-2s; 2.1-3s; 3.1-4s; 4.1-5s; 5.1+s. There was a significant association between duration of thinking episode and teachers’ response, Pearson’s chi-square = 48.99, $df = 5$, $p < .001$. As can be seen in Table 2, this was largely due to teachers’ changing their response type after the first second of the interaction. So, when children had been thinking for 0.0-1.0 seconds, there was a greater tendency than chance to avoid interrupting that child. However, when children had been thinking for 1.1-5.0 seconds, there was a greater tendency than chance to interrupt than not; a pattern which attenuates once children’s response latency exceeds 5 seconds. So, it appears that teachers associate increased response latency with the child being in need of prompting/ re-direction.

Table 2

Summary of study 1a results

The likelihood that a teacher will interrupt a child during natural classroom question-answer interactions does not appear to be influenced by the child’s gaze behaviour in terms of percentage of time spent in GA during thinking time. Instead, we see evidence that teachers pick up on another (potentially salient) cue - absolute duration of the thinking stage - and adjust their interruption rate accordingly, with interruption occurring after a relatively short period of non-response on the part of the child. Alternatively teachers may

be picking up on other cues that determine their interruption of the child. Study 1b allowed us to investigate this further.

Study 1b. Teachers' commentaries on their own teacher-pupil interactions.

Method

Participants. Participants comprised the same sample of teachers used in Study 1a.

Procedure. Within two weeks of Study 1a teachers received the video recordings and a transcript of each of their own teacher-pupil interactions ($n = 3$ per teacher). Each teacher provided comments on these interactions by first describing any nonverbal behaviours he or she detected each child using during the teaching sessions, second by stating how he or she interpreted those behaviours, and finally how he or she believed this influenced his or her own behavioural response to the child.

Analyses and Design. The teachers provided 344 unique comments, so to enable data analyses comments were categorised as referring to one of the following: (a) the child's overt behaviour which could be: verbal; nonverbal - gaze related; or nonverbal - gaze unrelated, (b) judgments about the child's internal state – which could detail an attentional, cognitive, or emotional state, and (c) the teacher's own behaviour – which could be driven by the child's behaviour, or by an unspecified criterion. These categories were developed after all of the teachers' comments had been collected and scrutinised by three coders. Once the categories had been developed, two independent coders were asked to classify teachers' comments according to these categories, for which there was a 100% agreement across the full dataset. This information was then used to give us measures of (a) the teachers' explicit detection of the child's behaviour (verbal, nonverbal gaze-related, non-verbal gaze unrelated), (b) the teachers' interpretation of the child's internal state on the basis of these behaviours, and (c) the teachers' description of their own behavioural responses to these behaviours.

Results

As can be seen in table 3, the most common of teachers' comments referred to judgements of their pupils' internal state (37% comments) and the description of their own behaviours/actions (38% comments). Of those comments referring to judgements of the pupils' internal state, the single most common (65%) referred

to the cognitive (as opposed to emotional or attentional - 19% and 15% respectively) state of the child. Of those comments referring to a description of the teachers' own behaviours, the single most common (70%) referred to actions taken as a result of the child's behaviour suggesting that teachers are driven in large part by the child's behaviour. Eighty-four of teachers' comments referred to an overt behaviour on the part of the child, and half of these referred to gaze-related behaviours (child gaze behaviours accounted for 32% of the total teacher comments). Therefore children's gaze appears to be a fairly salient overt behaviour for the teachers in relation to other child behaviours, but does not account for a large proportion of the comments overall. Given the findings of study 1a- that child GA was not associated with teacher interruption of thinking time- it appears that teachers are either picking up on other aspects of gaze or are not interpreting gaze and GA according to criteria that influence when they decide to interrupt.

Table 3

As shown in table 3, there were 84 occasions where teachers offered comments on the child's overt behaviour. Of these, there were 64 instances (i.e., 76%) whereby they also provided their own interpretation of those behaviours. As shown in table 4, of these 64 instances, the majority (62%) of comments referred to interpretations based on gaze-related behaviours. Of these, 20/40 (i.e., 50%) mentioned a link between GA and thought. A further 36% of the comments referred to interpretations based on gaze-unrelated behaviours. Of these, 10/23 (i.e., 43%) mentioned a link between a gaze-unrelated behaviour and thought. So, although teachers do use GA as a signal of thought, it is only one behavioural cue which they use to judge a child's level of involvement.

Table 4

Study 2 Questionnaire analyses of teachers awareness of gaze aversion

In study 2 we asked teachers to complete a questionnaire designed to access their explicit understanding of children's gaze and GA behaviour in relation to children's interest, thinking and comprehension.

Method

Participants. Fifty-two teachers (4 male, 47 female; 1 unidentified) from Glasgow primary schools took part in the study. Their mean age was 44 years (range = 23 years to 57 years), and the mean duration for which they had been teaching was 17 years (range = 1 year to 36 years). At the time of testing, 9 teachers

exclusively taught children aged 4-5 years; 6 exclusively taught children aged 6-7 years; 9 exclusively taught children aged 7-8 years; 11 exclusively taught children aged 9-10 years; 14 exclusively taught children aged 11-12 years; and 3 taught children across each level of primary education. During their working career, all but 3 had previously taught children of a different age to those currently taught. None had previously participated in related experiments.

Stimuli. A 12-page questionnaire was developed to examine (a) whether primary teachers detect children's use of gaze behaviours during teaching interactions, and (b) how teachers interpret those gaze behaviours. The questionnaire was separated into two sections. In Section one teachers were asked to make inferences about 3 mental states of children during one-on-one interactions - understanding of what teacher says, interest in what teacher says, and thinking about what teacher says - on the basis of children's engagement in various nonverbal behaviours (e.g. fidgeting; tapping fingers; making eye contact). To avoid making the focus of the study transparent, twelve different gaze behaviours were embedded within twenty other questions about other nonverbal behaviours.

For each behaviour listed, respondents had to make a decision on a 6-point Likert scale as to whether that behaviour was indicative of each mental state. So, for the 'comprehension' measure, teachers rated the value of each behaviour as a cue to a child's comprehension of lessons using the following scale: complete confusion (1) through complete understanding (6). For the 'interest' measure, teachers rated the value of each behaviour as a cue to a child's interest in lessons using the following scale: complete boredom (1) through complete interest (6). For the 'still thinking' measure, teachers rated the value of each behaviour as a cue to whether a child was still thinking about the content of lessons using the following scale: completely given up thinking (1) through still thinking completely (6). Judgments about each mental state were blocked, with the order of presentation randomised across participants.

For each mental state examined (understanding; interest; and thinking) we had three categories of gaze behaviours which could potentially serve as cues to the child's mental state:

1. Three behaviours that lead to a decrease in GA with teacher (eyes widened, makes eye contact with teacher, directs eyes towards teachers' face). This gave us our DGA category.

2. Five behaviours that lead to an increase in GA with teacher, whereby a specific locus of gaze attention is specified (looks toward ceiling, looks toward floor, looks toward window, looks toward wall, looks toward another child). This gave us our IGAsp category.
3. Four behaviours that lead to an increase in GA with teacher, where there is unspecified withdrawal of gaze from the teacher (avoids eye contact with teacher, avert eyes away from teachers' face, shuts eyes, covers eyes). This gave us our IGAsp category.

In section two of the questionnaire respondents were asked to indicate when they were aware of children's use of GA under a variety of teaching situations: when thinking about an easy question; when thinking about a hard question; when listening to the teacher; while thinking of a response; while speaking to a teacher. Seven other filler items were also included (e.g. while child is telling the truth). Respondents had to make a decision as to whether GA was engaged in during each teaching situation on a 6-point Likert scale, ranging from never (1) through always (6). The responses to the teaching situations were categorised as follows for analyses: analysis 1 - stage of question-answer interaction (listening, thinking, speaking); analysis 2 – impact of question difficulty during thought (easy, hard).

Procedure. The head teachers from 155 Glasgow primary schools were contacted to enquire about their interest in staff participation. Batches of 5 questionnaires were distributed to interested schools (n = 62), whereupon participation was voluntary; teachers self-selected. There was a response rate of 17%. Questionnaires took approximately 15 minutes to complete, and were returned anonymously in pre-paid envelopes.

Results

Section 1. Teachers' interpretation of children's gaze behaviours

A 3 (gaze behaviour category: DGA, IGAsp, IGAsp) x 3 (child mental state: thinking, interested, understanding) mixed design ANOVA was employed, where gaze behaviour acted as the within-groups variable and child mental state the between-groups variable. Means for each condition are presented in Table 5.

Table 5

There was a significant effect of gaze type, $F(2, 294) = 272.22$, $\eta^2 = 0.65$, $p < .001$, a significant effect of mental state, $F(2, 147) = 7.91$, $\eta^2 = 0.10$, $p < .001$, and a significant interaction between these two variables, $F(4, 294) = 16.99$, $\eta^2 = 0.19$, $p < .001$. Simple main effects analyses showed that DGA behaviours were rated as indicating greater interest in the lesson and greater thought about the lesson than understanding of the lesson, $F(2, 147) = 30.75$, $\eta^2 = 0.30$, $p < .001$. The IGAsup behaviours were rated as indicating greater thought about the lesson and greater understanding of the lesson than interest in the lesson, $F(2, 147) = 5.14$, $\eta^2 = 0.07$, $p < .05$. The IGAsp behaviours were rated as indicating greater thought about the lesson than interest in the lesson, $F(2, 147) = 3.87$, $\eta^2 = 0.05$, $p < .05$. Finally, compared with both IGAsup behaviours and IGAsp behaviours, teachers rated DGA behaviours to indicate a greater understanding of what the teacher is saying, $F(2, 146) = 19.40$, $\eta^2 = 0.21$, $p < .001$, a greater interest in what the teacher is saying, $F(2, 146) = 127.97$, $\eta^2 = 0.64$, $p < .001$, and a greater likelihood that children were still engaged in thought, $F(2, 146) = 68.98$, $\eta^2 = 0.49$, $p < .001$. So, whilst teachers were more likely to associate gaze behaviours with thinking over and above interest and understanding, they did not appear to differentiate between the type of gaze behaviour being used; they failed to differentiate between looking away from and looking toward the teacher. Contrary to all the previous studies on children's GA that show that children increase GA when thinking (Doherty-Sneddon et al., 2002; Doherty-Sneddon & Phelps, in press; Phelps et al., in press) the teachers appeared to associate GA with having giving up thinking.

Section two. Teachers' detection of children's GA

1. Stage of the teacher-child interaction. A one-way ANOVA was used, with stage of the interaction (listening, thinking, speaking) acting as the within-groups variable. The dependant variable was the rating of the likelihood of occurrence of GA in each scenario. Analyses showed a significant effect of stage of interaction, $F(2, 96) = 33.08$, $p < .001$. Paired t-tests showed that teachers perceive children to look away more frequently when thinking than when both listening, $t(49) = 5.02$, $p < .001$ and speaking, $t(48) = 7.00$, $p < .001$; and, when listening than when speaking, $t(48) = 4.00$, $p < .001$. Mean (listening = 3.08; mean thinking = 3.78; mean speaking = 2.55). The peaking of GA during thinking is consistent with behavioural data, which shows that GA peaks during thinking about a question, and is less during speaking and listening (Doherty-Sneddon et al., 2002). So, it appears that teachers are indeed detecting appropriately-timed use of GA during pedagogical interactions.

2. Impact of question difficulty during thinking. A paired t-test was used to assess teachers' detection of GA for easy versus hard questions. Analyses showed that teachers perceive children to look away more frequently when thinking about hard questions than when thinking about easy questions, $t(48) = 5.84$, $p < .001$ (mean easy = 2.62; mean hard = 3.78). So, teachers are noticing more GA during hard questions which is consonant with previous findings (Doherty-Sneddon et al., 2002; Doherty-Sneddon & Phelps, in press; Phelps et al., in press). However teachers' detection-rate of GA when children are thinking about hard questions is only around the 'sometimes' mark, whereas previous quantitative data shows that children avert their gaze often around 70-80% of the time when they are thinking about difficult questions (Doherty-Sneddon et al., 2002; Doherty-Sneddon & Phelps, in press).

Discussion

Results of study 1a showed that children's GA cues typically do not influence whether or not their teacher interrupts them either prior to or during a response they are making to a question asked of them. There could be a number of reasons for this. First teachers may use question-answer sequences in small group teaching in a 'pseudo' way where they are not actually trying to assess the child's knowledge but instead to drive the group discussion. In this case the questions would be asked primarily for the benefit of the group rather than the individual. It would therefore not be surprising that an individual child's GA is not responded to. Second it could be that the teachers do not in fact notice children's GA cues. Alternatively, it could be that teachers do indeed detect children's GA cues, but fail to interpret them appropriately. The results of study 1b suggest the second explanation is not valid. When the teachers were asked to comment on the video recordings of their teaching sessions they often referred to individual children's mental and attentional states, and these references were often linked explicitly to children's gaze behaviour. This makes sense given earlier work that shows patterns of gaze to be useful in determining cognitive difficulty, thinking and attention (Doherty-Sneddon et al., 2002; Doherty-Sneddon & Phelps, in press; Phelps et al., in press). Given that teachers can indeed detect children's gaze related cues, it may be that teachers could be encouraged to develop their teaching strategies ensuring that they make full use of their intuitions about children's gaze behaviour in real-time classroom teaching. For example if a child is asked a question but doesn't respond immediately, a relatively high proportion of time spent averting gaze typically indicates that they are still thinking about what their response will be (i.e. they have not simply given up). It is therefore worthwhile waiting a little longer before interrupting to see what they child has to say. The importance of correctly identifying 'thinking

time' during teacher assessments of children is noted by Davenport (2003). Study 1b suggests that teachers are good at noticing relevant gaze behaviours when they watch recordings of their interactions with children. However study 1a shows that they do not typically appropriately act upon these gaze cues during real-time teaching.

In study 2 teachers rated children's gaze behaviours that resulted in less GA (and hence more eye contact with the teachers) during one-on-one classroom activities as more likely to indicate greater understanding, interest and thinking than gaze behaviours that resulted in GA (e.g. looking at the ceiling). This result is consonant with earlier experimental work but only when the child is a passive listener- children typically engage in high levels of face gaze (and little GA) with others when they are listening (Doherty-Sneddon et al., 2002; Doherty-Sneddon & Phelps, in press; Phelps et al., in press). 'Understanding of lessons' and 'interest in lessons' could be considered as two child mental states that would correspond to the listening stage of an interaction. Where the current results deviate from previous experimental work is in the situation where the child is an active participant in an interaction and is required to think – a child mental state we examined in Study 2: 'still thinking about the lesson'. Active thinking and concentration has been shown to be strongly associated with GA, whereas looking at an interlocutor has not (Doherty-Sneddon et al., 2002; Doherty-Sneddon & Phelps, in press; Phelps et al., in press). Teachers therefore are not associating active thinking (in comparison with 'giving up') with GA.

In section two of study 2 teachers were asked specifically to distinguish between children's listening, thinking and speaking and the difficulty of questions on the basis of children's GA. Here teachers clearly appreciated the association of GA with thinking time. However, in contrast to earlier work they associated more GA with listening than speaking. Doherty-Sneddon et al., (2002) found that older children (8-year-olds) averted their gaze more while speaking response than listening to questions and interpreted this to reflect that formulating spoken responses is more cognitively demanding than listening. In addition speaking requires internal processing of information and hence a rejection of environmental stimulation. In contrast when children are listening they attend to various visual non-verbal channels of communication (including eye gaze, facial expressions and gestures) that contribute to their understanding of the message/question they are receiving (Corsini, 1969; Doherty-Sneddon & Kent, 1996). Younger children did not show a dip in GA

while speaking that was evident in the older children (Doherty-Sneddon et al., 2002). This might mean that they are less able to effectively direct their attention from external to internal processing while speaking, and/or perhaps younger children are more likely to monitor an adult's reaction to their answer. It is therefore puzzling that teachers associated more GA with listening than speaking.

In addition teachers associated more GA with harder questions compared with easy ones. Teachers do therefore appreciate the link between cognitive difficulty of material and GA. However along with the results of section 1 (the belief that GA is not associated with comprehension or still thinking) this could be interpreted to mean that teachers do not recognise the function of GA under these circumstances- i.e. to facilitate cognitive processing. High amounts of GA indicate cognitive difficulty but at the same time also show that the child is actively engaged in finding a solution to the problem. Indeed preliminary data suggest that very high amount of GA indicate that children are working within their zone of proximal development (Longbotham, 2001; Vygotsky 1978). How teachers interpret GA during difficult problem-solving will influence how they in turn respond to the child. If GA only signals difficulty you would be more likely to interrupt thinking time with further help for the child. If however you see GA as a sign of active engagement with difficult material you are more likely to wait and see if the child can come up with something upon which to build further instruction. This is of direct relevance to 'wait time'. (see for example Hyman & Whitford, 1990; Swift & Gooding, 1984; Davenport, 2003). The benefits of increasing how long teachers wait for student responses are documented (see e.g. Rowe, 2003). Any behavioral cue that helps teachers accurately determine how long wait time should be is therefore potentially very important. The results of study 1 show that teachers' interrupts of children's thinking time are not influenced by how much GA the child engages in.

It appears that teachers have a good implicit understanding of the link between GA, cognitive difficulty of tasks and thinking. When probed to do so they make predictions in line with the growing number of empirical studies of children's GA during pedagogical question-answer sequences (Doherty-Sneddon, 2004; Doherty-Sneddon et al., 2002; Phelps et al., in press). However teachers sometimes misinterpret these cues or fail to act upon them appropriately. It may be that within a complex and demanding teaching situation that it is difficult to take all relevant cues on board. We have found that teachers to whom we have disseminated

our findings, readily identify the link between GA and their own teaching experiences. Many teachers have received in-service training encouraging them to allow children appropriate ‘thinking time’ (wait time) during activities. The teachers that took part in the current research welcomed GA as one way of recognising when children were still engaged in active thinking. It is likely that drawing explicit attention to the usefulness of GA as an indicator of attention and thinking is sufficient to allow teachers to begin constructively using it as a cue during teaching. However future research is required to objectively test how easily implemented this knowledge will be within classroom activities.

In addition future research must address the implications of GA work for practise in assessing and working with children with a range of learning difficulties. We are currently carrying out studies with both mainstream and special needs children to investigate whether or not their patterns of gaze and GA give similar clues as to their engagement, thinking and level of difficulty. This work promises to have important implications for teachers and Educational Psychologists alike.

Conclusion

While the current results show that teachers’ questioning of children during real-time classroom teaching is typically uninfluenced by children’s gaze and GA teachers do make appropriate inferences about children’s mental states associated with GA. Training teachers to make use of GA cues promises therefore to facilitate the appropriate use of important phenomena in the classroom such as wait time.

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Table 1. OBSERVED and EXPECTED COUNTS of TEACHERS' RESPONSE for EACH LEVEL of GAZE AVERSION DURING THOUGHT

Level of gaze

Aversion	frequencies:	Teachers' response:		
		no interruption	interruption	total
Low	observed	120 (10.85%)*	77 (6.96%)	197 (17.81%)
	expected	120.2	76.8	197.0
Medium	observed	28 (2.53%)	16 (1.45%)	44 (3.98%)
	expected	26.9	17.1	44.0
High	observed	527 (47.65%)	338 (30.56%)	865 (78.21%)
	expected	527.9	337.1	865.0
Total	observed	675 (61.04%)	431 (38.97%)	1106 (100%)
	expected	675.0	431.0	1106.0

*In parentheses: Percentage of teachers' response falling in each condition.

Table 2. OBSERVED and EXPECTED COUNTS of TEACHERS' RESPONSE for EACH LEVEL of THINKING DURATION.

Duration of thinking

		frequencies:	Teachers' response:		
			no interruption	interruption	total
0.0s-1.0s	observed	378 (34%)	158 (14%)	536	
	expected	327.1	208.9	536	
1.1s-2.0s	observed	165 (15%)	130 (12%)	295	
	expected	180	115	295	
2.1s-3.0s	observed	58 (5%)	64 (6%)	122	
	expected	74.5	47.5	122	
3.1s-4.0s	observed	20 (2%)	26 (2%)	46	
	expected	28.1	17.9	46	
4.1s-5.0s	observed	10 (1%)	20 (2%)	30	
	expected	18.3	11.7	30	
5.1s+	observed	44 (4%)	33 (3%)	77	
	expected	47	30	77	
Total	observed	675 (61%)	431 (39%)	1106	
	expected	675	431	1106	

Table 3. TEACHER COMMENTARY OBSERVATIONS.

Mentions child's overt behaviour:	N	Percentage
Verbal	13	15
Nonverbal (gaze related)	42	50
Nonverbal (gaze unrelated)	29	35
Total	84	
Judgement about child's internal state:	N	Percentage
Attentional	20	15
Cognitive	83	65
Emotional	25	19
Total	128	
Describes own behaviour:	N	Percentage
Driven by child's behaviour	92	70
Driven by other (unspecified) criterion	40	30
Total	132	

Table 4. TEACHER COMMENTS LINKING CHILD'S BEHAVIOUR with an EXPLICIT INTERPRETATION of that BEHAVIOUR

	N	Percentage
Verbal behaviour leading to interpretation	01	2
e.g., calls out answer		
Nonverbal (gaze related) behaviour leading to interpret	40	62
e.g., looks away = thinking, looks away = bored		
Nonverbal (gaze unrelated) behaviour leading to interpret	23	36
e.g., hand raised = knows answer, shuffles = bored		
Total	64	100.00

Table 5. Teachers' rated interpretation of children's gaze related behaviours. Standard errors in parentheses.

Mental state	Mean rating for each type of gaze behaviour		
	DGA	IGAusp	IGAsp
Still thinking ¹	4.29 (0.10)	2.54 (0.10)	2.72 (0.11)
Shows interest ²	4.52 (0.10)	2.15 (0.10)	2.31 (0.11)
Shows understanding ³	3.42 (0.10)	2.55 (0.10)	2.49 (0.11)

¹Where: 1 = completely given up thinking, through to 7 = still completely thinking

²Where: 1 = complete boredom, through to 7 = complete interest

³Where: 1 = complete confusion, through to 7 = complete understanding

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