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Helping Children Think: Gaze Aversion and Teaching.

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Abstract

Looking away from an interlocutor's face during demanding cognitive activity can help adults answer challenging arithmetic and verbal-reasoning questions (Glenberg, Schroeder, & Robertson, 1998). However, such 'gaze aversion' (GA) is poorly applied by 5-year old school children (Doherty-Sneddon, Bruce, Bonner, Longbotham, & Doyle, 2002). In Experiment 1 we trained ten 5-year old children to use GA whilst thinking about answers to questions. This trained group performed significantly better on challenging questions compared to ten controls given no GA training. In Experiment 2 we found significant and monotonic age-related increments in spontaneous use of GA across three cohorts of ten 5-year old school children (*M* ages: 5;02, 5;06 and 5;08). Teaching and encouraging GA during challenging cognitive activity promises to be invaluable in promoting learning, particularly during early primary years.

Typically, people spontaneously and consistently look away from the face of an interlocutor during cognitively demanding activity by engaging in the overt behavioural response of ‘gaze aversion’ (GA) (e.g., Doherty-Sneddon, Bruce, Bonner, Longbotham, & Doyle, 2002; Glenberg, Schroeder, & Robertson, 1998). Whilst GA occurs very little when people are listening to another person speak (e.g., Argyle & Cook, 1976; Doherty-Sneddon et al., 2002; Glenberg et al., 1998), it predominantly occurs whilst thinking and (albeit to a lesser extent) whilst speaking. So, the occurrence of GA potentially reflects the need to concentrate on drawing information from memory and/or engage in on-line cognitive processing, such as speech-planning and mental arithmetic (Doherty-Sneddon et al., 2002; Glenberg, 1997; Glenberg et al., 1998). Conversely, given that, under normal circumstances, speech perception may be facilitated by the processing of visual information from a speakers face (e.g., Erber, 1979; Neely, 1956; McGurk & MacDonald, 1976), having access to relevant visual cues is likely to be most beneficial whilst listening to a speaker. In other words, we attend to visual cues when they are most useful to us, but when we need to concentrate on our internal cognitive processing we ‘ignore’ them by averting our gaze away from the person with whom we are interacting (Doherty-Sneddon et al., 2002; Glenberg, 1997; Glenberg et al., 1998).

Recent results have shown that this tendency to look away from an interlocutor’s face increases when <u>thinking</u> about the solutions to increasingly difficult questions (Doherty-Sneddon et al., 2002; Glenberg et al., 1998; see also Doherty-Sneddon et al., 2000). For example, Glenberg et al. (1998; Experiments 1-3) found that adults’ use of GA during the thinking stage of a question-answer interaction increased as arithmetic and verbal questions became more difficult. Eight year-old children have also been shown to increase the frequency with which they use

GA during the thinking stage of a question-answer interaction as arithmetic and verbal questions prove increasingly difficult (Doherty-Sneddon et al. 2002). Given this finding, GA might be argued to be an overt sign of cognitive activity. Indeed, others have suggested that GA operates by enabling the thinker to concentrate and exert control over their own cognitive processing (see Doherty-Sneddon et al., 2001; Doherty-Sneddon et al., 2002; Glenberg, 1997; Glenberg et al., 1998). Consistent with this interpretation is the finding that GA occurs in response to objects other than faces, including video cameras (e.g., Kocel, Galin, Ornstein, & Merrin, 1972; Ehrlichman, Weiner, & Baker, 1974; Meskin & Singer, 1974). It appears then that people don't just avert their eyes from faces when they are thinking (see Ehrlichman, 1981), but also from any potentially distracting stimulus.

Of specific interest here, it appears that, under certain task conditions, engaging in GA whilst thinking can significantly benefit performance (e.g., Doherty-Sneddon et al., 2001; Glenberg et al., 1998: Experiment 4). For example, Glenberg et al. (1998: Experiment 4) required adults to answer easy, moderately difficult, and difficult arithmetic and general knowledge questions whilst either looking at an interviewer's face or closing their eyes. They found that when adults closed their eyes whilst thinking about moderately difficult problems they answered with greater accuracy as compared to conditions where they looked at the interviewer's face. No performance benefit was found for very easy or very difficult problems.

So, when questions prove challenging yet solvable, looking away from an interlocutor's face can benefit performance. This benefit of diverting one's attention away from potentially distracting visual cues has also been reported for children's performance on visuospatial memory tasks. For instance, when 6- and 10-year old children completed The Mr Peanuts Task (De Ribaupierre & Bailleux, 1994) and The

Corsi Block Task (Corsi, 1972), their performance was poorer when they had to look at a face during a 10 second retention interval as compared with looking at the floor or at a moving visuospatial pattern (Doherty-Sneddon et al., 2001). Further, instructing 10-year old children to look at a face whilst forming a mental image of a verbally-described abstract shape also impaired performance, as evidenced by both a decrease in accuracy and an increase in time to respond (Doherty-Sneddon et al., 2001; see also Doherty-Sneddon, McAuley, Bruce, Langton, Blokland, & Anderson, 2000). So, when we have to concentrate on internal processing of information, unhelpful or task-irrelevant visual cues can prove distracting, and consequently impair cognitive performance.

This finding of a functional benefit of GA during cognitively demanding activity is consequential given recent reports that GA is used inefficiently by certain populations. For instance, Doherty-Sneddon et al. (2002) have reported age-related differences in the effective use of GA: whilst GA is spontaneously employed by 5-year old children, they tend to use GA less often and less consistently than both older (8 year-old) children (see Doherty-Sneddon et al., 2002) and adults (see Glenberg et al., 1998). So, compared to 8-year old children, 5-year old children have been shown to use less GA whilst thinking about and speaking their responses to both verbal and arithmetic questions (Doherty-Sneddon et al., 2002). Furthermore, whilst both 8-year old children (Doherty-Sneddon et al., 2002) and adults (Glenberg et al., 1998) have been shown to consistently increase their use of GA in response to increasing cognitive difficulty, 5-year old children have been reported to do so only inconsistently (see Doherty-Sneddon et al., 2002).

Since it is difficult to draw any causal links between GA and performance benefits in <u>children</u> from this earlier work of Doherty-Sneddon et al. (2002), the main motivation in the current study was to see whether this is the case. We selected 5-year old children following Doherty-Sneddon et al.'s (2002) earlier report that such young children use GA inconsistently and relatively infrequently; an important finding given the reports that GA can benefit performance on a range of tasks requiring cognitive processing (e.g., Glenberg et al., 1998; Doherty-Sneddon et al., 2000; 2001). Five-year old children therefore represent a group for whom there is strong potential for increasing spontaneous levels of GA, thus enabling an ideal opportunity to measure any benefits of increased use of GA on task performance. Indeed, if any functional benefits of GA training can be shown with 5-year old children, this would provide an educationally relevant strategy for teaching young children.

The purpose of the experiments reported here is to examine the role of GA in 5-year old children, focussing on the extent to which they may be encouraged to adopt GA as a behaviour (Experiment 1), the extent to which its use may facilitate performance (Experiment 1) and the extent to which spontaneous engagement in GA develops throughout the first year of formal education (Experiment 2).

Experiment 1

In Experiment 1, we wanted to see whether we could train a group of 5-year old children to increase the proportion of time they spent looking away from a questioner's face whilst thinking about answers to arithmetic and verbal-reasoning questions. In addition, we wanted to see whether any increase in GA for 5-year old children would lead to an improvement in response accuracy.

Method

Participants

Twenty 5-year old children were recruited from an LEA primary school in Stirlingshire. Ten were randomly allocated to a control condition (6 boys, 4 girls, *M* age = 5 years 2 months, range = 4 years 9 months to 5 years 4 months) and ten to an experimental (avert group) condition (6 boys, 4 girls, *M* age = 5 years 1 month, range = 4 years 9 month to 5 years 5 months). Planned comparisons showed groups were comparable in terms of age, $t(18) = 0.53$, $p = .61$.

Stimuli

Children were asked verbal (n = 26) and arithmetic (n = 18) questions (source: Wechsler Preschool and Primary Scale of Intelligence (WPPSI), Wechsler, 1967). Class teachers confirmed that half of the questions used were easy (predicted 80%-100% accuracy), and half moderately difficult (predicted 30%-50% accuracy). Examples of the type of stimuli used are included in Table 1.

INSERT TABLE 1 NEAR HERE

Procedure

Children were asked the questions individually in a quiet location separate from their classroom, and were seated directly facing the questioner at a distance of approximately 1.5 feet, thus enabling the questioner to maintain her gaze on the child's face throughout testing. The questioners' locus of gaze (i.e., the child's face) was held constant in both conditions since the critical manipulation of interest was to see whether 5-year old children could be successfully trained to increase their use of GA during one-to-one pedagogical interactions, and to establish whether this trained behaviour would significantly benefit performance. Prior to test proper all children first answered 20 practice questions. At this stage, children in the avert group were instructed as follows: 'I'm going to ask you some questions. Once I finish asking the question I want you to look away from my face and try to think of the answer. If you don't know the answer it's okay – just so long as you try your best.' Children in the control group were given similar instructions: ‘I’m going to ask you some questions. Once I finish asking the question I want you to try to think of the answer. If you don’t know the answer it’s okay – just so long as you try your best.’ All children were asked the same set of practice questions once. Test proper followed the practice session immediately, lasting approximately 15 minutes per child. During test proper the avert group were instructed to continue using GA whilst thinking about their answers to questions, whilst the control were again given no instruction as to where to focus their gaze whilst thinking. Ordering of question type, question difficulty, and the individual questions was fully counterbalanced across participants. To enable quantification of children’s direction of eye gaze during the thinking stage of the question-answer interaction, a front-on view of each child’s head and shoulders was video-recorded throughout testing using a digital camcorder. The presence of the same experimenter and filming technique was maintained in both conditions to preclude the possibility that any benefits of GA training be attributable to either factor. Whilst all children were fully aware that they were being filmed, they were not aware that their gaze behaviour was of specific interest.

Results and Discussion

The effects of task difficulty and gaze training on both response accuracy and the percentage of time that gaze was averted during the thinking episode (i.e., the interval between the questioner having finished speaking and the child having started speaking) were analysed separately. For the accuracy data, correct answers were given a score of 1 and incorrect answers a score of 0. These data were then used to calculate the percentage of correct answers for each child under each condition. For the GA data, the proportion of time spent looking away from the questioner during the thinking episode was calculated to millisecond resolution. Interjudge reliability as to whether GA had occurred was calculated for a random sample of 10% of the participants. In total 88 episodes were coded by two judges, for which there was 92.05% interjudge agreement. Furthermore, the coders' scoring for the duration of GA correlated significantly, r (87) = .69, p < .0001.

Proportion of Thinking Episode Engaged in Gaze Aversion

A 2 (question type: arithmetic, verbal reasoning) X 2 (question difficulty: easy, moderately difficult) X 2 (group: control, avert) mixed design ANOVA was carried out on the proportion of time spent averting gaze whilst thinking. Question type and question difficulty were the within-groups variables, and group the between-groups variable. Means for each condition are displayed in Table 2.

INSERT TABLE 2 NEAR HERE

Whilst there was no effect of question type, F(1, 18) = 1.43, $\eta_p^2 = .07$, p = .25, there was a main effect of question difficulty on use of GA, F(1, 18) = 9.31, $\eta_p^2 = .34$, p <.01, with more GA occurring in response to moderately difficult questions than easy questions (*M*'s: easy = 39.20%, moderately difficult = 48.03%). There was also a main effect of group on use of GA F(1, 18) = 12.72, $\eta_p^2 = .41$, p < .005, with children in the avert group using significantly more GA (*M*'s: avert group = 52.50%, control group = 34.73%). There was a significant interaction between question type and group, F(1, 18) = 5.56, $\eta_p^2 = .24$, p < .05, which was further qualified by a three-way interaction between question type, question difficulty, and group, F(1, 18) = 6.78, $\eta_p^2 = .27$, p < .05. Simple effects analyses showed that, whilst the avert group used significantly more GA than the control group when thinking about both easy,

$F(1, 18) = 20.82$, $\eta_p^2 = .54$, $p < .0001$, and moderately difficult verbal questions, $F(1, 18) = 10.95$, $\eta_p^2 = .38$, $p < .005$, they only used significantly more GA in relation to the control group when thinking about moderately hard arithmetic questions, $F(1, 18) = 4.73$, $\eta_p^2 = .21$, $p < .05$, with no difference between the two groups for easy arithmetic questions, $F(1, 18) = 1.41$, $\eta_p^2 = .07$, $p = .25$. Further, although both groups increased their use of GA in response to increasing question difficulty, for the avert group this pattern was only significant for arithmetic questions, $F(1, 18) = 11.37$, $\eta_p^2 = .39$, $p < .005$, whereas for the control group this pattern was only significant for verbal questions, $F(1, 18) = 4.80$, $\eta_p^2 = .21$, $p < .05$. Finally, whilst the control group used significantly more GA for easy arithmetic questions than easy verbal questions, $F(1, 18) = 6.70$, $\eta_p^2 = .27$, $p < .05$, the avert group used significantly more GA for easy verbal questions than easy arithmetic questions, $F(1, 18) = 7.52$, $\eta_p^2 = .30$, $p < .05$, with no between-group differences in use of GA when thinking about moderately difficult arithmetic and verbal questions. No further interactions were found: question type and question difficulty $F(1, 18) = 3.29$, $\eta_p^2 = .15$, $p = .09$, question difficulty and group $F < 1$.

Accuracy

A 2 (question type: arithmetic, verbal reasoning) X 2 (question difficulty: easy, moderately difficult) X 2 (group: control, avert) mixed design ANOVA was carried out on accuracy scores, with question type and question difficulty the within-groups variables and group the between-groups variable. Means for each condition are displayed in Table 3.

INSERT TABLE 3 NEAR HERE

Whilst there was no effect of question type, F(1, 18) = 1.52, η_p^2 = .08, *p* = .23, there was a main effect of question difficulty on accuracy, *F*(1, 18) = 80.97, η_p^2 = .82, *p* < .0001, with more correct answers for easy questions (*M*'s: easy = 79.75%, moderately difficult = 48.76%). There was a main effect of group on accuracy, *F*(1, 18) = 6.39, η_p^2 = .26, *p* < .05, with more correct answers given by the avert group (*M*'s: avert group = 72.58%, control group = 55.93%). There was a significant interaction between question difficulty and group, *F*(1, 18) = 4.77, η_p^2 = .21, *p* < .05. Simple effects showed that the performance advantage for the avert group relative to the control group was evident for moderately difficult questions only, *F*(1, 18) = 8.05, η_p^2 = .31, *p* < .01, with no significant group difference for easy questions. No further interactions were significant: question type and question difficulty *F*(1, 18) = 1.06, η_p^2 = .06, *p* = .32, question type and group *F* < 1, question type, group and question difficulty *F*(1, 18) = 2.81, η_p^2 = .14, *p* = .11.

The results of Experiment 1 have shown that it is possible to encourage 5-year old children to increase their use of GA when thinking about the answers to arithmetic and verbal reasoning questions. We found an increase in GA for the avert group relative to the control group for each type of question at each level of difficulty. However, there was no significant increase in GA for the avert group relative to the control group for easy arithmetic questions. Whilst this finding occurs because controls used substantially higher levels of spontaneous GA overall for arithmetic questions than verbal questions, coupled with the fact that the avert group used least GA for easy arithmetic questions, we don't attach any significance to this observed interaction since it likely reflects a ceiling effect for easy arithmetic questions, as we discuss below. To summarise, these data clearly demonstrate that, given minimal training (practice of GA on a sample of 20 pre-test questions), 5-year old children can be encouraged to substantially increase the proportion of time they spend engaged in GA while thinking.

Further, our results show that 5-year old children's ability to answer arithmetic and verbal questions can be significantly improved as a result of GA training. This finding is novel, since there have been no previous reports of performance benefits for children answering arithmetic and verbal-reasoning questions under conditions which mimic classroom one-to-one teacher-child interactions. So, consistent with the adult literature (Glenberg et al., 1998), for arithmetic and verbal questions of moderate difficulty, we found a significant increase in response accuracy. Inconsistent with the adult literature, we further found a significant increase in response accuracy for easy verbal questions. Whilst there was no significant increase in response accuracy for the easy arithmetic questions, inspection of accuracy data for this condition suggests that controls were already performing at ceiling in this condition (see Table 3).

This pattern of results would suggest that any benefits of GA are limited to situations where there is room for improvement in performance. So, when questions prove trivial (as with our easy arithmetic questions), GA is unlikely to help the thinker solve the question. However, when questions prove challenging (as with our moderately difficult arithmetic and verbal questions and the easy verbal questions), GA can potentially enable the thinker to arrive at the solution to that question. This interpretation may also account for our finding that whilst the control group spontaneously increased their use of GA in response to question difficulty, they did so only for the verbal questions.

In addition to these main findings, we also observed another interesting pattern of behaviour when we considered the spontaneous GA rates of the control children. Using similar questions to those currently used in Experiment 1, Doherty-Sneddon et al. (2002) found that 5-year old children at the end of primary year 1 used substantially more spontaneous GA (GA *M*'s: easy = 69%, hard = 75%) than the 5-year old children in our control group, who were only at the beginning of primary year 1 (GA *M*'s: easy = 30%, hard = 39%). This observation potentially points to a substantial development in children's use of GA during the first year of formal education. If this is indeed the case, then the manner in which primary year 1 teachers interpret and respond to their pupils' use of GA will also need to be flexible during this first critical year of formal education. So, in Experiment 2 we examined a cohort of 5-year old children in the middle of primary year 1 in an attempt to describe the development of GA in this first year of formal education.

Experiment 2

The motivation behind Experiment 2 was to explore the possibility of a substantial change in children's spontaneous use of GA over their first year in formal education. Whilst we have shown that children at the beginning of their primary year 1 (Experiment 1) use considerably lower levels of GA whilst thinking than children nearing the end of their primary year 1 (Doherty-Sneddon et al., 2002), we wanted to examine this difference statistically. In Experiment 2, therefore we compared the spontaneous levels of GA of the children from the Doherty-Sneddon et al. (2002) study with that of our 'control group' from Experiment 1. Added to this, in order to provide a more detailed picture of the changes that may occur in GA during primary year 1, we also collected new data on the spontaneous use of GA for a group of children who were in the middle of primary year 1. All cohorts of children were asked verbal and arithmetic questions with two levels of difficulty (i.e., easy and hard).

Method

Participants

Three cohorts of five-year old children were used. The first cohort comprised the ‘control group’ of Experiment 1, representing ten children who had just entered formal education (*M* age = 5 years 2 months, range = 4 years 9 months to 5 years 4 months). These children were tested in the October of their primary year 1.

The second cohort comprised a new sample of ten children who were six months into their first year of formal education (*M* age = 5 years 6 months, range = 5 years 3 months to 5 years 8 months). These children were tested in the February of their primary year 1.

The third cohort comprised a randomly selected sample of ten children from those previously reported by Doherty-Sneddon et al. (2002) (*M* age = 5 years 8 months, range = 5 years 3 months to 6 years 4 months). These children were tested in the June of their primary year 1.

Stimuli

As in Experiment 1, for each cohort, the questions used were drawn from the items described in the WPPSI, and were either verbal (cohort 1, n = 26; cohort 2, n = 24; cohort 3, n = 24) or arithmetic (cohort 1, n = 18; cohort 2, n = 24; cohort 3, n = 14). (See Table 1 for examples of stimuli used). Following the same criteria as in Experiment 1, consultation with the participants’ teachers established that half of the questions were easy (predicted accuracy 80%-100%) and half difficult (predicted accuracy 30-50%).

Procedure

For each cohort, the procedure was the same as that of the ‘control group’ of Experiment 1.

Results and Discussion

The effects of task difficulty and cohort on percentage of time that gaze was averted during the thinking episode were analysed.

Spontaneous Gaze Aversion During Thinking stage

Analyses of spontaneous GA were conducted to see how its use changes over the child’s fifth year/first year of formal education. A 2 (question type: arithmetic, verbal reasoning) X 2 (question difficulty: easy, difficult) X 3 (cohort: start year 1, mid year 1, end year 1) mixed design ANOVA was employed, with question type and question difficulty the within-groups variables, and cohort the between-groups variable. Means for each condition are displayed in Table 4.

INSERT TABLE 4 NEAR HERE

Whilst there was no main effect of question type, $F(1, 27) = 3.21$, $\eta_p^2 = .11$, $p = 0.08$, there was a main effect of question difficulty $F(1, 27) = 8.49$, $\eta_p^2 = .24$, $p < .01$, with more GA for hard questions (*M*’s: easy = 50.74%, hard = 58.15%). There was also a main effect of cohort, $F(1, 27) = 16.06$, $\eta_p^2 = .54$, $p < .0001$. Unpaired t-tests showed that there were significantly lower levels of spontaneous GA for: children at the start of primary year 1 relative to children in both the middle of primary year 1, $t(18) = 2.09$, $p = .051$, and at the end of primary year 1, $t(18) = 7.56$, $p < .0001$ and; children in the middle of primary year 1 relative to children at the end of primary year

1, $t(18) = 3.01$, $p < .01$ (*M*'s: start year 1 = 34.73%, mid year 1 = 51.82%, end year 1 = 76.77%). None of the interactions were significant: question type by cohort, $F < 1$; question difficulty by cohort, $F(2, 27) = 1.96$, $\eta_p^2 = .13$, $p = .16$; question type by question difficulty, $F < 1$; question type by question difficulty by cohort, $F < 1$.

These results point to a substantial acquisition of GA during the first year of formal education, with significant increments in the spontaneous use of this behaviour throughout primary year 1. So, as children progress through their first year of formal education they rapidly become more sophisticated in their use of GA. Despite this trajectory in primary year 1, even by the end of it, spontaneous levels of GA are still below those observed elsewhere in 8-year old children (Doherty-Sneddon et al., 2002), suggesting that the use of GA is still not fully developed by the end of primary year 1.

Despite the observed rapid acquisition of GA during the first year of formal education, we have nonetheless shown that even at the beginning of this event, 5-year old children do increase their use of GA when thinking about more difficult questions. So, although GA is less frequently applied at the onset of primary year 1, it still acts as a reliable overt signal that a child is engaged in challenging cognitive activity.

General Discussion

In Experiment 1 we demonstrated the efficacy of instructing 5-year old children to increase their use of GA whilst thinking about their answers to arithmetic and verbal-reasoning questions. The performance benefits which arose as a result of this increased use of GA were limited to questions which proved challenging to the children, with no advantage for using GA while solving easy problems. This pattern of results mirrors that reported in the adult literature (Glenberg et al., 1998: Experiment 4), and concords with the assertion that GA is a behaviour which grants thinkers the opportunity to concentrate on internal processing of information (e.g., Doherty-Sneddon et al., 2002; Glenberg, 1997; Glenberg et al., 1998).

The finding that GA serves to facilitate performance when children (and indeed adults) are challenged could be taken to suggest that the best time at which to encourage a child to use GA would be when they are challenged, but working within their current cognitive understanding of a given operation, or in Vygotsky's (1934/1962) terminology, when working within their 'zone of proximal development'. Indeed, preliminary work (Longbotham, 2001) suggests that when 6-year old children are required to learn and apply complicated arithmetic operations (adding tens and units and reversibility) their use of GA can be reliably used as a cue to whether they are working within their zone of proximal development. Similarly, Goldin-Meadow and Singer (2003) report how children make use of another nonverbal communication signal – hand gestures - to communicate their comprehension of tasks and readiness to learn. Further, more recent work suggests that, as with GA, hand gestures can serve to benefit task performance (Wagner, Nusbaum, & Goldin-Meadow, 2004). So, nonverbal communication cues, including GA and hand gestures, promise to serve as reliable and overt cues of a child's cognitive involvement in a task and their readiness to learn. Further, the use of these nonverbal cues appears to benefit learning.

Given that 5 -year old children could readily be trained to increase their use of GA, coupled with the finding that this training could significantly benefit performance, encouragement of GA while the child is thinking appears to be a simple, yet effective way in which to significantly improve a 5-year old child's cognitive performance. This finding has clear implications for learning - for both young children and potentially also for other cohorts who experience dysfunctional patterns of gaze, for example, children with learning disabilities such as Williams Syndrome which is characterised by excessive levels of gaze at interlocutors (e.g., Mervis, Morris, Klein-Tasmen, Bertrand, Kwinty, Appelbaum, & Rice, 2003).

In Experiment 2 we found a developmental trajectory in the spontaneous use of GA over the child's first year of formal education. Further, this developmental increase in the spontaneous use of GA was independent of the effects of task difficulty; levels of GA increased systematically with age for both easy and hard questions. However, what still remains open to question is whether this developmental change occurs because of age-related advancements in the child's cognitive development or because of increased exposure to pedagogical interactions as a result of having entered formal education.

To conclude, the current experiments have shown that 5-year old children can be readily trained to increase their use of GA during the thinking stage of a question-answer interaction. Importantly, this behaviour helped them correctly answer questions which are typical of everyday pedagogical interactions. However, the benefits of GA appear limited to situations where those questions prove challenging. Given the observed benefit of GA, it is important to note a developmental trajectory in the use of this behaviour. So, whilst 5-year old children at the onset of Primary 1 were beginning to use GA to exert control over their cognitive processing, use of this behaviour had become more frequent by the time children were nearing the middle of their fifth year. Consequently, GA, at any age, can be considered an overt sign that a child is engaged in cognitive activity. Given the relatively small sample sizes used in the current experiments, a certain degree of caution should be exercised in considering the implications of these results. However, despite the small sample sizes a clear influence of GA on facilitating thought and concentration was observed, thus highlighting the importance of GA during pedagogical interactions.

These findings have potentially important implications for children's attainment and for teaching methods. First, GA should prove useful as a tool by which to identify children who are engaged in cognitive activity. More importantly, children actually benefited from appropriately-timed GA on tasks typical of everyday pedagogical interactions. So, GA whilst thinking is a simple behaviour by which children can more effectively exert control over their own cognitive processing, potentially offering a means to more effective learning. This is an important finding for teachers seeking to provide optimal support to children engaged in problem solving activities.

References

Argyle, M., & Cook, M. (1976). *Gaze and Mutual Gaze*. Cambridge University Press.

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.

Corsi, P. M. (1972). Human memory and the medial temporal region of the brain. *dissertation Abstracts International*, *34*(*2*), 891B.

De Ribaupierre, A., & Bailleux, C. (1994). Developmental change in a spatial task of attentional capacity: An essay toward an integration of two working memory models. *International Journal of Behavioural Development*, *17*, 5-35.

Doherty-Sneddon, G., Bonner, L., & Bruce, V. (2001). Cognitive demands of face monitoring: Evidence for visuospatial overload. *Memory & Cognition*, *29* (*7*), 909-919.

Doherty-Sneddon, G., Bruce, V., Bonner, L., Longbotham, S., & Doyle, C. (2002). Development of gaze aversion as disengagement from visual information. *Developmental Psychology*, *38* (*3*): 438-445.

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., & Phelps, F. G. (in press). Gaze aversion: a solution to cognitive or social difficulty? *Memory and Cognition*.

Ehrlichman, H. (1981). From gaze aversion to eye-movement suppression: An investigation of the cognitive interference explanation of gaze patterns during conversation. *British Journal of Social Psychology*, *20*, 233-241.

Ehrlichman, H., Weiner, S. L., & Baker, A. H. (1974). Effects of verbal and spatial questions on initial gaze shifts. *Neuropsychologia*, *12*, 265-277.

Ellyson, S. L., Dovidio, J. F., & Corson, R. L. (1981). Visual differences in females as a function of self-perceived expertise. *Journal of Nonverbal Behaviour*, *5,* 164-171.

Erber, N. P. (1979). Auditory-visual perception of speech with reduced optical clarity. *Journal of Speech and Hearing Research*, *22*, 212-223.

Gale, A., Lucas, B., Nissim, R., & Harpham, B. (1972). Some EEG correlates of face-to-face contact. *British Journal of Social and Clinical Psychology, 11*, 326-332.

Glenberg, A. M. (1997). What memory is for. *Behavioural & Brain Sciences*, *20*, 1-20.

Glenberg, A. M., Shroeder, J. L., & Robertson, D. A. (1998). Averting the gaze disengages the environment and facilitates remembering. *Memory & Cognition*, *26* (4), 651-658.

Goldin- Meadow, S., & Singer, M. A. (2003). From children's hands to adult's ears: Gesture's role in the learning process. *Developmental Psychology*, 39 (3): 509-520.

Kleinke, C. L., & Pohlen, P. D. (1971). Affective and emotional responses as a function of other person's gaze and co-operativeness in a two-person game. *Journal of Personality and Social Psychology, 17*, 308-313.

Kocel, K., Galin, D., Ornstein, R., & Merrin, E. L. (1972). Lateral eye movement and cognitive mode. *Psychonomic Science, Vol. 27* (*4*), 223-224.

Longbotham, S. (2001). *Can gaze aversion be used to predict a child's understanding, learning and teaching abilities*? Unpublished undergraduate dissertation, University of Stirling, Scotland.

McGurk, H., & MacDonald (1976). Hearing lips and seeing voices. *Nature*, *264,* 746-748.

Mervis, C.B., Morris, C.A., Klein-Tasmen, B.P., Bertrand, J., Kwinty, S., Appelbaum, G., & Rice, C.E. (2003). Attentional characteristics of infants and toddlers with Williams syndrome during triadic interactions, Developmental Neuropsychology, 23, 243-268.

Meskin, B. B., & Singer, J. L. (1974). Daydreaming, reflective thought, and laterality of eye movements. *Journal of Personality & Social Psychology*, *30*, 64-71.

Neely, K. K. (1956). Effect of visual factors on the intelligibility of speech. *Journal of the Acoustical Society of America*, *28*, 1275-1277.

Nichols, K. A., & Champness, B. C. (1971). Eye gaze and the GSR. *Journal of Experimental Social Psychology*, *7*, 623-626.

Vygotsky, L. (1962). *Thought and Language*. Cambridge, MA: MIT Press. (Original work published 1934)

Wagner, S. M., Nusbaum, H., & Goldin-Meadow, S. (2004). Probing the mental representation of gesture: Is handwaving spatial? *Journal of Memory and Language*, 50 (4): 395-407.

Wechsler, D. (1967). *Wechsler Preschool and Primary Scale of Intelligence*. New York: Psychological Corporation.

Footnotes

Removed to protect author anonymity.

Table 1. Examples of the type of stimuli used in Experiments 1 and 2.

		verbal	arithmetic
Definition			Addition
	Easy	what is a dog?	1 + 1?
	Moderate	What is a telescope?	4 + 4?
Spelling			Subtraction
	Easy	tap	2 – 1?
	Moderate	Desk	8 – 5?
Information			Multiplication
	Easy	tell me the colour of the sea?	1 X 1
	Moderate	tell me the 7 days of the week?	2 X 3
Serial recall			number use
	Easy	Girl, Ball, Hat	count to 10
	Moderate	Holiday, Lion, Broccoli, Taxi	count backwards from 10

Table 2.

Mean Percentages of Time Spent in Gaze Aversion by the Avert Group and Control Group During Thought (Standard Deviations in parentheses).

Question Type &	Verbal questions		Arithmetic questions	
Question Difficulty	Easy	Moderate	Easy	Moderate
Group				
Control	25.40	35.50	35.40	42.60
	(11.47)	(10.10)	(16.45)	(18.97)
Avert	53.30	54.50	42.70	59.50
	(15.56)	(15.09)	(10.40)	(15.63)

Table 3.

Percentage Accuracy of Responses to Different Question Types Across Training Groups (Standard Deviations in parentheses).

Question Type &	Verbal questions		Arithmetic questions	
Question Difficulty	Easy	Moderate	Easy	Moderate
Group				
Control	69.18	38.95	81.20	34.40
	(21.67)	(25.15)	(20.06)	(21.37)
Avert	82.53	57.08	86.10	64.60
	(11.17)	(17.47)	(17.87)	(20.95)

Table 4.

Spontaneous Levels of Gaze Aversion Across Each Cohort of Five-year Old children (Standard Deviations in parentheses).

	Cohort:		
Question Type:	Start Primary 1	Mid Primary 1	End Primary 1[1]
word easy	25.40 (11.47)	42.57 (25.66)	77.63 (16.02)
word hard	35.50 (10.10)	55.86 (27.64)	76.04 (15.79)
math easy	35.40 (16.45)	48.25 (20.32)	75.20 (12.34)
math hard	42.60 (18.97)	60.66 (27.37)	78.22 (26.92)