# CONTROLLING ATTENTION TO GAZE AND ARROWS IN ATTENTION DEFICIT HYPERACTIVITY DISORDER


## ABSTRACT

The aim of this research was to assess implicit processing of social and non-social distracting cues in children with ADHD. Young people with ADHD and matched controls were asked to classify target words (LEFT/RIGHT) which were accompanied by a distracter eye-gaze or arrow. Typically developing participants showed evidence of interference effects from both eye-gaze and arrow distracters. In contrast, the ADHD group showed evidence of interference effects from arrow but failed to show interference from eye-gaze. This absence of interference effects from eye-gaze observed in the participants with ADHD may reflect an attentional impairment in attending to socially relevant information.



**Keywords:** social attention, cognitive control, eye-gaze, arrow, ADHD

## 1. **Introduction**

The ability to follow another person's direction of gaze appears very early in life and marks an important breakthrough in the development of social communication, given that gaze provides important information regarding individual's interests and mental states (Emery, 2000; Moore & Dunham, 1995). By 2 years of age, children are using gaze following for words learning (Poulin-Dubois & Forbes, 2002). Four and 5-year old children are able to make inferences about another person's mental state, using eye gaze frequency and duration (Baron-Cohen, Campbell, Karmiloff-Smith, Grant, & Walker, 1995). Receptivity to the social meaning of gaze-direction continues to develop across childhood into adulthood (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001; Dawel, Palermo, O'Kearney, Irons, & McKone, 2015; Neath, Nilsen, Gittsovich, & Itier, 2013) and it is a strong predictor of adult social competence (Klin, Jones, Schultz, Volkmar, & Cohen, 2002). This skill-development outline does not necessarily apply to children with developmental disorders, such as the Attention Deficit Hyperactivity Disorder (ADHD). ADHD is a neuropsychiatric condition characterized by developmentally inappropriate levels of inattention, impulsivity and hyperactivity (Biederman, & Faraone, 2005) that negatively impacts multiple areas of children's lives, including their ability to develop healthy interpersonal relationships. Children with ADHD are less accepted by their peers and are perceived negatively by other children (Carlson, Lahey, Frame, Walker, & Hynd, 1987; Erhardt, & Hinshaw, 1994; Hoza et al., 2005; King, & Young, 1982; Klein, & Young, 1979). These problems are known to be strong predictors of serious negative outcomes in later adolescence and adulthood (Greene, Biederman, Faraone, Sienna, & Garcia-Jetton, 1997; Mrug et al., 2012). A factor that may in part contribute to these deficits is the failure to perceive, attend and interpret the meaning of social cues and drawing inferences about other people's thoughts, intentions, and feelings (Petersen, & Grahe, 2012; Uekermann et al., 2010). Consistent with this view, deficits in social cognition are an evident clinical phenomenon in ADHD and several studies have reported various impairments in domains such as facial affect recognition (Ibañez et al., 2011a; Sinzig, Morsch, & Lehmkuhl, 2008), theory of mind (Sodian, Hulsken, & Thoermer, 2003) and empathy (Braaten, & Rosen, 2000; Dyck, Ferguson, & Shochet, 2001). These findings suggest that children with ADHD are impaired in making explicit social judgments about other people's emotions. Much less is known about implicit processing of social cues such as eye-gaze direction.

Studies with typically developing individuals suggest that observing averted gaze can elicit a reflexive shift of attention to the gazed-at location and/or object (Friesen, & Kingstone, 1998; Hietanen, 1999; Marotta, Casagrande, & Lupiáñez, 2013). The mechanisms underlying the reflexive orienting towards the direction of other's eye gaze have been generally assessed using a variant of the traditional cueing paradigm (Posner, 1980). In this paradigm, a drawing/photograph of a face looking to the left or right is presented in the center of the screen. The participant is required to respond to a target that might appear either at the looked-at (valid) or at the opposite location (invalid). Quicker reaction times for validly cued targets are thought to indicate an allocation of attention to the looked-at location (i.e. gaze cueing effect). Over the last two decades, reflecting the idea that gaze cueing paradigm tapped into social cognition, several researchers have successfully adapted and applied this paradigm to study social attention in both healthy (Cole, Smith, & Atkinson, 2015; Marotta, Lupiáñez, Martella, & Casagrande, 2012; Schulz, Velichkovsky, & Helmert, 2014; Zhao, Uono, Yoshimura, & Toichi, 2014) and clinical populations (Akiyama et al., 2008; Dalmaso, Galfano, Tarqui, Forti, & Castelli, 2013; Marotta, Pasini et al., 2013). Importantly, in a recent study Marotta and colleagues used the cueing paradigm described above and found that children with ADHD children showed evidence of reflexive orienting only to locations previously cued by non-social stimuli (arrow and peripheral cues) but failed to show such orienting effect in response to social eye gaze cues (Marotta et al., 2014). These findings suggested that automatic processing of gaze direction may be impaired in ADHD.

In line with our previous data demonstrating social attention impairments in ADHD, in the present research, we have examined whether ADHD individuals also exhibit impairments in the cognitive control of social information. Several studies have reported that children with ADHD have social cue processing deficits (Matthys, Cuperus, & Van Engeland, 1999; Milich & Dodge, 1984), have biased interpretations of social information (Murphy, Pelham, & Lang, 1992), and generate more inappropriate and fewer social responses than children without ADHD (King et al., 2009; Matthys et al., 1999). Collectively, these findings are indicative of deficits in the cognitive control of social information in ADHD. However, to our knowledge, no previous study has investigated the ability to inhibit irrelevant eye-gaze information in ADHD. The aim of the present study is to address this issue directly. A widely used method for investigating inhibition of interference is the Stroop task. It is important to underline that gaze orientating task and the Stroop task map onto different attentional systems. The orienting of attention refers to the processing or selection of one out of several sources of information separated from one another in space. This process does not entail the logical relation of conflict or agreement, but only that of alignment o disengagement of attention from the target. On the other hand, the Stroop task applies to stimuli whose constituent features are in conflict or agreement with that of another. Because the the presence of congruent and incongruent information combinations, the Stroop task is it is widely considered a prime process of executive attention (Botvinick, Braver, Barch, Carter & Cohen, 2001). Therefore, "orienting and executive control are widely thought to be relatively independent aspects of attention that are linked to separable brain regions" (Fan et al., 2005, p. 471). In the present study, to investigate executive cognitive control of social information in ADHD individuals we employed an interference Stroop-like task in which manual responses to a target word (LEFT/RIGHT) are required in the context of to-be-ignored arrow (pointing left or right) or eye-gaze (left or right averted) distracters. To the extent that the unattended distracter is processed, target response times (RTs) are generally slowed by incongruent—relative to congruent— distracters with both eye-gaze and arrow cues in typically developing children (Barnes, Kaplan, & Vaidya, 2007; Marotta & Casagrande, 2016). To our knowledge, no previous experiment has used this paradigm with children with ADHD. The predictions were straightforward: whether people with ADHD attend to fewer or less-relevant social cues, and spend less time generating possible responses to social information than we expect that eye-gaze distracter should not capture attention and influence their classification performance. Interference effects from eye-gaze should be observed only within typically developing participants. In contrast, no difference between ADHD group and matched comparison group should be observed for arrow distracters since normal levels of attentional orienting have been generally reported with non-social cues in individuals with ADHD (for a review, see Huang-Pollock, & Nigg 2003).

## 2. **Method**

### *2.1. Participants*

A total of 38 children and adolescents (aged 7–17 years) participated in the study: 19 were diagnosed with ADHD[1] (mean age 12.3 ± 3.1 years; 14 males/5 female) and 19 were typically developing individuals (mean age 12.2 ± 2.9 years; 14 males/5 female). The ADHD group included 11 participants who met the criteria for the ADHD/C subtype (exhibit both inattentiveness and hyperactivity/impulsiveness symptoms) and 8 who met the criteria for ADHD/I (show prevalently inattentive symptoms; Diagnostic and Statistical Manual of Mental Disorders, DSM-IV, 2000). All participants with ADHD were drug-naive patients first admitted to the Day Hospital of the Child Psychiatry Unit of the University of Rome ''Tor Vergata.'' A psychopathological evaluation was performed by a team of child psychiatrists by means of the Kiddie Schedule of Affective Disorders (K-SADS; Kaufman, Birmaher, Brent, Rao, & Ryan, 1996), the Conners' Parent Rating Scale, the Conners' Teacher Rating Scale (Conners, 1989), the Children Depression Inventory (Kovacs, 1985), and the

[1] Although the present study follows the authors' recently published work on the same topic (Marotta et al, 2014), it is important to note that a different group of ADHD individuals participated in this experiment.

Multidimensional Anxiety Scale for Children (March, 1997). The inclusion criteria to participate in the study were the diagnosis of ADHD (based on the DSM-IV criteria and confirmed by K-SADS), no history of mental retardation, brain trauma, neurological diseases or physical impairment, a lack of comorbid mental disorders with the exception of oppositional defiant disorder (ODD). The participants for the control group were matched in gender and age with the ADHD group and were recruited from two public schools in Rome. The control group participants had no history of cerebral injury or other neurological or psychiatric disorders. All participants aged 11 years and older had a full-scale IQ greater than 80 on the Progressive Standard Matrices, and all children aged 10.5 years or younger had an IQ that fell above the 75 th percentile on the Progressive Colored Matrices (Raven, Court, & Raven, 1990; Raven, Raven, & Court, 1993). The presence of ADHD in participants from the control group was assessed via an independent evaluation carried out by the teacher and by one parent who completed a DSM-IV-TR report card. Any participant with a possible indication of ADHD was not considered. The mean age and IQ scores of participants from the two groups did not differ significantly ($F < 1$). Participant demographic characteristics are showed in Table 1. The Ethical Committee of Child Psychiatry and Neurology Institute approved the study. The experiment was conducted according to the ethical standards of the 1964 Declaration of Helsinki. All parents or legal guardians of children gave written informed consent before testing.

**[INSERT TABLE 1 ABOUT HERE]**

## 2.2. *Apparatus*

Stimuli were presented on a 15-inch colour monitor. A computer running E-Prime software controlled the presentation of the stimuli, timing operations, and data collection. Responses were gathered with a standard keyboard.

## 2.3. *Stimuli*

In the gaze condition, the distracter was represented by the eye region of a face with the pupils directed to the left or to the right (2° x 12° degree of visual angle). In the arrow condition, the distracter was an arrow directed either to the left or to the right (2° x 7° degree of visual angle). Target stimuli were the words ‘‘Sinistra’’ or ‘‘Destra’’, Italian words for “LEFT” or “RIGHT” presented immediately above the distracter stimuli (the distance between the center of the target and the center of the distracter stimuli was 2.3º). Sample stimuli are shown in Figure 1. Distracters pointed in a direction congruent (e.g. word ‘LEFT’ in the context of leftward arrow or gaze) or incongruent (e.g. word ‘LEFT’ in the context of rightward arrow or gaze) to the word’s meaning; Distracters without directional information were also included (e.g. a bar without arrowheads and direct gaze).

## 2.4. *Procedure*

Participants were seated at the distance of about 56 cm in front of a computer monitor, in a dimly lit, sound-attenuated room, and their heads were held steady with a chin/head rest.

Each trial began with a display consisting of a cross presented in the center of the screen for 100 msec replaced by the stimulus display. The target display remained until response, or until 1200 ms had elapsed. Participants were instructed to attend to the words ‘‘Sinistra’’ or ‘‘Destra’’ (Italian words for “LEFT” and “RIGHT”) and to ignore arrows or faces that would appear with the words. Participants were told to respond to the word as quickly and accurately pressing either the “C” key (with the left hand) or the “M” key (with the right hand) on the computer keyboard for the word “LEFT” and “RIGHT”, respectively. Participants completed a practice block of 10 trials, followed by two experimental blocks of 42 trials (one for each stimulus type). Trials were presented in a pseudorandom order with no more than three successive trials of the same type and response.

**[INSERT FIGURE 1 ABOUT HERE]**

*2.5. Design*

The experiment used a mixed factor design with the following factors: Group, Cue Type and Trial Type. Group had two levels: ADHD and typically developing people[2]. Cue Type had two levels: gaze and arrow. Trial Type had two levels: congruent trials (the direction indicated by the arrows or eye gaze was the same as

[2] The effect of ADHD subtype (Combined vs. Inattentive) on performance was examined first. The main effect was not significant ($F < 1$), and no interactions were observed with the ADHD subtype (Cue Type by Subtype: $F_{1,17}= 1.38$, $p= .257$; Trial Type by Subtype: $F< 1$; Cue Type by Subtype by Trial Type: $F_{1,17}= 2.92$, $p= .105$). Given the limited number of participants, interference effects were also compared between ADHD subtypes using a non-parametric Mann–Whitney U Test. Results showed that there was no significant difference between ADHD subtypes for interference effect from arrow ($U = 22$; $p= .314$) or interference effect from gaze ($U = 29$; $p= .791$). Since the preliminary analyses showed no differences between the ADHD subtypes, we entered the factor Group into the statistical analyses with just two levels (ADHD and typically developing people).

the target word) and incongruent trials (the direction indicated by the cues was the opposite as the target). Planned comparisons were used for the analysis of interactions. To examine whether direct gaze affects the performance of individuals with ADHD, a Group by Cue Type ANOVA was also conducted on the reaction times and accuracy of the trials without interference[3]. Trials with reaction times (RTs) faster than 200 ms (0.4% of the trials) as well as incorrect responses (misses and mistakes: 4.2% and 12.3% of the trials, respectively) were excluded from the RTs analysis. Mean RTs and mistakes percentages are displayed in Table 1.

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[3] Consistent with the majority of the studies investigating interference effect from gaze by means of Stroop tasks (Barnes et al., 2007; Marotta et al., 2016; Schwartz, et al., 2010) in the present study direct gaze trials were not considered an appropriate comparison condition and were not included in the analysis because they are not neutral in terms of attentional demands. Indeed, perception of direct gaze involves different cognitive and neural processes than those in the perception of averted gaze (for reviews, see George & Conty, 2008; Senju & Johnson, 2009). However, since deficits in the perception of direct gaze have been observed across a range of psychiatric conditions characterized by social and interpersonal dysfunctions, including autism spectrum disorder (e.g., Senju et al., 2008), and schizophrenia (e.g., Schwartz, Vaidya, Howard, & Deutsch, 2010), in the present study direct gaze trials were examined separately to investigate whether direct gaze also affects the performance of individuals with ADHD. Moreover, although the results regarding the difference between interference trials (congruent and incongruent) and trials without interference are not germane to the questions addressed in this article, they may be of interest to some readers. For that reason, the results of a full ANOVA Group (ADHD vs. typically developing people) x Cue Type (gaze vs arrow) x Trial Type (trials without interference, congruent trials, incongruent trials) are presented here. Results only showed a significant effect of Trial Type ($F_{2,72}$= 14.41; $p< .001$), with longer RTs for incongruent trials than congruent trials ($F_{1,36}$= 23.31; $p< .001$) or trials without interference ($F_{1,36}$= 18; $p< .001$). RTs for congruent trials were not significantly different from RTs for congruent trials (p= .606). All other main effects and interactions failed to reach significance (all $p > .148$).

## 3. **Results**

*Reaction Times*. ANOVA revealed a significant main effect of Trial Type ($F_{1,36}$= 23.31; p< .001; $\eta_p^2$ = .39), with longer RTs for incongruent trials than congruent trials (606 ms vs. 640 ms). Neither the main effects of Group (F< 1; p= .52) and Cue Type ($F_{1,36}$= 2.51; p= .122) nor the interactions Group by Trial Type ($F_{1,36}$= 1.51; p= .227), Group by Cue Type (F< 1) and Trial Type by Cue Type ($F_{1,36}$= 1.91; p= .176) were significant. Importantly, the critical Group by Cue Type by Trial Type interaction was significant ($F_{1,36}$= 4.70; p= .037; $\eta_p^2$ = .12, see figure 2). To further examine the three-way interaction, Group by Trial Type ANOVAs were conducted for each Cue Type separately.

The ANOVA for the gaze condition revealed a significant effect of Trial Type ($F_{1,36}$= 9.26; p= .004; $\eta_p^2$ = .20) with longer RTs for incongruent trials than congruent trials (628 ms vs. 605 ms). The main effect of Group was not significant (F< 1; p= .49). Importantly, the critical Group by Trial Type interaction was significant ($F_{1,36}$= 10.53; p= .003; $\eta_p^2$ = .22). Planned comparisons showed that RTs were significantly faster on congruent trials than on incongruent trials (580 ms vs. 627 ms) only in the control group ($F_{1,36}$= 19.31; p< .001; $\eta_p^2$ = .35). In contrast, no differences were found between congruent and incongruent trials (630 ms vs. 629) in the ADHD group (F< 1; p= .93).

The analysis for the arrow cue condition showed a significant effect of Trial Type ($F_{1,36}$= 13.18; p< .001; $\eta_p^2$ = .27) with longer RTs for incongruent trials than congruent trials (651 ms vs. 608 ms). The main effect of Group was not significant (F< 1; p= .57). Of interest, the interaction Group by Trial Type was not significant ($F< 1$; $p= .54$): planned comparisons showed that RTs were significantly faster on congruent trials than on incongruent trials both in ADHD (614 ms vs. 665 ms; $F_{1,36}= 9.56$; $p= .005$; $\eta_p^2 = .20$) and in control group (602 ms vs. 638 ms; $F_{1,36}= 4.56$; $p= .039$; $\eta_p^2 = .11$).

*Errors*. The Group by Trial Type by Cue Type ANOVA on error percentages revealed a significant main effect of Trial Type ($F_{1,36}= 11.44$; $p< .002$; $\eta_p^2 = .24$), indicating that participants committed significantly more incorrect responses on incongruent trials than on congruent trials (11.9 % vs. 7.4 %). No other main effect or interactions were found (Group: $F_{1, 36}= 2.54$; $p= .12$; Cue Type: $F <1$; $p= .71$; Group by Cue Type: $F_{1, 36}= 1.33$; $p= .26$; Group by Trial Type: $F_{1, 36}= 3.02$; $p= .091$; Cue Type by Trial Type: $F_{1, 36}= 2.55$; $p= .12$; Group by Trial Type by Cue Type: $F< 1$; $p= .79$).

Trials without interference

The ANOVA on reaction times did not reveal any significant main effects or interaction (all $F< 1$). In the same way, the ANOVA on incorrect responses did not reveal any significant main effects or interaction: Group ($F_{1, 36}= 1.03$; $p= .316$), Cue Type ($F< 1$) and Group by Cue Type ($F< 1$).

**[INSERT FIGURE 2 AND TABLE 2 ABOUT HERE]**

## 4. Discussion

In this study, we examined whether gaze direction and arrow cues capture the attention of people with and without ADHD when their attention is directed to another task. Participants performed a word directional classification task in the context of arrows and eye gaze cues, either congruent or incongruent with the target word. Eye-gaze and arrow cues represented social and non-social distracter signals, respectively. When arrow stimuli were used as distracters, interference effects were observed in all participants. In contrast, when eye gaze was used, important differences were observed between participants with ADHD and the control group: a significant interference effect (RTs advantage for congruent than for incongruent trials) was only observed in typically developing individuals, while in participants with ADHD gaze stimuli failed to show such interference effect, suggesting that young people with ADHD were more effective at ignoring another person's distracting gaze than controls. Although such results may be construed as instances in which the ADHD group has an advantage, this seems unlikely for the following reason. Eye-gaze following behavior has been posited as vital in the development of important social communicative skills, such as language acquisition, cultural learning and theory-of-mind development in children (Baron-Cohen et al., 1995; Bruner, 1983; Tomasello, 1995) and impairments in the receptivity to the social gaze-direction in childhood represent a strong predictor of abnormal social competence in adults (Klin et al., 2002; Toth, Munson, Meltzoff, & Dawson, 2006). In the ADHD group, our data suggest that the receptivity to the eye-gaze direction is considerably flatter than in the control group, maybe as a consequence of an attentional difficulty in modulating responses to socially relevant information. This is consistent with the "response modulation" hypothesis Newman and Wallace (1993) according to which some individuals have an intrinsic deficit in their ability to switch attention while they are actively engaged in performing a task. Thus, in the present study, the lack of interference effects from eye-gaze observed in ADHD people might be due to their inability to shift from the execution of a dominant response to relevant social cues. These results are of considerable clinical interest, suggesting that many of their socially inappropriate interactions might be in part due to a single-minded pursuit behavior insensible to social relevant information that should constrain or interrupt their inadequate behavior. Our results are also consistent with recent findings demonstrating that ADHD showed evidence of reflexive orienting only to locations previously cued by non-social stimuli (arrow and peripheral cues) but failed to show such orienting effect in response to social eye gaze cues (Marotta et al., 2014). Taken together, these findings suggest a specific social impairment in the ability to attend another person's eye-gaze direction, which is in keeping with evidence of ADHD difficulties in the ability to decode more complex social cues such as the emotions and mental states of others (Pelc et al., 2006; Sinzing et al., 2008; Sodian et al., 2003). It might be argued that the poor sensitivity to the eye-gaze of others shown by people with ADHD is linked to their dysfunctional activity in right cerebral hemisphere (Acosta, & Leon-Sarmiento, 2003; Lee et al., 2005; Overmeyer et al., 2001; Sandson, Bachna, & Morin, 2000) the brain area mainly involved in orienting to gaze cues (Green & Zeidel, 2011; Kingstone, Friesen, & Gazzaniga, 2000; Marotta, Lupiáñez, & Casagrande, 2012). Various other brain areas have been implicated in attention deficit hyperactivity disorder, including temporal areas implicated in face perception (i.e. fusiform gyrus and superior temporal sulcus, Ibañez et al., 2011a), frontoparietal attention regions (Silk, Vance, Rinehart, Bradshaw, Cunnington, 2009) and areas implicated in emotion and social cognition (i.e. medial prefrontal cortex; Kain & Perner, 2003) and these regions have also been tentatively linked to processing of eye gaze cues driving social attention (Itier & Batty, 2009; Grosbras et al., 2005; Laube, Kamphuis, Dicke, & Their, 2011; Nummenmaa & Calder, 2009).

The finding that ADHD have specific tendency to ignore eye-gaze direction suggests that they may have fundamental problems establishing eye-contact and joint attention with others. Given the importance of joint attention in facilitating social interactions and communication (Langton, Watt, & Bruce, 2000; Mundy, Sigman, & Kasari, 1990; Stone, & Yoder, 2001), these difficulties may have negative implications for social functioning in ADHD. In particular, previous research has reported that when interacting with their peers, children with ADHD engage in more socially inappropriate behaviours including problems with maintaining conversations (e.g. not listening to others, frequently shifting the conversation, not following the details of the conversation, interrupting others) (Nijmeijer et al., 2008). Eye-gaze plays an important role in signalling turn-taking in conversational settings and thus problems in responding to eye-gaze in individuals with ADHD could contribute to their socially inappropriate interactions with others. Further studies are required to directly investigate the link between ADHD impairment in attending to eye-gaze cues and social functioning.

Finally, our results are different to those reported by a study with patients with schizophrenia (Schwartz et al., 2010), who are generally referred to as impaired in social attention behaviour (Sasson et al., 2006). In particular, Schwartz and colleagues (2010) found that interference effects from averted gaze did not differ between patients and controls. These findings suggest that the absence of interference effect from averted gaze observed in people with ADHD may be representative of this specific disorder and it cannot be generalized to all populations with impaired social attention behaviour. Future studies will be important in clarifying and strengthening this conclusion.

### *4.1. Limitations*

Interpretation of our findings should be tempered by some limitations of our study. First of all, a limitation of the present study concerns the grouping of participants diagnosed with ADHD/C subtype and those diagnosed with ADHD/I. Although our preliminary analyses support the notion of an undifferentiated cognitive profile, it is plausible that the different ADHD subtypes may exhibit differential social attentional profiles. Indeed, some studies have found differences in important classification dimensions (e.g. demographics, family history, and symptom presentation), suggesting that children with ADHD/I may have a distinct disorder and not a subtype of ADHD (Adams, Derefinko, Milich, & Fillmore, 2008; Barkley, 2001; Milich, Balentine, & Lynam, 2001). Future studies should address this limitation by means of a larger sample including groups of different ADHD subtypes. Another limitation of this study was the lack of information on reading fluency levels of the subjects. Moreover, in the present study, only the eye region of a face was presented to reduce the amount and complexity of details that could potentially draw and hold more attention in the eye-gaze condition as compared to the arrow condition. Nevertheless, this does raise the question as to whether our results can be generalized to full faces.

Therefore, further research will be necessary to shed light upon this issue. Finally, comparisons of social attention performance should include other disorders that occur co-morbidly with ADHD, such as bipolar disorder and schizophrenia (Barr, 2001; Ibañez et al., 2011b; Lus, & Mukaddes, 2009).

## 5. **Conclusions**

The present findings lead to some new insights about social attention in ADHD. Despite being irrelevant to the task, ADHD attended to arrow to the same extent as typically developing individuals as evidenced by equal behavioral response interference. However, unlike typically developing individuals, ADHD did not show interference effects from eye-gaze cues and therefore they showed no evidence of attending to eye-gaze direction. This dissociation highlights that people with ADHD demonstrate to have a specific impairment in social attention that could account at least partially for the higher levels of interpersonal problems generally observed in ADHD. Accordingly, understanding the nature of basic social attention deficits, and further uncovering its specific association with the social behavioral problems of ADHD, represents an essential next step toward knowing and treating individuals with ADHD.

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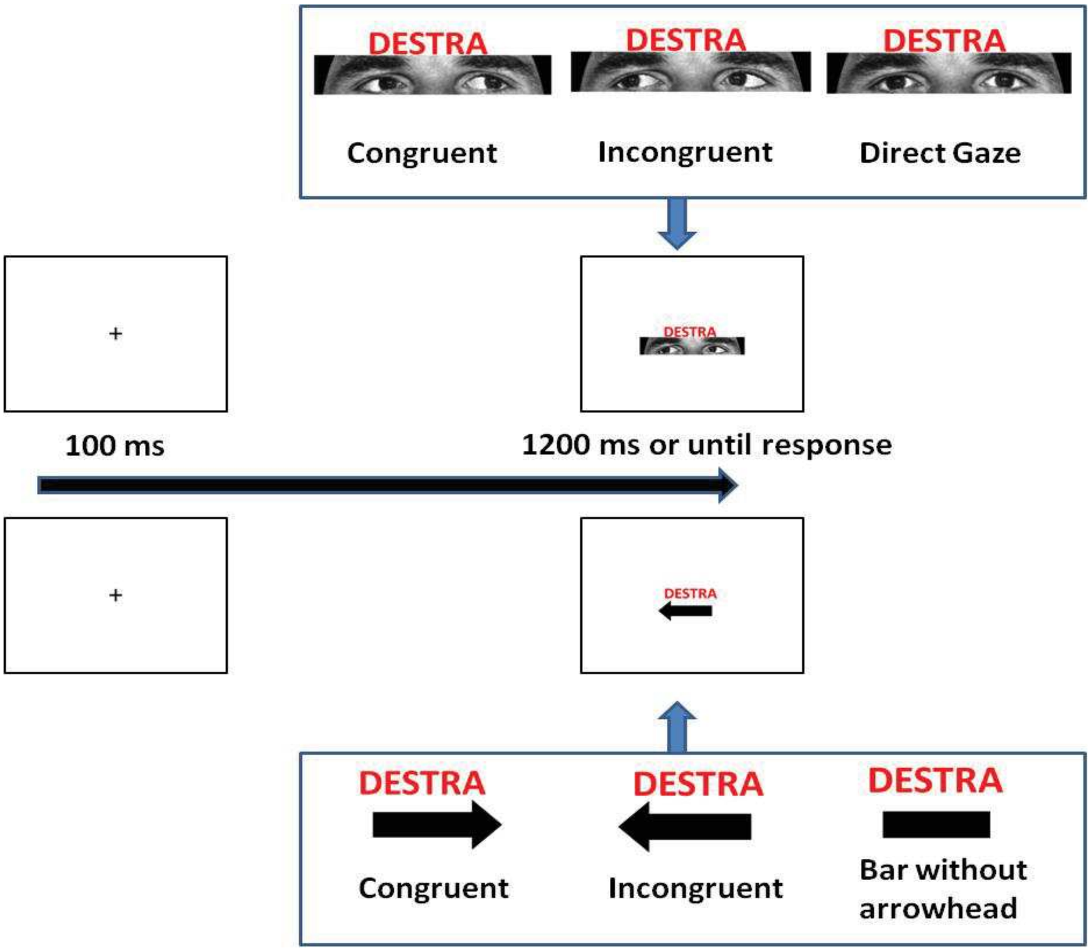


**Figure 1** Illustration of the trial sequence. The panel above depicts the displays observed in the gaze cue condition, and the panel below depicts those in the arrow cue condition. ‘‘Destra’’ is the Italian word for “RIGHT”.

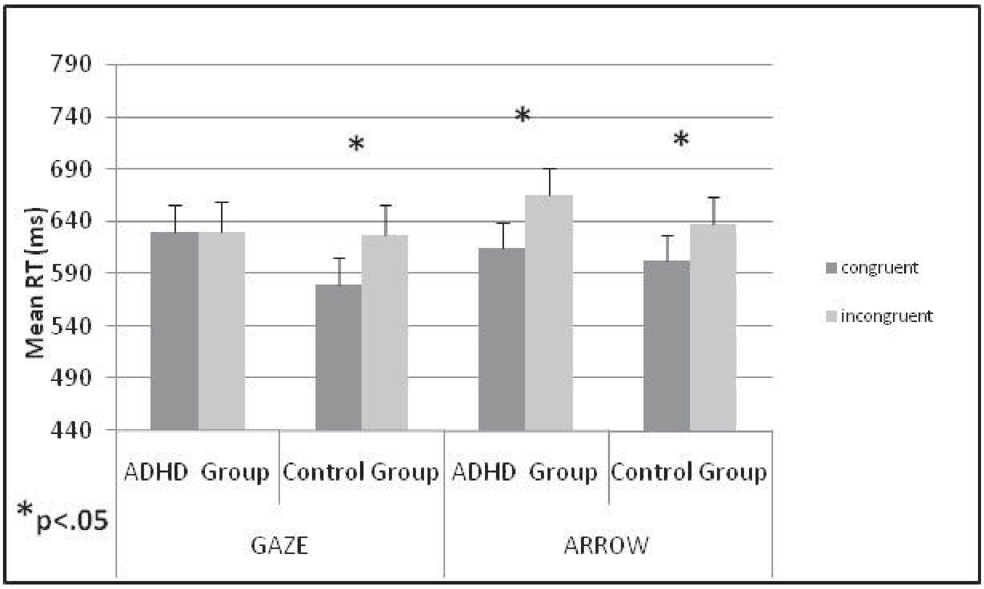


**Fig. 2** Mean reaction time as a function of Trial Type (congruent or incongruent) for each combination of Cue Type (gaze and arrow) and group (ADHD group or control group)

**Table 1.** Mean Correct Response Times (RTs, in Milliseconds), Standard Deviations (SD) and Percentages of Incorrect Responses Errors (%IR) for Each Experimental Condition and Group.

| GROUP | GAZE | | | | | | | | | ARROW | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CONGRUENT | | | INCONGRUENT | | | DIRECT | | | CONGRUENT | | | INCONGRUENT | | | BAR | | |
| | RT | SD | %IR | RT | SD | %IR | RT | SD | %IR | RT | SD | %IR | RT | SD | %IR | RT | SD | %IR |
| ADHD | 630.06 | 123.07 | 15.7 | 629.09 | 137.07 | 18.4 | 622.66 | 151.55 | 12.5 | 614.08 | 120.70 | 11.9 | 664.61 | 104.28 | 20.4 | 612.89 | 118.09 | 14.9 |
| CONTROL | 579.72 | 102.83 | 7.1 | 627.09 | 115.33 | 7.4 | 598.83 | 110.60 | 9.5 | 601.69 | 97.74 | 8.2 | 637.65 | 120.07 | 14 | 604.70 | 104.55 | 8.3 |

**CONTROLLING ATTENTION TO GAZE AND ARROWS IN ATTENTION DEFICIT HYPERACTIVITY DISORDER**


## ABSTRACT

The aim of this research was to assess implicit processing of social and non-social distracting cues in children with ADHD. Young people with ADHD and matched controls were asked to classify target words (LEFT/RIGHT) which were accompanied by a distracter eye-gaze or arrow. Typically developing participants showed evidence of interference effects from both eye-gaze and arrow distracters. In contrast, the ADHD group showed evidence of interference effects from arrow but failed to show interference from eye-gaze. This absence of interference effects from eye-gaze observed in the participants with ADHD may reflect an attentional impairment in attending to socially relevant information.



**Keywords:** social attention, cognitive control, eye-gaze, arrow, ADHD

**Highlights**

- We examined whether gaze and arrow cues capture the attention of people with ADHD
- ADHD children did not show interference effects from eye-gaze cues
- ADHD attended to arrow cues to the same extent as typically developing individuals

# CONTROLLING ATTENTION TO GAZE AND ARROWS IN ATTENTION DEFICIT HYPERACTIVITY DISORDER

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