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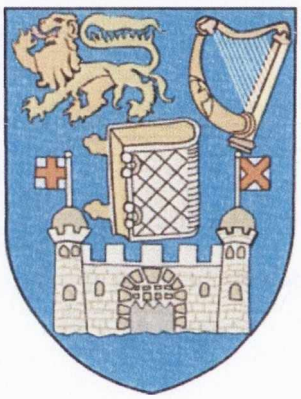
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The role of body information in the perception of social attention.

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BA MSc



A thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy to the University of Dublin, Trinity College

Supervisor: Professor Fiona N. Newell

School of Psychology

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Declaration

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Summary

The computation of where another person is attending constitutes a crucial part of our daily lives and is necessary for adequately interacting with other human beings in our social environment. The focus of the present dissertation is on social perception, a term often used to refer to the initial stages in the processing of socially relevant information (e.g., gaze, head and body direction, implied or actual body movements) that culminates in the accurate analysis of the dispositions and intentions of others. Despite increasing interest in the influence of body information (orientation, posture, represented action) as well as in the interrelationship between body and other social cues (e.g., head and eye-gaze) on the computation of the direction of social attention, the exact role of directional body information in this process remains unexplored. Chapter 1 provides a review of existing research as well as the theoretical context, in which current studies are situated. In the further chapters, behavioural studies are presented which contribute to this new emerging field of investigation and aim to examine the function of information about human body posture on the computation of where another person's attention is directed as well as the interrelationship between the body and other cues to social cognition using four different methodologies.

The first study (Chapter 2) used an adapted Stroop-type interference paradigm to investigate the hypothesis that directional head and body cues interact in the explicit discrimination of another individual's direction of social attention. The results demonstrate that gaze and head direction judgments are not solely driven by the face region but can also be affected by directional body information and that the body information is analyzed automatically, even when it is irrelevant to the observers' task and despite their intention not to do so. Moreover, our data provided evidence for a two-stage process in the computation of the direction of another person's attention in which directional head and body cues are first processed independently and in parallel, followed by a process of referential coding of the head relative to the body.

The experiments described in Chapters 3 and 4 inspected the role of directional body information in the activation of directional spatial codes using an adapted Simon paradigm. In these studies we demonstrated that (task-irrelevant)

body orientation is automatically processed and activates a directional spatial code. In the absence of directional head information, a directional code consistent with the direction of the body was activated. However, when head information was available, activation of a spatial code in a direction opposite to that of the orientation direction of the body was observed. This reversed activation pattern when head and body information are both available is consistent with the view that head orientation may be coded relative to body orientation.

Chapters 5 and 6 examined effects of directional body information in a Posner spatial cueing paradigm with central social cues. The experiments reported in Chapter 5 focused on the body's propensity to voluntarily and/or reflexively orient the attention of the viewer when head information is not available. We observed significant voluntary cueing effects towards the location to which the human body was oriented for standing and walking poses. Reflexive cueing however was limited to poses without implied action. In Chapter 6, which examined full body stimuli (i.e., head and body information available), reflexive attentional cueing from head direction was observed, however these cueing effects were restricted to those conditions in which the orientation of the observed person's body was not aligned with the orientation of the head, suggesting that cueing effects are limited to those poses which signal an averted gaze in the observed person's own frame of reference.

In a final study (Chapter 7) we examined whether and how the orientation of an observed person's body relative to their head affects the perception of where that person is attending to in their environment. The perceived direction towards which the observed person was attending was systematically shifted in the direction opposite to the direction of the body when misaligned with the head. This finding suggests that, in the process of social attention orienting, head orientation is initially referenced in relation to the observed person's frame of reference, and only then in relation to the observer.

In Chapter 8, the empirical data presented in this thesis are discussed in relation to existing models on the integration of social directional information found in the literature. Finally, a two-stage process model is proposed that is able to account for each of the results obtained within the present dissertation and a wide variety of other results within the literature.

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CHAPTER 1

GENERAL INTRODUCTION

1.1 Introduction

Social skills are essential for an individual to be capable of forming and maintaining social relationships and subsequently to participate and function within a community (e.g., Cacioppo, 2002). Because of the nature of our social environment, which is composed of human beings and is created or affected by them (Hari & Kujala, 2009), the perception of nonverbal, social cues is an essential skill enabling us to navigate this interpersonal world (Ochsner, 2004), to control our actions, to search for agency, causal explanation and meaning of another parties' actions (Gallese, Keysers, & Rizzolatti, 2004; Hari & Kujala, 2009). Reciprocal actions, pursuing interactions, forming coalition and knowledge of third party relationships would not be possible without the elaborate system of audio-visual signalling that primates[1] produce (Cheney & Seyfarth, 1990; Emery, 1997; Ochsner, 2004; Tomasello & Call, 1997). Malfunctioning social skills can seriously affect quality of life by compromising the ability to produce and maintain successful interactions, which in turn can result in psychological distress, social isolation, and limited communicating capabilities (e.g., Frith & Frith, 1999). Therefore, the domain of social cognition has become an active research topic for scientists from many domains: social and political, developmental and, finally, the neurological and psychological fields (Beauchamp & Anderson, 2010).

The domain of Social Psychology generally endeavours to analyze and comprehend people's thoughts, feelings, and behaviours and how they influence and are influenced by the actual, imagined, or implied presence of others (Allport, 1968). Within the area of social behaviour three different levels can be identified: *social function*, *social skills*, and *social cognition* (Yager & Ehmann, 2006), where social functioning refers to the way an individual performs in a social environment by relying on both other concepts: social skills and social cognitive skills (Beauchamp & Anderson, 2010). Social skills refer to the cognitive and interpersonal abilities that are responsible for appropriate social behaviour and

[1] Most of the studies on the elaborate system of visual signalling in social functioning have been carried out in both human and non-human primates (Allison, Puce, & McCarthy, 2000; Cheney & Seyfarth, 1990; Emery, 2000; Tomasello & Call, 1997). However, the skill of using sophisticated visual, social signalling to associate multiple meanings is characteristically unique for humans (for a review, see Emery, 2000).

interpersonal interactions (Beauchamp & Anderson, 2010). These abilities comprise accurate selection of relevant information from a social context, using that information to interpret the intention and the goal of the action of another person, and appropriately executing one's own behaviour in the interpersonal interaction (Bedell & Lennox, 1997). Social cognition, in turn, refers to the mental processes that subserve perception and the processing of social cues and, according to an evolutionary approach, some prosocial mechanisms (e.g. cooperative and altruistic behaviour) as well as coercion, deception and manipulation of other parties. Thus social cognition can be particularized from general cognitive skills as a specialized domain accountable for higher cognitive function underlying fluent social interactions: attending, understanding, processing interpersonal cues, and executive function, which are necessary for adequate social functioning (Penn, Corrigan, Bentall, Racenstein, & Newman, 1997). A recently presented definition of social cognition, the most relevant to the current work present in this thesis is: "Social cognition explains the mechanisms of social behaviour using concepts and methods shared with related fields of cognitive psychology and cognitive science (…)" (Winkielman & Schooler, 2008, p. 49). The particular advantage of the cognitive approach to social behaviour is bridging the gap between mental processes (e.g., thinking, remembering, decision making) and social cognitive neuroscience (which investigates brain function) (Oshsber & Lieberman, 2001). Social cognitive neuroscience in turn tries to identify the psychological and neural bases of socio-emotional experience and behaviour (Ochsner, 2004). Although this new interdisciplinary field is currently in the spotlight, the traditional behavioural research area should not be underestimated or neglected, as it has established a primary conceptual framework for the growing empirical literature in newly emerging domains. Therefore, the author of the present dissertation decided to explore the classical methodologies of social psychological research in order to ascertain the missing parts of the foundational framework of human social attention perception to the benefit of future research, which will be conducted using modern, recently established methods.

Much remains to be understood regarding, for example, how the visual percept of another human affects our cognitive functioning, attentional processes and decision-making. Despite the fact that social information is not only derived

from visual input but also from other senses (e.g., auditory, tactile, olfactory; Newport, & Howarth, 2009; Soto-Faraco, Sinnett, & Alsius, 2005; Ryan, Young, Moy, & Crawley, 2008), the scope of the current thesis is on visual social cues signalled by observed humans and processed by human observers. Yet, many aspects of social functioning and social cognition remain poorly understood including discerning the relationships between different social cues, the dependence of social cue perception on environmental factors, and issues regarding the frame of reference in which processing of social cues operates. Finally, the exact mechanisms underlying the processing of the direction of attention from information extracted from multiple directional social cues remain to be revealed. An interesting extension to this problem is how particular arrangements between social cues affect the estimation of the direction of attention and, as a consequence, the interpretation of the intentions and goals of the action of an observed person. Existing theoretical models on social cue processing, such as Theory of Mind (Baron-Cohen, 1994), Direction of Attention Detector (Perrett, Hietanen, Oram, & Benson, 1992), the congruency model (Langton, 2000) or the reversed congruency model (Hietanen, 1999, 2002) are often equivocal and, when compared, often inconsistent with each other (see Section 1.2 "Models of the perception of social attention in humans"). Few existing studies have tried to address this issue. To this point, multidisciplinary perspectives and multi-factor accounts (claiming a variety of factors that influence the social skills) have provided a relatively small contribution to our understanding of reading the direction of social attention. As a result, there remains a gap in knowledge with respect to our ability to explain and predict how information about the direction of attention is extracted and computed from social, visual cues. In other words, the gap exists on how different models of the reading of social attention should be integrated and interpreted together. This gap could be filled using the same tools as were used by authors of existing models in order to find the common ground between them, that is, classical, behavioural research. Current neurological findings are doubtlessly spectacular and remarkably informative (Ochsner, 2004), nevertheless these findings require the continuation of progress in behavioural science. Thus, future advances in social cognition research depend upon the ceaseless progress in the behavioural approach and the active endeavour to consequently integrate contemporary

outcomes of social cognitive research with cognitive neuroscience theory and methodology.

1.1.1 Understanding human social cognition: social attention reading

Determining the exact direction of another's attention is an essential ability for all primates. Eye-gaze provides salient information about the allocation of attention as well as information for more complex social cognition, such as visual perspective taking and Theory of Mind (Whiten, 1996; 1997a, b). An outstanding feature of human social experience is its intuitiveness (Gallese et al., 2004). The automatic nature of the processing of social cues may have evolved in order to facilitate the direct understanding of others' actions and intentions (e.g., cooperative or hostile; Dunbar & Shultz, 2007). Such expressive social, directional cues as human body posture, head orientation and gaze direction can provide a ''window into the other's mind'' (Baron-Cohen, 1995a; Perrett et al., 1992; Perrett & Emery, 1994).

Human beings are instinctively concerned with where and towards what other people are directing their attention. They use the visual information from the eyes, head and other parts of the body to infer where an observed person's attention is focused (Emery, 2000). According to Birmingham and Kingstone (2009), humans' natural interest in where other people are attending is well described by the term *social attention*. Social attention-shifting skill begin to mature in humans already from the age of 3–4 months onwards (e.g., Butcher, Kalverboer, & Geuze, 2000; Farroni, Johnson, Brockbank & Simion, 2000; Johnson, Posner & Rothbart, 1994), when an infant is able to follow the direction of another person's gaze (for a review, see Johnson et al. 2005). However, there is also some evidence that even newborns reveal a preference for human over non-human stimuli (e.g., face), which bespeaks an early foundation of social development (Brazelton, Koslowski, & Main, 1974; DeCasper & Fifer, 1980; Pascalis, de Schonen, Morton, Deruelle, & Fabre-Grenent; 1995). Between 6 and 12 months of age the process of establishing joint attention emerges, which is a key contributing factor to social interaction (Mundy, Block, Delgado, Pomares, Van Hecke, & Parlade 2007). From around the age of 10 months infants begin to spontaneously follow the gaze of adults (Butterworth & Cochran, 1980;

Butterworth & Grover, 1990; Butterworth & Jarrett, 1991; Corkum & Moore, 1995; Deák, Flom, & Pick, 2000; D'Entremont, 2000; Morissette, Ricard, & Decarie, 1995; Scaife & Bruner, 1975), and from 12 months onwards they are able to draw another person's attention to themselves by a deictic gesture (referred to as protodeclarative/informative pointing, or referential communication; Baron-Cohen, 1995a; Emery, 2000; Liszkowski, Carpenter, Henning, Striano, & Tomasello, 2004; Liszkowski, Carpenter, Striano, & Tomasello, 2006).

This inclination in humans to automatically process the attentional states of others determined the origin of research in social attention. Preverbal infants share many primary competences of social cognition with apes and monkeys, such as recognizing conspecifics (i.e., other individuals of the same species), observing others' actions, selectively attending to faces, bodies and actions, understanding basic mental states such as goals and perceptions engaging in contingent interactions, etc. (e.g., Saxe, Carey, & Kanwisher, 2004). However, the ability to follow the gaze of another party has been demonstrated most successfully in human infants (Emery, 2000).

Because of the involuntary nature of the interpretation of social cues by humans, which occurs also at the fast, even perceptual level, deliberate reasoning is not always involved in this process (Gallese et al., 2004; Jellema et al. 2009). However, the development of reasoning, which occurs later in the life span, allows human adults to perform higher-level social cognition, as inferring the intentions, wishful thinking or mood of an observed party (Saxe, 2006) in order to understand other individuals' minds at the conceptual, declarative level (Gallese et al., 2004), and to predict and react adaptively to others' actions. This process has been referred to as *the decoding stream-of-consciousness* (Saxe, 2006), which allows us to comprehend the mental representations of the world of other people and to identify the differences between those and the reality. This uniquely human component of social cognition is presented as the *Theory of Mind* (Baron-Cohen, 1994, 1995a; see Section 1.1.2 and 1.2.1). Even infants from the age of 3- to 6-months can attribute goals to observed actions and are even sensitive to the situational constrains (for review, see Gergely, 2010). Yet, as mentioned before, unconscious inferences may also significantly influence our conscious social judgments (Bargh, 2006; Lieberman, Gaunt, Gilbert, & Trope, 2002; Satpute &

Lieberman, 2006; for a review, see Bargh, 2007) and that makes human social cognition peculiar and very complex.

Another distinctive feature of human social cognition is the ability to use intricate visual signals, such as a direct gaze (that is the capability of precise interpretation of a mutual gaze), as a social cue, which can have multiple possible meanings. Whereas many species react on a gaze contact with an aversive response, human primates are capable of associating this cue with a large selection of other social signs and communicating behaviours and through that successfully interpret its meaning and synchronize their own interactive behaviour with another party (Kleinke, 1986; Patterson, 1982; Senju & Johnson, 2009).

A further feature, which exemplifies the superiority of human social cognition over other primates, is the ability to understand dyadic relations (i.e., an observer understanding the intention of an observed person in relation to himself, i.e., the observer; Flombaum, & Santos, 2005; Tomasello, Carpenter, Call, Behne, & Moll, 2005; Saxe et al., 2004) and the ability to comprehend triadic relations (i.e., an observer understanding the interaction between two observed other individuals). Tomasello and colleagues (2005) argue that the inclination for forming triadic relations is an essential and exceptional component of human social cognition (see also Baron-Cohen, 1994), which involve species-unique attention monitoring and visual checking-back behaviours (Gergely, 2010). They additionally claim that what differentiates human beings from nonhuman primates, is the capacity for *shared intentionality* (Beauchamp & Anderson, 2010). Sharing intentionality allows an understanding of others' goals and intentions, then combine them with one's own intentions and actions and, finally, coordinate reciprocal interaction based on that action. Sharing intention involves sharing a goal and to coordinate a reciprocal action plan, thus it allows humans to engage in collaborative actions (Tomasello et al., 2005).

All these phenomena, which will be discussed in more detail in the following sections, illustrate that humans, as social species, use a sophisticated social system that relies on complex information inferred from visual behaviour and meaningful visual signals (Emery, 2000; Gallese et al., 2004).

This section is aimed at showing that what distinguishes the human social attention system from that of other species is the complexity of associations between social signals, which allow for the integration of information on a higher

cognitive level. Even though we intuitively consider eye-gaze as a special social attentional cue (which indeed can indicate where someone is looking with a reasonable degree of reliability), neurological and behavioural studies have found that humans not only respond to gaze direction but also to the orientation of head, trunk, limbs and the whole body posture of another person (Emery, 2000). The role of body information has been largely neglected in the recent stream of research on the computation of social attention. This gap will be addressed in the current dissertation and one of the aims of this thesis is in assessing the significance of body information on social attention computation as a social cue. We will investigate, whether body information is automatically processed and combined with visual information from other cues. In particular, the interaction between body posture on social attention processing and other social cues such as eye-gaze, head direction will also be investigated. By investigating this issue, we might open the door to a new sub-field of research on human social cognition, which would turn the focus on the importance of contextual information, (e.g., the performed action of an observed person, performed interaction with other parties, background information about the context of the social scene, etc.) which can vary the perception of social attention.

1.1.2 The Mindreading system

The main question that social psychologists ask themselves is how exactly perceivers make sense of the behaviour of others (Mitchell, 2009). Recent research goes beyond the traditional question, which concerns an attribution of an individual's behaviour to internal or external factors and concentrates deeper on the actual basis and origin of these attributions. Thus, the questions are: how do we represent the minds of others and how do we use available social information to make inferences about another's mental state?

This ability to attribute mental states, such as beliefs, desires and intentions to other individuals, has been referred to in the literature as an ability of *mentalizing* or *Theory of Mind* (Baron-Cohen, 1995a). Within the *Theory of Mind* three components have been identified, which are of relative importance to the empirical investigation presented here: the ability to attribute intentions, the ability to recognize objects to which attention is shared, and the ability to monitor

another's direction of gaze. In order to have a theory of mind, we must acknowledge that behaviour of other people is driven by their goals and intentions. Besides, we need to understand that other people are agents who have a different perspective on the world from our own. To comprehend the motives of their behaviour we need to recognize the state of the world from their own perspective, which is different from ours. However, how do we put that into practice? How do we analyze, compute and surmise the perspective of the other person?

Baron-Cohen (1994, 1995a) was the first to indicate a direct link between the calculation of the direction towards where the person is attending, and reading intentions of others. In his model of the Theory of Mind Mechanism (ToM) he pointed out the perceptual mechanism of an eye-direction detector (EED) not only detects the presence of eyes and computes their direction, but also attributes a mental state to a viewed particular target, towards which the eyes of an agent are directed. According to the *Theory of Mind Mechanism* model, which will be described in more detail in Section 1.2.1, on the basis of calculating gaze direction a shared attention process can be achieved. This process is based on recognition by two parties, the self and another, that they are attending to the same thing, which in turn is the prerequisite of reading the mind of others.

Baron-Cohen was the first to stress the enormous significance of decoding the direction of attention of an agent in order to infer his/her beliefs, goals, intentions and future actions (Baron-Cohen, 1994, 1995a). He noted as well, that this process occurs just via the initial perception of gaze direction. That means that our expectations of what another person is going to do are derived, in a large part, from the visual information especially information conveyed by the face. The primary aim of the research presented in this thesis is to isolate and analyze the impact of (other) visual social signals, (which are informative of the direction of social attention of an observed agent) on social cognition and Theory of Mind.

1.1.3. Behavioural investigations of the perception of social cues of attention

In many cases, eye-gaze provides a particularly efficient and powerful cue for inferring another person's focus of attention (e.g., Baron-Cohen, 1995a; Gibson & Pick, 1963; Langton, Watt, Bruce, 2000; for recent reviews, see

Becchio, Bertone, & Castiello, 2009; Frischen, Bayliss, & Tipper, 2007). That is due to the special morphology of eyes, which is characterized by the relative position of the irises within the visible part of the sclera. Additionally, the human eye is characterized by much higher contrast between dark-iris and white-sclera than all nonhuman primate eyes (Kobayashi & Koshima, 1997). This peculiar morphology promotes the fast and automatic discrimination of gaze direction (e.g., Ando, 2002; Anstis, Mayhew, & Morley, 1969; Baron-Cohen, 1994; Langton et al., 2000; Emery, 2000; Riciardelli, Betta, Pruner, & Turatto, 2009). Zorzi and colleagues showed in a study based on an adapted Simon task (Stimulus-Response Compatibility paradigm; see Lu & Proctor, 1995; Simon & Craft, 1970) that gaze direction generates automatically a directional, spatial code (Zorzi, Mapelli, Rusconi, & Umiltà, 2003; Ansorge, 2003a). In their study participants were presented with simple, schematic outlines of eyes and were asked to respond to the colour of the irises by pressing one of two laterally positioned response keys. Although the eye-gaze stimulus was task-irrelevant (and the stimuli were not lateralised as in the regular Simon paradigm) the gaze direction facilitated responses to the colour of the eyes at the corresponding hemifield. Thus, task-irrelevant directional gaze information automatically generated a directional spatial code, which in turn affected the behavioural response of the observers (Lu & Proctor, 1995; Zorzi & Umiltà, 1995). Because of the fact that humans readily use eye gaze information to compute another person's direction of attention (Birmingham & Kingstone, 2009), they instinctively orient their attention in response to someone else's gaze direction. Eye gaze information is considered to be essential in triggering attention shifts in the observer, because they naturally attract the observer's attention even if they are irrelevant to the task (Birmingham, Bischof, & Kingstone, 2009; Downing, Dodds, & Bray, 2004) and, when the gaze is laterally oriented, it triggers reflexive shifts of the viewer's visuospatial attention (Bayliss & Tipper, 2006a, 2006b; Driver, Davis, Ricciardelli, Kidd, Maxwell, & Baron-Cohen, 1999; Friesen & Kingstone, 1998).

1.1.3.1. Gaze cueing of attention

Evidence for automatic shifting of attention in the direction of where another person is looking has been derived from both naturalistic gaze following and lab-based attention-cueing studies (e.g., Driver et al., 1999; Friesen & Kingstone, 1998; Kuhn & Land, 2006; Kuhn & Tatler, 2005; Kuhn, Tatler, Findlay, & Cole, 2008). The first lab-based experimental studies that investigated the cognitive mechanisms underlying attention shifts in response to observed eye-gaze direction used a modified model task popularized by Posner (1980; Posner's cueing paradigm, see Figure 1.1) and used it to investigate whether people are preferentially biased to attend to where someone else is looking.

Friesen and Kingstone (1998) conducted one of the first studies that investigated the eye-gaze cueing phenomenon. They explored whether gaze direction can affect the allocation of attention in a similar way to cues previously used in the attentional literature (e.g., peripheral luminance or central arrows) and if they produce orienting responses in observers. They used an adapted version of the previously mentioned Posner paradigm, with spatially nonpredictive central gaze cues, and reported evidence for reflexive attentional shifts in the direction of the eye-gaze. This automaticity strongly suggests that gaze direction is very likely to be transformed into a spatial code, which subsequently produces a shift in the allocation of attention (Zorzi et al., 2003). In their study, participants were presented with a centrally positioned schematic face with pupils oriented to the left, right, or straight ahead, which were not predictive of the location or the identity of the target. Participants were required to respond to a target that appeared to either the left or the right of a presented face with varying stimulus onset asynchronies (SOA). Three sorts of tasks were conducted: the detection of the target's appearance, indicating the target's location or categorizing the target's identity by pressing appropriate response keys. The authors found that reaction times were facilitated on valid-cue trials (when the target appeared in the gazed-at location) relative to neutral (when the face gazed ahead, and the target appeared randomly on either side) and invalid-cue trials (when the target occurred in the opposite location). In two response conditions the cueing effect emerged at the shortest SOA (i.e., of 105 ms) and it appeared in all conditions at an SOA of 300 ms. At the longest SOA of 1,005 ms the cueing effect disappeared. This effect of attention shifting by an observer towards the gazed-at location as a response to

eyes averted to the left or right has been labeled as exogenous and reflexive (i.e., automatic) cueing (Bayliss & Tipper, 2006a, 2006b; Driver et al., 1999; Friesen & Kingstone, 1998; Fox, 2005).

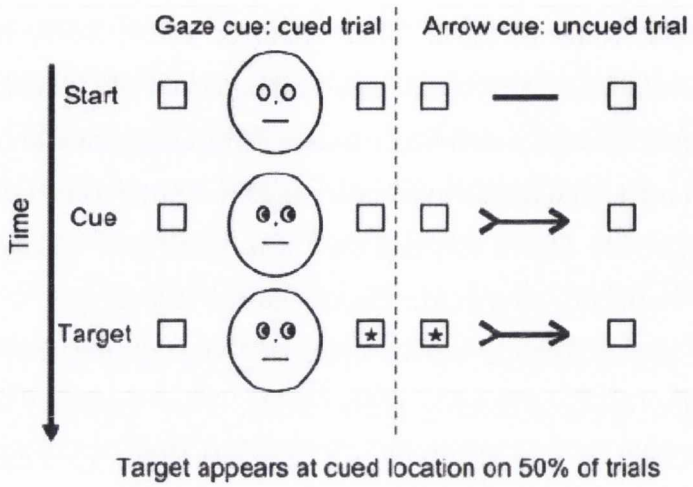


Figure 1.1. A schematic illustration of the gaze cueing paradigm (left), used in Friesen and Kingstone's (1998) study, and the arrow cueing paradigm (right). In the new paradigm, instead of the symbolic arrow used in previous studies of attention orienting (Posner, 1980; Posner, Snyder, & Davidson, 1980), the gaze direction of the face stimuli served as a central cue (Adapted from Birmingham & Kingstone, 2009, p. 126).

In a similar study, Driver et al. (1999) presented centrally located photographs of a real face with eyes looking to the right or to the left. The gaze of the central face was spatially nonpredictive of target location or identity. The task was to discriminate a target letter that could appear on the left or right side of the face after different SOAs of either 100, 300, or 700 ms. Driver et al. reported a similar pattern of results as Friesen and Kingstone (1998): RTs were significantly faster on valid compared to invalid trials at both the 300 and 700 ms SOAs. Additionally, the results of Experiment 3 of their study showed that attentional orienting via gaze direction was executed not only in a covert and reflexive way, but it was also involuntary (i.e., resistant to intentional inhibition). Even though the central gaze cue was counter-predictive as the target was four times as likely to appear at the uncued side and participants were explicitly instructed to attend to the side opposite to that of the gaze direction, participants simply could not inhibit the automatic orientation triggered by the gaze direction at short cue-target

intervals. Facilitation was still obtained for the cued location at the 300-ms SOA and only at longer intervals of 700 ms were participants able to voluntarily redirect their attention to the target side.

On the basis of these results, which showed that (1) a nonpredictive averted gaze triggers shifts of visual attention and (2) the attentional shift was not accompanied by any RT delay at the uncued location, (3) the shift appears rapidly and (4) is short-lived, the authors of these pioneering studies concluded that gaze information (even in a simple, schematic face) can be compared to other attentional cues (e.g., peripheral stimulus onset) capable of eliciting reflexive shifts of attention (for hallmarks of reflexive shifts of covert attention, see Cheal & Lyon, 1991; Jonides, 1981; Müller & Rabbitt, 1989a). These studies highlight the effectiveness of the human behavioural response to the signal of eye-gaze direction as well as the powerful effect that gaze direction can have on attentional orienting.

1.1.3.2. Interaction between gaze and head orientation in estimating gaze direction.

As people are very sensitive to the presence of eye information as well as to gaze direction (Birmingham, Bischof, & Kingstone, 2008a, 2008b), people are also highly accurate in detecting whether someone else's gaze is directed at them or not (see Section 1.2.1.1 "Mutual Gaze"). However, the judgments of precise looking-at direction tend to err when the observed head is not oriented directly towards the observer but is averted to a certain degree to the left or right (Anstis et al., 1969; Cline, 1967; Gibson & Pick, 1963). Eye gaze direction rarely coincides with the direction of the head, trunk or other parts of the body, as we are usually in constant movement, thus an interesting issue is whether perceived social attention is also affected by cues other than gaze. Several studies have already shown that the perceived direction of gaze is influenced by the observed person's head orientation (e.g., Anstis et al., 1969; Cline, 1967; Gibson & Pick, 1963; Langton, Honeyman, & Tessler, 2004; Maruyama & Endo, 1983; Maruyama, Endo, & Sakurai, 1985; Seyama & Nagayama, 2005; for an overview of these and related studies, see Klutz, Mayes, West, & Kerby, 2009; Ricciardelli & Driver, 2008; Todorowić, 2006). For example, Gibson and Pick (1963) simultaneously

manipulated head and gaze orientation of an agent and required observers to assess whether the agent was looking at them or not. When the agent's head was oriented 30 degrees to the observer's right, observers responded that they were being looked at, when the agent was actually looking askance approximately 3 degrees to the right of the observer. Cline (1967) observed similar effects by asking participants to indicate of the exact location of the agent's eye-gaze focus. When the observed person's head was deviated 30° to the side, the perceived gaze location was systematically biased in the opposite direction of the head orientation.

Overshoot effect

The effect revealed by Gibson and Pick (1963) and Cline (1967; also see Anstis et al., 1969) was later termed the *head-turn* or *overshoot* effect (Langton et al., 2004). It is characterized by a systematic error in perceived gaze orientation induced by the angle between the direction of eye-gaze and the orientation of the head in the opposite direction of the head orientation.

In a Posner attentional cueing paradigm (Posner, 1980), Hietanen (1999) observed that reflexive orienting of attention in the direction of gaze was induced only when the head was oriented incongruently to the eyes. A central, non-predictive, averted gaze cue with a congruently oriented head facing the same direction did not facilitate responses to targets appearing at the gazed at location, however an averted gaze with a frontal facing head did. Furthermore, a laterally oriented head with a frontal gaze, which shouldn't produce the gaze cueing effect (because gaze is directed towards the viewer), also facilitated observers' reaction times when the head was oriented to the opposite side of the target stimulus. The latter finding bares a strong resemblance to the overshoot effect described above, i.e., attentional cueing effects were observed in a direction opposite to the direction of the orientation of the head.

Towing effect

In an apparent contradiction to the *overshoot* result, some studies have reported the opposite effect on the perceived direction of gaze and its relationship to the head orientation, called in the literature a *towing* effect (Langton et al., 2004; Maryuama & Endo, 1983; Maryuama et al., 1985). In this case, the

perceived direction of gaze is usually estimated to be in between the true line of regard and the head orientation. For example, Langton et al. (2004) asked participants to judge whether eye gaze of the presented face stimuli was direct or averted. The stimuli consisted of combinations of frontal and laterally oriented faces (16°) with eyes either directed towards or averted 16° to the left or right of the observer. With a frontal head orientation and a direct gaze, participants judged the gaze direction as being directed towards them in 93% of the trials, whereas they judged the same in only 22% of trials when the head was averted, even though the gaze was still oriented directly towards the participant. When head and gaze direction were both oriented to the left or right of the observer, on average participants correctly judged the gaze direction as being averted in 89% of the trials, whereas this was only 45% with head and gaze oriented in opposite directions. While the errors in perceived gaze direction in the direct gaze condition with sideways head orientation can be explained both in terms of *overshooting* in the opposite direction of the orientation of the head and a *towing* of the gaze towards the orientation of the head, the errors in the condition with head and gaze oriented in opposite directions are only compatible with the *towing* account (i.e., a bias in the perceived direction of gaze towards the orientation of the head resulting in a direct perception of gaze 55% of the time).

The outcome of Langton's (2000) earlier study, based on an adapted Stroop task (Stroop, 1935), also argued in favour of the *towing* account. Participants' RTs were faster at judging the direction of the person's eyes or head, when the orientations of the eyes and the head coincided, than when they were oriented incongruently (for a more detailed description, see Chapter 2). Seyama and Nagayama (2005) asked their participants the same question in the same type of task, using a more complex inter-cue manipulation however (i.e., they crossed the factors of gaze direction, head and torso orientation). The Langton's eye-head congruency effect was replicated, but the effect, which occurred between the torso and gaze, was in the opposite direction. The reaction times were faster to the incongruent arrangements, which again suggested a reversed congruency effect (see *overshoot effect*).

1.1.3.3. Interaction between head and body orientation in estimating gaze direction.

Whilst cues from the eye and head direction, which obviously provide essential information for determining where another person is attending, have been studied in the literature quite extensively (for a review, see Frischen et al., 2007), the role of body information (i.e., the direction of the torso, arms, and legs) on the perception of social attention has been not thoroughly explored. It is known however, that human bodies are processed by a specialized processing mechanism, (e.g., Reed, Stone, Bozova, & Tanaka, 2003; Reed, Stone, Grubb, McGoldrick, 2006; Yovel, Pelc, & Lubetzky, 2010). A brain region in the occipital-temporal cortex shows special sensitivity to human bodies and body parts (Peelen & Downing, 2007). Yet, few studies have focused on the issue whether human bodies are processed holistically or not. It has been found that body parts are better recognized when presented in the context of the whole body image than when displayed in isolation (Reed et al., 2006; Seitz, 2002). Yovel et al. (2010) provided evidence that discrimination of body postures is dependent on head presence and head position, which might imply that the head has a special status in the processing of the human body image. Hietanen (2002) investigated the relationship between head and body direction on the reflexive orienting of the viewer's attention. This study, together with his experiment on the relationship between eye-gaze and head direction (Hietanen, 1999), provided support for the idea that a large variety of cues are involved in deriving the information about the other person's direction of attention according to an allocentric reference frame. Thus, Hietanen claimed, that only after coding and combining the directional information from social cues (as gaze, head and body posture), the final directional information about attention direction is related to the observer according to the egocentric frame of reference (Hietanen, 2002). By using the spatially nonpredictive cues of a person's head and upper part of the torso in a Posner paradigm, he obtained a facilitation effect when a cue contained a torso that was oriented incongruently to the head but no effect when the cue consisted of a head and upper-trunk which were directed identically. Based on this effect, he proposed a model, in which social attention orienting uses a hierarchy of social attention cues (Hietanen, 1999, 2002). According to this model, eye-gaze direction is inferred relative to head orientation, and head orientation in turn is

inferred relative to body orientation. If the derived relationships between these cues suggest that the other person has a laterally averted attention direction, a spatially defined directional code is then activated which may trigger an automatic shift of the observer's own attention in that direction.

1.1.4. Are social directional cues special?

Section 1.1.3.1 described the most prominent evidence for reflexive cueing of attention by a central gaze, on which basis an eye stimulus can be compared to other, non-social attentional cues. Many researchers tried afterwards to determine whether the effects of gaze cueing have any special, unique characteristics and whether they are distinctive from the effects of cueing by other central, symbolic cues such as arrows. An arrow sign has a similar directional property as eye gaze, but it has no biological significance. Some researchers within the domain of the perception of social attention stated that a gaze cue has a special status as an attentional cue (Emery 2000; Langton et al., 2000). Indeed, with closer scrutiny (for instance, while examining a specific patient group) subtle but profound features distinguish attention cueing by gaze from cueing by other cues such as arrows (Akiyama et al., 2006). For example, neurotypical participants have more difficulties with suppressing cue-target conflicts for a counter-predictive social cue (e.g., gaze direction) than for cue of no social relevance (e.g., arrows; see Friesen, Ristic, & Kingstone, 2004). On the other hand, patients suffering from autism, who reveal a lack of reciprocal visual interaction (e.g., via gaze directions), demonstrate the opposite tendency: A better ability in overcoming counter-predictive gaze than for counter-predictive non-social directional cues (Senju, Tojo, Dairoku, & Hasegawa, 2004). Furthermore, split-brain patients who show a hemispheric dissociation for the gaze direction effect (Kingstone, Friesen, & Gazzaniga, 2000), show no such dissociative effect between hemispheres for the arrow orientation effect (Ristic, Friesen, & Kingstone, 2002). These findings suggest that the neural substrates for processing gaze and other symbolic cues might be different.

Despite those subtle differences, once normal participants are exposed to non-social, directional cues, such as arrows, their attention is also shifted involuntarily to the direction of the cue (an *arrow effect*) and participants achieve

faster RTs to targets at the congruent side of the arrow and slower to incongruently positioned targets (Eimer, 1997; Ristic et al., 2002; Tipples, 2002). Moreover, cueing effects similar to the *gaze effect* have been shown using a whole range of biological and nonbiological cues that convey directional information (Birmingham & Kingstone, 2009). Hommel, Pratt, Colzato, and Godijn (2001) reported reflexive orienting triggered by centrally presented nonpredictive arrows as well as to nonpredictive directional words (e.g., "left," and "right"), demonstrating a strong link between the representations of overlearnt symbols and reflexive shifting of visual attention. Finally, even a central face with its tongue aiming towards the left or right can trigger similar attention shifts (Downing et al., 2004, Experiment 1). Birmingham and Kingstone (2009) argued that every cue, which possesses a directional component, which can potentially be spatially compatible or not compatible with the target location, may produce automatic orienting of attention. Any behavioural differences found between cues may in turn be attributed to the differences in the cues' ability to convey directional information (e.g., left versus right).

In sum, the results discussed above are rather equivocal with regard to the uniqueness of the cueing effect by gaze. Gibson and Kingstone (2006) admit that the stimulus of eyes is indeed special, however that doesn't necessarily concern their cueing capabilities. They share similar abilities in terms of conveying directional information as it is reflected in the cueing paradigm. Birmingham and Kingstone (2009) claim that despite occasionally emerging differences between gaze and arrow cueing, not enough key distinguishable features have been captured across studies so far to call eye stimuli *special*, and significantly *different* from other stimuli, such as arrows. Kuhn and Kingstone (2009) recently suggested that even though social and non-social cues (e.g., arrows) may be equally relevant when seen in isolation, differences between them may only become apparent when they are embedded within a richer environment. The implication from that point is that researchers of social stimuli may benefit by considering alternative, but already existing methodologies for studying the cognitive processing of eye-gaze stimuli and other social cues.

1.2. Models of the perception of social attention in humans

In this section recent models of the computation of the direction of social attention will be reviewed. The review will be followed by a discussion of the existing inconsistencies between the presented models and possible hypotheses resolving equivocal findings presented so far in the literature.

1.2.1. Theory of Mind (ToM)

Baron-Cohen (1995a) claimed that "the eyes are windows to the mind in the further sense that by observing the direction of someone's eyes we can identify the target of that person's desire" (p. 106). The eyes are also the best window to connect with somebody else's mind while engaging in joint attention (see also Section 1.2.1.3). Baron-Cohen proposed a model of making mental state attributions to other agents, the so-called Theory of Mind, in which he puts an explicit emphasis on the function of the detection of eye direction (1994). In fact, eye gaze is considered to be of such great importance to social perception that many prominent models of social attention have placed it at the primary position within all other possible social cues (Baron-Cohen, 1995a; Perrett et al., 1992). Human eye-gaze direction provides a wealth of varied social information including even very subtle signals to other individuals (e.g., for reviews, see Birmingham & Kingstone, 2009; Emery, 2000). These signals allow for the decoding of one's interpersonal behaviour by communicating emotion and focus of interest in their internal (emotional and intentional) and external (other individuals, objects, events, etc.) environments (Emery, 2000; Senju & Johnson, 2009). In that way, gaze can modulate social interaction by communicating social dominance (Dovidio & Ellyson 1982; Ellsworth 1975) or social appeasement, or by facilitating conversation turn taking (Argyle & Cook, 1976; Exline, 1971; Exline, Ellyson & Long, 1975; Kendon, 1967; Kleinke, 1986; Lochman & Allen, 1981). The modular system proposed by Baron-Cohen (1994) consists of four cognitive components[2]: the eye-direction detector (EED), the intentionality detector (ID), the shared-attention mechanism (SAM), and the theory-of-mind mechanism (ToM). The first module (EED) serves the processing the basic social

[2] These components shared many properties of Fodorian modules (see Modular Theory of Cognition, Fodor, 1983).

information, such as joint attention (see Section 1.2.1.3) and gaze following behaviour (see Section 1.2.1.2), which in turn is combined with information from the intention module (ID) via the shared attention mechanism (SAM[3]; see Section 1.2.1.4) into an understanding of higher mental states. In this way the link is created between objects and people who are looking at them, recognizing the mental state of the person, as *seeing, wanting, knowing, believing, imagining*, and *deceiving, thereby* deducing another person's intention to act upon the observed objects (Langton et al., 2000; Emery, 2000). Thus, in this model, gaze conveys the necessary, basic social information for higher levels of social information processing (i.e., the modules: SAM and ToM), which results in understanding higher mental states. The final module in the mindreading system (ToM), infers the mental state knowledge to explain and predict another person's behaviour. We are therefore able to decode intentions and future actions of another person by sharing the same perception of the situation or object. In fact, Baron-Cohen was the first to indicate a direct link between the processes of calculating the direction of attention and inferring the mental states. He was also the first to stress the importance of visual information extracted from social cues for reading the intentions and predicting the actions of others. Therefore, perceiving the direction of another person's gaze is a precursor of the Theory of Mind (ToM) and it is a crucial factor in the human ability to attribute mental states to other people (Baron-Cohen, 1995a).

1.2.1.1. Mutual Gaze

Baron-Cohen specified particular stages of eye direction processing and classified them according to particular functions of gaze information in our behaviour. Thus, on the basis of the ability to use information on gaze direction, he distinguished states of *mutual gaze, gaze following, joint attention* and *shared attention* (Emery, 2000; Baron-Chen, 1994). Mutual gaze occurs when the attention of individuals A and B is directed towards one another (Emery, 2000). It

[3] Shared attention is the process through which the self and another recognize that they are attending to the same target. According to Baron-Cohen (1995a, 1995b) SAM uses information provided by Eye Direction Detection (about the object observed by another individual) and compares this with the current perceptual image of oneself. The state of shared visual attention is reached, when the two perceptual states match.

can be considered as a similar concept to *eye contact* (Bailenson, Blascovich, Beall, & Loomis, 2001; Bard et al., 2005; Leeb & Rejskind, 2004; McAndrew & Warner, 1986), which occurs "when two people look each other in the area of the eyes simultaneously". The effect of eye contact has been defined by Senju and Johnson (2009) as "the phenomenon that perceived eye contact modulates the concurrent and/or immediately following cognitive processing and/or behavioural response" (p. 127).

Many studies have reported that the processing of direct and averted gaze in humans is dissociated, which establishes a high efficiency in the detection of mutual gaze (Conty, Tijus, Hugueville, Coelho, & George, 2006; Senju, Hasegawa, & Tojo, 2005; Von Grünau & Anston, 1995). The efficient decoding of gaze contact is important for well-adapted social interactions since, for example, the intention of the observer directed to another person is usually first communicated by the gaze directed straight at this person (Conty et al., 2006). Knowing, that one is being observed by another party (e.g., a potential enemy or friend) is of enormous social relevance. Direct gaze conveys various important social signals from regulating interaction, exercising social control, expressing dominance or intimacy to facilitating task goals (George & Conty, 2008, Kleinke, 1986; Vuilleumier, George, Lister, Armony & Driver, 2005).

Neurological and physiological studies

Direct gaze affects perception, cognition and arousal in normal adults (Senju & Johnson, 2009). Neurological and physiological studies showed that mutual eye-gaze directly activates the brain arousal system (Gale, Kingley, Brookes, & Smith, 1978; Gale, Spratt, Chapman, & Smallbone, 1975; Hietanen, Leppanen, Peltola, Linna-aho, & Ruuhiala, 2008; Nichols & Champness, 1971), elicits a strong emotional response[4] (George, Driver, & Dolan, 2001; Kawashima et al., 1999). Direct gaze which evokes mutual gaze perception triggers stronger activation in the STS area of the observer's brain compared to an averted gaze (Calder et al. 2002; George et al., 2001; Hoffman & Haxby, 2000; Pelphrey et al.,

[4] Kawashima et al.'s showed in his PET study the selective activation in the amygdala triggered by a mutual gaze when compared to averted gaze. This activation was apparently associated with greater activity in visual areas (revealed in neuroimaging studies) when the same stimuli were perceived (e.g., George, Driver, & Dolan, 2001; Wicker et al., 1998; Wicker, Perrett, Baron-Cohen, & Decety, 2003).

2003; Pelphrey, Viola, & McCarthy, 2004; Puce et al., 1998; Wicker, Michel, Henaff, & Decety, 1998). A few studies have also indicated autonomic[5] responses as indicators of increased arousal in response to direct gaze (when compared to averted gaze), which were an increased heart rate (Coutts & Schneider, 1975) and elevated skin conductance responses (Nichols & Champness, 1971; see review by Kleinke, 1986). The raised arousal or emotional levels triggered by a direct gaze plays a modulatory role with respect to subsequent perceptual and cognitive processing (Senju & Johnson, 2009). However, to fully understand the behavioural consequences of mutual gaze perception, further investigation research is needed (Vuilleumier et al., 2005).

Behavioural consequences of perceiving a mutual gaze

Conty and colleagues suggested that while perceiving the direction of eyes, direct gaze might be detected earlier than averted gaze (Conty et al., 2006). Perceiving gaze contact (i.e., direct gaze) can capture our visuospatial attention, which can result in increased attentional time on the gazer's face and delayed disengagement of attention (when somebody looks directly at a perceiver). This effect has been attributed to deeper face processing during the eye contact (Hood, Mqcrqe, Cole-Davies, & Dias, 2003; Vuilleumier et al., 2005). The allocation of attention on the face would imply that visual processing outside the facial area can be inhibited via direct gaze, which is in turn reflected in the delayed orienting of attention towards peripheral cues (Senju & Hasegawa, 2005).

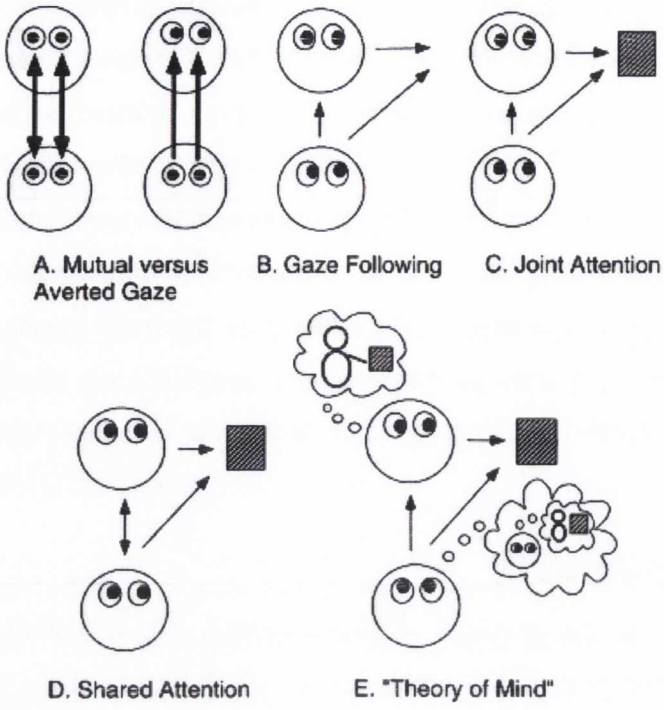
Results from other behavioural studies also suggested that mutual gaze might be a qualitatively special signal (Cline, 1967), by examining the accuracy of judgments of gaze direction (Anstis et al., 1969; Gale & Monk, 2000; Symons, Lee, Cedrone, & Nishimura, 2004). The errors in angle estimation were exceptionally small when the eye-stimuli were oriented directly at the observer, thus people are particularly efficient at detecting when another person is looking directly at them (Cline 1967; Gibson & Pick, 1963; Lord & Haith, 1974). More recent research has revealed a high visual acuity also for judging deviated gaze, which is thought to be around 30 sec of arc (Symons et al., 2004). However, with increasing distance between the agent and the observer, participants were more

[5] Autonomic responses, as indicators of arousal in response to gaze direction, were assessed in only a few studies (for review, see Kleinke, 1986).

biased to judging that the looker was gazing directly at them when in fact he or she was not (Gamer & Hecht, 2007; Vine, 1971). Martin and Jones (1982) used signal detection theory to examine eye-gaze direction discriminability and potential biases in the participant's criterion. They also found a decline in discriminability with increasing distance between the agent and the observer. Moreover, they also suggested, that when observers were in doubt, e.g., when the direction of gaze was ambiguous or when gaze information was reduced, they tended to perceive a mutual gaze (Martin & Jones, 1982; see also Ellgring, 1970; Gamer & Hecht, 2007; Lord & Haith, 1974; Martin & Rovira, 1981, 1982; Vine, 1971).

1.2.1.2. Gaze Following

As mentioned in the previous section, primates are exceptionally skilled in discriminating whether they are observed or whether another individual's gaze is averted away from them (Emery, 2000). In humans, determining the precise direction of another person's allocation of attention is possible due to the special morphology of the eyes, which allows the differentiation between the sclera and the iris. According to Emery's (2000) definition: "Gaze following is where individual A detects that B's gaze is not directed towards them, and follows the line of sight of B onto a point in space" (p. 590), and can be reached by simple discrimination of the pattern composed of the dark and bright eye elements the dark part at the left/right side of the eye will indicate looking left/right, while the dark part in the centre of the eye will signify eye contact. Observational learning would be impossible without gaze following. For example, when an individual A's attention is directed to the object X and this individual A produces an emotional reaction, his/her emotional state can therefore be associated with the object X (Mineka, Davidson, Cook, & Keir, 1984). According to Emery (2000) observational learning requires both information about another's direction of attention and the joint attentional state between the individual A and the conspecific B, who is directing attention onto object X (see Figure 1.2).



A. Mutual gaze is where the attention of individuals A and B is directed to one another. Averted gaze is where individual A is looking at B, but the focus of B's attention is elsewhere.

B. Gaze following is where individual A detects that B's gaze is not directed towards him/her, and follows the line of sight of B onto a point in space.

C. Joint Attention is the same as Gaze Following except that there is a focus of attention (such as an object), so individuals A and B are looking at the same object.

D. Shared Attention is a combination of Mutual Attention and Joint Attention, where the focus of individual A and B's attention is on the object of joint focus and each other (i.e. "I know you're looking at X, and you know that I'm looking at X").

E. Mental state attribution or Theory of Mind, probably uses a combination of the previous A-D attentional processes, and higher-order cognitive strategies (including experience and empathy) to determine that an individual is attending to a particular stimulus because they intend to do something with the object, or believe something about the object.

Figure 1.2. Schematic visual representation of mutual gaze, gaze following, joint attention, shared attention and Theory of Mind mechanisms (Adapted from: Emery, 2000, p. 590).

How does gaze following emerge?

Different levels of sophistication can be distinguished within gaze following processes (Triesch et al., 2006). Some researchers claim that some elementary skills of gaze following are present already in newborns (Farroni, Massaccesi, Pividori, & Johnson, 2004). It has been noted that for such basic visual tracking mechanisms, motion cueing of a centrally located stimulus may initially be necessary, however already at the age of 9 months, a static head pose alone can be sufficient for an infant to follow the gaze (Moore et al., 1997). Three major stages of gaze following development have been proposed (Butterworth & Jarrett, 1991; Deàk et al., 2000), which emerge around 6, 12 and 18 months respectively: at first infants learn how not to be distracted by irrelevant visual objects in order to keep their attention on the observed target, secondly they learn how to follow somebody else's gaze to a location outside of their visual field, and finally they are able to follow gaze direction just on the basis of an adult's eye movements (Butterworth & Jarrett, 1991). It has also been suggested that because of the limitations of face processing skills in young children, infants rely more on the caregiver's head pose than their eyes (Caron et al., 2002). This important line of research, which concerns the specific features that are being used to establish the agent's direction of gaze, has continued intensively within recent years and is also continued in the presented work. It has been suggested that young infants may learn to follow gaze only on the basis of visual signs, without conceptualizing the caregiver's looking behaviour in terms of social understanding (Corkum & Moore, 1995; Moore & Corkum, 1994). Other research has showed that indeed early gaze following skills probably do not require any representation of the strategy or intentions of the observer towards the observed object (Leekam et al., 1998; Woodward, 2003). This would suggest that the mechanism of gaze following might be best investigated as a concept decoupled from the Theory of Mind and based only on the visual perception of directional, social cues (the primary signals of social attention direction, from which social attentional skills are learned). That is why it is of great importance to understand the mechanisms of perceiving the direction of the focus of attention from human visual cues and decoding that direction from a combination of directional signals. This issue plays a central role in the current dissertation and its empirical work.

1.2.1.3. Joint Attention

Joint attention is most commonly understood as the process of sharing one's experience of observing an object or event, by following gaze or other deictic gestures. This feature of social cognition provides information about the focus of attention, interest, and intentions of a person, with whom the agent interacts (Hari & Kujala, 2009). The following is a definition provided by Emery (2000, p. 588):

> "(Joint attention) requires that two individuals… are attending the same object… based on one individual using the attention cues of the second individual. (…) Joint attention is the same as gaze following except that there is a focus of attention (such as an object), so individuals A and B are looking at the same object."

This ability to follow gaze in a certain direction can be observed in infants as young as 12 months of age, however at this age the state of joint attention with another agent is not reached yet (Butterworth, 1991). Yet, at the age of 18 months, infants can direct their attention to a specific object, even if the object is outside of the field of view. Joint attention is of crucial importance even at the early stage of language development, for example while making the first associations between notions and the physical objects in the environment. This stage of language learning is almost impossible to achieve without the ability to follow gaze or deictic gestures to specific targets (Dunham, Dunham & Curwin, 1993; Mundy & Gomes, 1998; Tomasello & Farrar, 1986).

1.2.1.4. Shared Attention

In spite of the fact that in the literature the terms *shared attention* and *joint attention* are sometimes used interchangeably (referring to the situation, when one's focus of attention matches that of another person), these processes differ from each other in a subtle way (Emery, Lorincz, Perrett, Oram, & Baker, 1997; Perrett & Emery, 1994). Joint attention of two individuals means that they are attending to the same object, with one of them using the directional, attentional cue(s) of the other. Yet, shared attention is a more complex form of communication as it assumes that both individuals attend to the same object, and each person is conscious that the other person is focusing at the same target at which he/she is looking ("I know you're looking at X, and you know that I'm

looking at X", Emery, 2000, p. 590; see also Tomasello, 1995). Thus, the term *shared attention* denotes a set of social skills comprising the decoding deictic gestures, gaze following, and consciously establishing a joint attentional state (Triesch et al., 2006). Gaze following and joint attention (defined as looking where somebody else is looking) can therefore be considered as precursors (or precedents) to the emergence of shared attention. This issue will be investigated in more detail in the last empirical study of the current dissertation (see Chapter 7).

Importantly, to reach this state of joint attention in the presence of multiple possible targets of attentional focus, the observer may make use of a variety of attentional cues made available by the observed person, such as the relative position of the irises within the visible part of the sclera, head and body orientation, pointing gestures, etc. Despite significant advances in the fields of social perception, cognition, and neuroscience, much remains to be understood regarding the weight given to different social directional cues and how different combinations of these cues interact and affect the computation of the direction of social attention and the establishment of joint attention (Symons et al., 2004). As it was presented in the Figure 1.2, to determine an individual's mental state one probably uses a combination of all distinguishable attentional processes: mutual gaze, gaze following, joint attention and shared attention, as well as higher-order cognitive strategies (as e.g., experience and empathy) to attribute intentions of the agent towards the observed target (Emery, 2000). In the present work the author focused specifically on the role of the visual information of the agent's trunk, limbs and head in determining the focus of attention direction, which in turn can lead to decoding of intentional aspects of the observed person.

1.2.2. Direction of Attention Detector (DAD)

Perrett and Emery (1994), in response to Baron-Cohen's Mindreading system, proposed a different schema of processing visual social cues and calculation of the direction of attention. They introduced the Direction of Attention Detector system (DAD), which could analyze all potential attention cues (e.g., eyes, head, body) in order to combine the information from multiple social signals for the precise determination of where another individual is focusing his or her attention. Baron-Cohen's model, by accentuating the main role

of gaze information, did not foresee the importance of other social cues in the computation of the direction of human attention (Wieser, Pauli, Alpers, & Muhlberger, 2009). Although the eyes are the primary source of information about the focus of another individual's attention, information about the direction of attention is not limited to gaze. Perrett and colleagues (Perrett & Emery, 1994; Perrett et al., 1992) have suggested that an eye direction detector constitutes only a part of a system designed to compute the direction of social attention. Their single-cell studies revealed that individual cells in the STS region of the temporal lobe of macaques are responsive to conjunctions of eye, head and body orientation. Thus, the activation of some cells, which are sensitive to gaze directed downwards increases when the head is also directed downwards or when the body implements a quadrupedal posture. Based on these findings, which show neural responses not only to gaze, but also to other directional cues, Perrett and colleagues proposed the existence of a direction-of-attention detector (DAD), which combines information from separate detectors which analyze the orientation of the eyes, head and body (Perrett & Emery, 1994; Perrett et al., 1992). These detectors were thought to be organized in a network based on inhibitory connections, thus if the eyes are visible, information from them can directly inhibit input to the STS from cells coding an inconsistent head direction and the direction of attention would be coded the same as the orientation of the gaze. Similarly, information specifying a particular head angle can inhibit cells coding an incongruent body position. Interestingly, this *overwriting of information* procedure works only in one direction and not vice versa (Langton et al., 2000). However, in cases where gaze information is unavailable (for instance because of occlusion or poor lighting conditions), head information becomes the most important source of information. Similarly, the computation of attention direction will be based on body information when neither gaze nor head information are available (Emery, 2000) (see Figure 1.3).

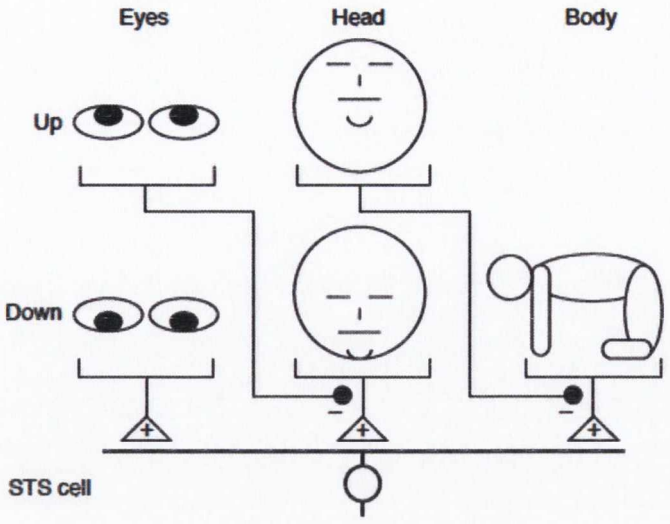


Figure 1.3 An illustration of the direction-of-attention detector as proposed by Perrett et al. (1992) on the basis of their single-cell studies on macaques. Perrett and colleagues suggested that the organization and the functions of cells responsive to social cues in the temporal cortex of the human brain might work in a similar manner. This schema represents how the connections and visual input to an STS cell signal that another individual's attention is directed downwards. The cell receives excitatory connections (triangles) from cells selective to the appearance of eyes, head and body, which are directed downwards. When gaze is directed upwards, inhibitory connections (filled circles) prevent any response to the downward directed head and body cues (Adapted from Perrett, Hietanen, Oram, & Benson, 1992).

The proposed system allows computation of the direction of social attention under a variety of viewing conditions as well as under a variety of orientational angles of the cues themselves. If at certain head orientations the direction of gaze is not clear enough, the system, by default, signals the direction of attention from the orientation of the head. If, in turn, the orientation of the head is not visible at certain body postures, then the directional information will be provided by the orientation of the body cue.

1.2.3 Positive congruency model of social cues integration

Contrary to the Perrett et al.'s proposal (1992), several studies have provided evidence that information from the eyes does not completely suppress directional information from the head (e.g., Langton, 2000; Lorincz, Baker, &

Perrett, 1999). For example, Lorincz et al. (1999) found that monkeys tended to follow head orientation rather than gaze while observing head and gaze cues which were positioned in conflicting directions. Langton (2000) presented human participants with similar stimuli, which consisted of head and gaze cues in potential conflict, in a Stroop-like interference paradigm. Participants were required either to ignore the orientation of the head while judging the direction of gaze, or vice-versa. He observed facilitated judgments (faster reaction times) when the head and gaze were oriented to the same side of space (i.e., congruent conditions) than in the condition where both cues were orientated in opposite directions (i.e., incongruent) for both tasks. Thus, Langton and colleagues rejected the possibility of the existence a blocking/inhibition mechanism. On the basis of positive congruency effects, they proposed the existence of a model in which different social cues (e.g., gaze direction, head orientation and also bodily gestures or posture) are processed independently and in parallel, and results in additive effects (Langton, 2000; Langton et al., 2000). Thus gaze information may possibly attenuate the signal from the detector of head orientation. This would serve as evidence that in the case of conflicting information from different directional, social cues (e.g., between gaze direction and head orientation), information from the cue which is positioned lower in the hierarchy (e.g., head relative to gaze), still contributes to the computation of the direction of attention and also has an effect at a subsequent response selection stage.

1.2.4 Reverse congruency model of social cues integration

In contrast to the findings of Langton (2000), some behavioural studies have provided evidence for an opposite effect, namely a *reverse congruency effect* (e.g., Ricciardelli & Driver, 2008; Seyama & Nagayama, 2005). In fact, early studies on gaze perception showed that eye-gaze orientation is perceived as more extreme when the head is oriented to the opposite side to the direction of the gaze than when the gaze and head are oriented towards the same direction (i.e., the overshoot effect; e.g., Anstis et al., 1969). In a more recent task of explicit gaze direction discrimination, Seyama and Nagayama (2005) observed that the judgment of the eye-gaze direction of an observed person was performed faster when the person's trunk was oriented incongruently than when both eye-gaze and

trunk were aligned. However, this reverse congruency within the eyes/body relationship did not apply to the relationship between eyes and head orientation: the direction of eye-gaze was judged faster when the head was oriented to the same direction than when the both cues were oriented incongruently. Seyama and Nagayama (2005) suggested that a reverse congruency effect may occur only within a particular relationship between cues (i.e., the relationship between eye-gaze and trunk). In a Stroop task involving the judgment of gaze direction Ricciardelli and Driver (2008) manipulated the eye-head relationship. They observed positive congruency effects when participants were put under time pressure, however, reverse congruency effects were found without time pressure (we will return to this finding later in this chapter).

Hietanen (1999), adopting a Posner (1980) attentional cueing paradigm with central eye-head cues, observed reflexive orienting of the viewer's attention in the direction signalled by an averted gaze when the head of the observed person was facing the viewer, and not when its head was oriented in the same direction as the averted gaze. Analogical effects were observed within the head-body relationship (Hietanen, 2002). Furthermore, when an observed person's eyes were oriented towards the viewer and the head was averted, attentional cueing was found in the opposite direction of the averted head (an observation which shows similarities with the overshoot effect described earlier). On the basis of these results, Hietanen suggested that reflexive shifts of attention in the direction signalled by a directional social cue (e.g., eye-gaze, or head) are only triggered when information about the relationship between this cue and other available cues is combined and signal an averted attention direction in the observed person's own frame of reference. According to this suggestion, in the orienting of social attention, different cues are first used to derive whether the observed person has their attention diverted within their own, egocentric frame of reference (i.e., by referencing gaze orientation to the head orientation or/and the head orientation to body orientation). Only if such analysis implies that the other person has a laterally averted attention, the observer's attention will be shifted in the same direction.

1.2.5 Inconsistencies between models

Thus, the literature described so far indicates two types of congruency effects: positive, in which facilitation occurs when the eye and head are turned towards the same side (see e.g., Langton, 2000; Langton & Bruce, 2000; Seyama & Nagayama, 2005), and the opposite pattern of reverse congruency effects in which turning the head in one direction produces either a shift in the perceived direction of gaze towards the opposite direction, or a performance decrement such that responses are slower to congruent than incongruent conditions (e.g., Ricciardelli & Driver, 2008). An unanswered question in the literature is where exactly this discrepancy between findings of positive congruency effects versus an opposite pattern of reverse congruency effects come from? This issue is addressed in the experimental studies conducted as part of this dissertation.

A possible resolution to such apparent inconsistencies may be based on the time constraints given to participants in binary orientation judgment tasks (Ricciardelli & Driver, 2008). For example, Ricciardelli and Driver (2008) suggested that different origins of the positive congruency effect or the reversed congruency effect might be dependent on the time pressure imposed on the observer. As mentioned earlier, Ricciardelli and Driver (2008) observed a positive congruency effect between eye-head orientations when they imposed time limitations on the task (e.g., by requiring a speeded judgment of gaze direction), however, when response time was unconstrained, a reverse eye-head congruency effect was revealed (i.e., facilitation in the incongruent condition). They claimed that more time is necessary for the reverse congruency effect to appear, because the visual processing of the complex arrangement between social cues requires more complicated processing. Furthermore, Ricciardelli and Driver (2008) suggested that visual processing of the detailed geometry of the eye stimulus, as well as perceptual integration of eye-gaze, face and head cues involves more temporally extended cognitive processing. It has been suggested that longer processing time fosters the integral combination of the orientation of the cues' and encoding the motion implied in the articulated human poses (Freyd, 1983; Jellema & Perrett, 2003a, 2003b; Lorteije et al., 2007; Seyama & Nagayama, 2005). With more speeded decisions (i.e., with shorter RTs, thus shorter processing time) global head and gaze features may be processed only in parallel, as information from both cues is not yet integrated. Also, the angles of the head and the whole

face might be weighted more heavily under time pressure, which can result in more easy and rapid judgments of gaze and head directions than when they are oriented towards the same side. This would suggest that a positive congruency effect, according to Langton's model, occurs at the beginning of the encoding process and the reverse congruency effect appears at the later stage of processing, when information from different cues are already combined. These findings agree with observations from previous studies, where in relatively unspeeded tasks evidence for reversed congruency effects have been revealed (e.g., Anstis et al., 1969; Ricciardelli & Driver, 2008), whereas the most convincing verification of positive congruency comes from speeded tasks (as in the Stroop-like paradigm of Langton, 2000). This issue will be investigated further in Chapter 2.

1.3. Conclusions

Human beings can interpret an abundance of social visual cues in an exceptionally effortless way. Regardless of such high efficiency in reading social signals, much remains to be understood regarding the complex processes underlying human social skills (Jellema et al., 2009). Human capabilities of social cue interpretation are very important in order to exist in the social environment, to belong to local societies, and to be able to cooperate with other individuals and to exchange information. Understanding the intentions of others allows us to act appropriately to ongoing events, engage in a reciprocal action or avoid colliding or conflictive behaviours in others (Adolphs, 1999). It benefits our survival and is relevant to adaptation. An increasing amount of research over the last few decades which has been dedicated to these distinct human social abilities as well as to their neural substrates, has revealed that our *social brain* (Brothers et al., 1990) is not only responsive to the more obvious social signals (e.g., gaze direction) but also to the orientation of head, trunk, limbs and the whole range of complex body postures (Emery, 2000). As has been pointed out earlier, the role of body information has largely been neglected in the stream of research concerning the computation of social attention. Therefore, the empirical work of the present dissertation intends to raise this issue. Our endeavour to explore whether in our routine social experience information from a spatially oriented body is automatically processed and integrated with directional information from other

social cues will be based on four steps. Each step will focus on a different behavioural methodology. First, using a well-established Stroop interference paradigm, we will attempt to answer the question whether directional body information influences an explicit discrimination of the direction in which another person is looking. Next, adopting a Simon paradigm, we will explore whether the orientation of an observed person's body as well as the relationship between body and head orientation, activates a specific, spatially defined code. If that is the case, we will consequently investigate whether such a code is related to the orienting of visuospatial attention, thus whether body orientation triggers (voluntary and/or automatic) shifts of attention and whether it influences cueing effects triggered by other social cues. To this end, we will adopt a classic Posner attentional cueing methodology. In a final step, we will attempt to answer the question whether directional body information influences processes involved in the precise localization of where another person is looking. To examine this issue, we introduced a new *localization methodology*, by which the process of establishing a state of *joint attention* can be assessed. Finally, we intend to critically assess existing models of social cue integration and the computation of social attention direction against the empirical results obtained with the different behavioural methodologies in this dissertation. Furthermore, we will propose an overarching theoretical framework on the processing and integration of directional information from multiple social cues for the computation of social attention direction.

CHAPTER 2

THE ROLE OF INTEGRATED INFORMATION OF HEAD AND BODY ORIENTATION IN THE ANALYSIS OF SOCIAL ATTENTION DIRECTION IN THE ADAPTED STROOP TASK

Authorship

Results from the following chapter were presented at the Annual Meeting of the Belgian Association for Psychological Science (BAPS) 2009:

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Abstract

In three experiments we investigated whether head and body orientation interact in the processing of another individual's direction of their social attention. A Stroop-type interference paradigm was adopted, in which directional head and body cues were placed into conflict. Participants judged the looking direction of images of computer-generated human figures by making speeded key press responses. Although the direction of the body was irrelevant to the task, it nevertheless influenced the time it took to judge the direction of attention. These results, first of all, demonstrate that gaze and head direction judgments are not solely driven by the face region but can also be affected by information about body orientation (i.e., trunk, arms, and legs) (Hietanen, 2002; Seyama & Nagayama, 2005). Second, when judgements of the orientation direction of head were relatively easy, a positive effect between congruently oriented head and body cues was obtained (Experiment 1), but this effect was reversed when task difficulty was increased (Experiment 2 and 3). The results of the present study provide evidence for a two-stage process in the computation of the direction in which another person is attending, in which directional head and body cues are first processed independently and in parallel, followed by a process of referential coding of the orientation of the head relative to the body. We argue that the latter process is related to the processing of implied motion and requires additional processing time.

2.1 Introduction

The ability to determine the direction of another individual's attention as quickly and accurately as possible is of behavioural, cognitive and communicative value (Baron-Cohen, 1995a; Emery, 2000; Langton, 2000; Langton, Watt, & Bruce, 2000; Seyama & Nagayama, 2005). The direction of gaze of humans and other species can serve as a deictic signal in intended or unintended communication (Argyle & Cook, 1976; Gale & Monk, 2000; Kendon, 1967), signalling a change of another's focus of interest, thus indicating a significant event in the environment (Emery, 2000; Langton, 2000). Hence, it can facilitate the orienting of attention to the corresponding location, the detection of the event (e.g., Driver, Davis, Ricciardelli, Kidd, Maxwell, & Baron-Cohen, 1999; Friesen

& Kingstone, 1998; Hietanen, 1999; Langton & Bruce, 1999), as well as the appropriate response (Emery, 2000; Langton, 2000; Langton et al., 2000). Therefore, the ability to compute the direction of where another person is attending, is one of the most important prerequisites for establishing joint attention[6] and understanding the mental states and intentions of observed persons (Baron-Cohen, 1995b; Emery, 2000). It allows one to predict the future actions of others and to react/anticipate adaptively (e.g., Driver et al., 1999; Emery, 2000; Gallese, Keysers, & Rizzolatti, 2004; Langton & Bruce, 1999; Manera, Schouten, Becchio, Bara, & Verfaillie, 2010; Verfaillie & Daems, 2002).

An issue that has become a subject of extensive research in recent years is how the direction of attention of an observed person is derived from multiple social cues. Intuitively, the most crucial cue in the assessment of where another person is attending are the eyes, as the relative position of the irises within the visible part of the sclera is informative of the direction of that person's gaze (e.g., Ando, 2002; Anstis, Mayhew, & Morley, 1969; Baron-Cohen, 1994; Emery, 2000; Langton, Watt & Bruce, 2000; Riciardelli, Betta, Pruner, & Turatto, 2009). It has been shown that eye-gaze direction of an observed person acts as a reflexive cue to the viewer's locus of attention (e.g., Driver et al., 1999; Bayliss & Tipper, 2006; Friesen & Kingstone, 1998; Langton & Bruce, 1999). For example, using an adapted Posner paradigm (e.g., Driver et al., 1999), it has been found that the direction of the observed person's eyes facilitates the detection of a target when it appears at the same side of visual space (i.e., in a congruent location relative to the observed person's gaze).

Although humans are extremely sensitive to the direction of eye gaze of an observed person (e.g., Anstis et al., 1969; Cline, 1967; Vecera & Johnson, 1995), these judgments tend to be error prone (Anstis et al., 1969; Todorović, 2006), especially when the agent's head is not oriented directly (i.e., frontally) towards the observer (Gibson & Pick, 1963). Furthermore, the visual stimulus signalling the direction of the eye gaze is small in terms of angular size (Loomis, Kelly, Pusch, Bailenson, & Beall, 2008). For example, at a distance of 7.5 m or more,

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[6] Following the definition provided by Emery (2000), joint attention "requires that two individuals… are attending the same object… based on one individual using the attention cues of the second individual" (Emery, 2000, p. 588).

the informative value of eye gaze on the locus of their attention is rather poor (Hall, 1966). At such a distance the unique morphology of the gaze is barely discriminable as the eyes occupy a very small portion of the face (Bi, Su, Chen, & Fang, 2009). In circumstances where eye gaze information is poor or even absent, e.g., when observed from a non-optimal view perspective, a large distance, under strong lighting from above, or in a shadow (Perrett, Hietanen, Oram, & Benson, 1992), multiple cues to the direction of social attention are advantageous. As Seyama and Nagayama (2005) pointed out, while paying attention to a particular location or an object we are prone to orient our head and torso towards that direction. In other words, information about another person's direction of attention is not limited to the eyes as it can also be derived from other visual cues such as head orientation, pointing gestures and body posture (Emery, 2000; Hietanen, 2002; Langton, 2000; Langton & Bruce, 1999; Langton, O'Malley, & Bruce, 1996; Nuku & Bekkering, 2008; Seyama & Nagayama, 2005). For example, Doherty and Anderson (2001) showed that eye visibility is not a necessary condition for the computation of the direction of social attention; even when the observed person's eyes are covered with black circles, the locus of their attention can be inferred from head direction (see also Emery, 2000).

Apparently the locus of another person's attention can be derived not only from head position but also from body information, i.e., the position of the trunk, arms and legs (Emery, 2000; Jellema, Baker, Wicker, & Perrett, 2000; Jellema & Perrett, 2002; Perrett & Emery, 1994; Perrett et al., 1992). Langton and colleagues (Langton, 2000; Langton, Honeyman, & Tessler, 2004; Langton et al., 2000) reported evidence that the mechanisms responsible for the computation of gaze direction and those involved in processing information from head and body interact with each other. According to Langton et al. (2000), this interaction must occur at the relatively early stages of information processing, as the perceived direction of gaze is fast and automatic. Neurophysiological studies confirmed that to reach a state of joint attention in the presence of multiple objects in the environment, the observer makes use of a variety of attentional cues provided by the observed person, such as the relative position of the eyes relative to the head, head direction, and body orientation (Perrett et al., 1992). For example, the work of Perrett and colleagues indicated that individual cells in the STS regions of the macaque brain respond to the conjunctions of eye, head, and body orientation,

thus various social cues in their manifold views (varied in vertical and horizontal planes) are combined with each other while being analyzed by STS cells. However, these cells show a hierarchical preference by responding primarily to the direction signalled by gaze, secondarily to the direction signalled by the head and in the end by the body orientation. For example, they respond preferentially to eyes directed downwards when the head is also directed downwards as well as a posture of the body. However, the head cue has primacy and can inhibit the cellular response to the sight of the head when it is oriented incongruently (respectively the head cue can inhibit the cell response to an incongruent body posture, when only head and body are visible). However, Langton (2000) questioned whether these neurophysiological observations of single units correlate with the observable behaviour. Furthermore, it is not clear whether this hierarchical processing, as proposed by Perrett and colleagues, exists in humans (Nummenmaa & Calder, 2009) as for example Langton and Bruce (1999) showed that judgments of head and gaze direction are prone to interference effects from incongruent gaze-head pairings in a Stroop paradigm (i.e., interference effects of incongruent head direction in gaze direction judgment tasks, and vice versa, interference effects of incongruent gaze directions in head direction judgment tasks).

Several behavioural studies on the perceived direction of gaze have demonstrated contradicting results with regard to interference effects between different social cues. Initial work examining the perceived line of sight of an observed person showed that the computation of gaze direction is biased by the orientation of the observed person's head. In other words, an *overshoot effect* was observed in that the perceived direction of gaze tended to err towards the direction opposite to that of the head (e.g., Cline, 1967; Gibson & Pick, 1963). For example, in a *mutual gaze judgment task,* Gibson and Pick (1963) observed that the perceived direction of a person's gaze when their head was oriented 30° to the left or right in comparison to gaze directed at the observer, was mistakenly assessed as being 2.9° in the direction opposite to that of the head orientation. Cline (1967, Experiment 2) observed similar effects in a study that required participants to indicate where the observed person was looking. When the observed person's head was oriented 30° (e.g., to the right), the perceived locus of the gaze was systematically biased in opposite direction to that of the head (e.g.,

to the left). Anstis et al. (1969) confirmed this effect with models displayed on a TV screen; when the gaze and the head were oriented in opposite direction, the perceived direction of the gaze was more exaggerated than in the situation where the gaze and the head were oriented in the same direction.

However, in an apparent contradiction to the overshoot effect, some studies have reported a *towing effect* of the head on the perceived direction of gaze (Langton et al., 2004; Maryuama & Endo, 1983; Maryuama, Endo, & Sakurai, 1985). For example, Maruyama and Endo (1983) showed that the perceived line of gaze was *towed* towards the orientation of the head, resulting in a perceived direction of gaze which was in between the true line of regard and the orientation of the head (also see Langton et al., 2004).

A similar discrepancy between the effects of multiple directional social cues as the one sketched above, can be found in the results of studies using either a Stroop-type interference paradigm (to assess the speed of explicit gaze direction judgments) or studies using an adapted Posner paradigm (to assess the speed and automaticity of attention shifts based on social cues). For example, Langton (2000) asked participants to make an explicit speeded judgment of the direction of one cue (gaze or head) and manipulated the directional information of the other cue (head or gaze respectively). Faster reaction times were observed when the eyes and the head were oriented in the same direction, than when they were oriented in opposite directions. Based on this symmetrical interference pattern (i.e., on judged directions of both gaze and head) for incongruent gaze-head pairings, Langton proposed a *positive congruency model*, according to which the direction of attention is signalled most efficiently when eye-gaze, head and body cues are oriented in the same direction. Yet, in contrast, two studies reported by Hietanen (1999, 2002), in which an adapted Posner paradigm was applied to assess the speed of attention shifts based on social cues, target detection was facilitated when either the direction of the eye gaze and head (Hietanen, 1999), or head and trunk (Hietanen, 2002) were incongruent. Hietanen speculated that this *reverse congruency effect* (which bares a resemblance with the *overshoot effect* mentioned earlier) and the apparent contradictory *positive congruency effect* reported by Langton (2000) using a Stroop task might be related to different processes being involved in both tasks, namely processes which are involved in the voluntary discrimination of eye direction (Stroop task) resulting in positive

congruency effects, and those involved in the involuntary orienting of attention (Posner task) resulting in reverse congruency effects. However, Seyama and Nagayama (2005) observed a reverse congruency effect using a voluntary discrimination task of eye direction, in a similar Stroop-type task as Langton (2000), thus questioning the explanation based on differences between voluntary and involuntary processing. Furthermore, Seyama and Nagayama (2005) obtained a reverse congruency effect between gaze and trunk information and a positive congruency effect between gaze and head information. The authors tentatively suggested that different effects of congruency (positive or reversed) might thus reflect differences in the relationships between the cues, e.g., a positive congruency effect for the gaze-head relationship and a reverse congruency effect for the gaze-trunk relationship, yet further research into this issue is required.

Ricciardelli and Driver (2008), on the other hand, suggested that the origin of the contradictory findings, i.e., a positive congruency effects (reflecting a *towing* account) and reversed congruency effects (representing the *overshooting* account), may be explained in terms of the time pressure imposed on the viewer. In a Stroop task they found congruency effects for the eye-head relationship while imposing time pressure on participants, however with no time constrains, a reverse eye-head congruency effect was obtained. To explain these results, Ricciardelli and Driver argued that more time is necessary for the reverse congruency effect to appear because the complex arrangement between social cues requires some temporally extended visual processing. According to them, with more speeded decisions (with shorter RTs, thus shorter processing time) global head and gaze features may be processed only in parallel, and information from both cues cannot be integrated yet. This would suggest that the positive congruency model proposed by Langton (2000) would only apply to the start of the encoding process, followed by a reverse congruency effect at a later stage of processing, when information from different cues are already combined.

Whereas the eye-head relationship has been the focus of a large body of studies, only limited attention has been given to the head-body relationship in behavioural research. In particular, it is still uncertain how the direction of the torso, arms, and legs influence the voluntary discrimination of head orientation when inferring the direction of social attention in an observed person.

Present Study

The aim of the present study was to further examine the idea that task-irrelevant information derived from the orientation of the body is routinely processed and, along with gaze and head information, contributes to the computation of the perceived direction of attention of another person. Specifically, we wished to investigate the influence of the relationship between head and body orientation on decoding the direction of social attention. In order to explore whether head orientation and body orientation interact in the computation of the direction of social attention, we placed both social cues into conflict within a Stroop-type interference paradigm (Stroop, 1935; for a review, see MacLeod, 1991) in which participants made an explicit speeded judgment regarding the direction in which the observed person was looking.

A Stroop-type interference task is a useful tool for determining whether the stimuli under investigation are likely to come from interacting dimensions or not (Melara & Marks, 1990b). From an analytical point of view, the Stroop effect is the performance difference between congruent and incongruent stimulus combinations (for reviews, see Chajut, Schupak, & Algom, 2009; Langton, 2000). The presence of a Stroop effect based on relative orientations of the head and body would demonstrate (1) that task-irrelevant body information is being processed while assessing the direction of attention and that it influences the judgment of the head orientation, from which the direction of attention is inferred, and (2) that this breakdown in perceiving the direction of attention from head information arises through an integration of information from those two channels (head and body orientations) during information processing (e.g., Melara & Marks, 1990a, 1990b). A positive congruency effect would support the model suggested by Langton (2000), whereas a reverse congruency effect would confirm the model proposed by Hietanen (2002). The absence of a Stroop effect, on the other hand, would indicate that selectively attending to the orientation of the head might inhibit the encoding of information from the rest of the body, and that the head (which is a cue placed higher in the cue hierarchy) constitutes a sufficient source of information from which the perceived direction of attention can be derived (Perrett et al., 1992).

Furthermore, following up on Ricciardelli and Driver's (2008) suggestion that a possible factor determining positive or reverse congruency effects is the

processing time, we varied the difficulty of the task in three experiments by reducing the angle at which the head was oriented from 30 degrees to 5 degrees (the idea being that more processing time is required for more difficult direction judgments).

2.2 Experiment 1

In Experiment 1, we investigated the interplay between the orientation of the head and body on judging the direction where another person is looking. Participants were presented with images of computer-generated human figures whose heads were oriented to the left or right, and were asked to make a speeded keypress response based on the orientation of the head. The relative orientation of the character's body (i.e., trunk, arms, and legs), which was task-irrelevant, was manipulated as either congruent with the orientation of head (same direction), incongruent (opposite direction), or neutral (frontal view). Eye-gaze direction was always identical to the orientation of the head (i.e., pupils were centred within the eyes) and the head was oriented 30° away from a frontal view, making the task relatively easy. We predicted, following Ricciardelli and Driver (2008), that direction judgments of the head oriented by 30° would be relatively easy and thus require limited processing time, favouring parallel processing, thus resulting in a positive congruency effect as observed by Langton (2000) based on a similar Stroop paradigm. In addition, to control for possible effects of the eyes, the visibility of the eyes was manipulated by either having them visible or occluded by non-transparent sunglasses. We presumed that occluding the eyes with sunglasses and concealing to where the agent's eyes were directed could hamper direction judgments since eye gaze is the most informative directional cue. On the other hand, equivalent performance in judging head directions across conditions when eye information is available or not would suggest that the visibility of eyes is not essential in signalling the direction of another person's attention in the present task.

2.2.1. Method

Participants

Twelve undergraduate students of HUBrussel (Hogeschool-Universiteit Brussel), 9 males and 3 females (age 19 to 25) volunteered to participate in the experiment. All reported normal or corrected-to-normal vision and were naïve as to the purpose of the experiment. In this and the following experiments, informed consent was obtained from each participant prior to the experiment. Instructions were always provided in Dutch, the mother tongue of the participants.

Apparatus and stimuli

Stimuli were displayed on a 19-inch CRT colour monitor at a refresh rate of 75 Hz, driven by a Dell XPS 420 PC using E-prime software (version 2.0). Participants sat in a darkened room, with their head stabilized on a chin-rest positioned 80 cm from the screen. Responses were collected with a serial response box, model 200A (Psychology Software Tools), which was placed in front of the participant, aligned with the horizontal midpoint of the screen and the participant's body. Stimuli were presented on a white background. The images of the computer-generated human characters subtended a visual angle of 12° in height with a head size of approximately 0.9° x 0.7°, and were presented in the centre of the screen. A fixation cross subtended a visual angle of 0.5° x 0.5° and was centred on the screen where the head of the human figure subsequently appeared.

The images of the human figures were generated by 'Poser' computer graphics software (version 7.0, E-Frontier Inc.). Four models, two male and two female, were used and each wore different clothing. The models were presented in a relaxed and symmetrical standing pose. For each model twelve images were created, by combining two head orientations (30° left, and 30° right), three body orientations (30° left, a frontal view, and 30° right), and the eyes were either visible or occluded by dark non-transparent sunglasses (see Figure 2.1). As such, the stimulus set included 48 images (12 depictions of 4 computer-generated human characters). These stimuli were illuminated by three *infinite* lights (a frontal light and two lights positioned 30° left and right of the human figure, each

shining 45° down into the face of the viewer), which created smooth shading on the models. Images were rendered in colour without external shadows.

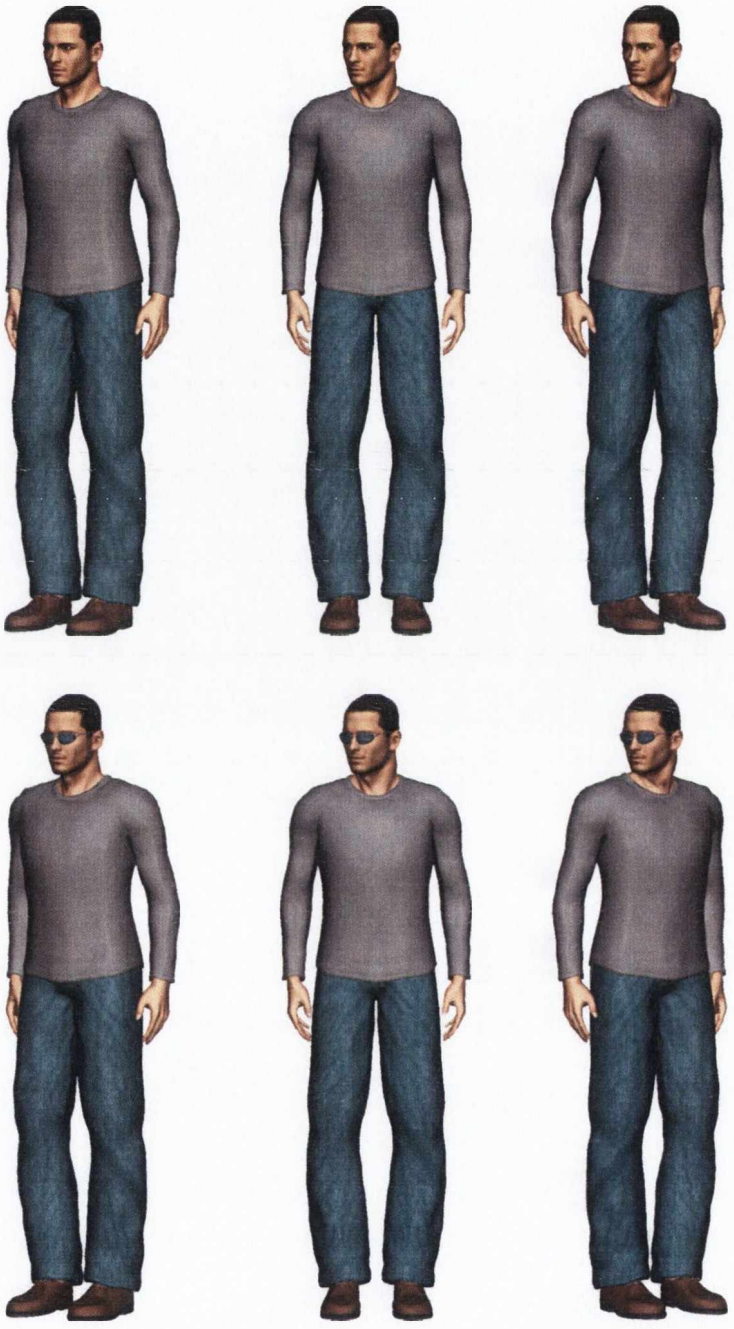


Figure 2.1. Examples of a human character stimuli used in Experiment 1. Computer-generated human figures are illustrated with (in left to right columns) congruent, neutral, and incongruent body orientation (relative to the left oriented head). In rows the characters are depicted with eyes visible (top) or eyes occluded by sunglasses (bottom).

Design

There were two within-subjects factors: eye visibility (visible versus occluded by glasses), and the orientation of the body relative to the head (congruent or incongruent). For the congruent body trials, the body was oriented in the same direction as the head (i.e., both either oriented 30° to the left, or 30° to the right), for the so-called neutral trials a frontal body orientation (i.e., 0°) was presented with the head oriented 30° left or right, finally for the incongruent body trials the body was oriented in the opposite direction as the head (body 30° right and head 30° left, or vice versa).

Procedure

Each trial began with the presentation of a fixation cross for 760 ms, followed by an 80 ms blank interval, and then the stimulus of the human character. Participants were instructed to keep their eyes on the fixation cross as long as it was presented and to indicate the orientation of the head as fast and as accurately as possible using the index finger of their right or left hand once the human figure appeared. The stimulus remained present until a button press was recorded. A response was followed by a feedback message for 240 ms. Correct responses were followed by a green plus sign (0.5° x 0.5°), incorrect responses by a red minus sign, which were presented at the location of the previous fixation cross. The inter-trial interval was set at 1000 ms.

Participants first completed a set of 48 practice trials, followed by ten blocks of 48 experimental trials. Each experimental block included a random presentation of the 48 stimuli (4 characters x 2 eye visibility x 3 body orientations x 2 head orientations). After every second block, participants were encouraged to take a one-minute pause. The entire experiment lasted approximately 25 minutes after which participants were debriefed and thanked for their participation.

2.2.2. Results

The mean RTs, and associated error rates, were derived for each of the six conditions (2 eye visibility x 3 congruency) for every participant. Individual trials were removed if responses were made in excess of 2.5 SD of each participant's mean reaction time. 3.43 % of the trials were excluded in this way. A two-way,

within-subject analysis of variance was carried out on the remaining, correct RT data and error rates.

The analysis of the correct RT data revealed a main effect of congruency, $F(2, 22) = 7.513$, $MS_e = 42.178$, $p < .005$. Planned pairwise comparisons revealed that discrimination of head orientation was faster in the condition with a congruent body orientation compared to the condition with an incongruent body orientation (360 ms versus 367 ms, $p < .001$), which is shown in Figure 2.2. Planned comparison of the neutral, frontal body condition (364 ms) with the congruent body orientation revealed no significant difference ($p = .15$), but comparison of the neutral body condition with the incongruent body orientation almost reached significance ($p = .06$). There was no main effect of eye visibility ($F < 1$), nor was there a significant interaction between congruency and eye visibility ($F < 1$).

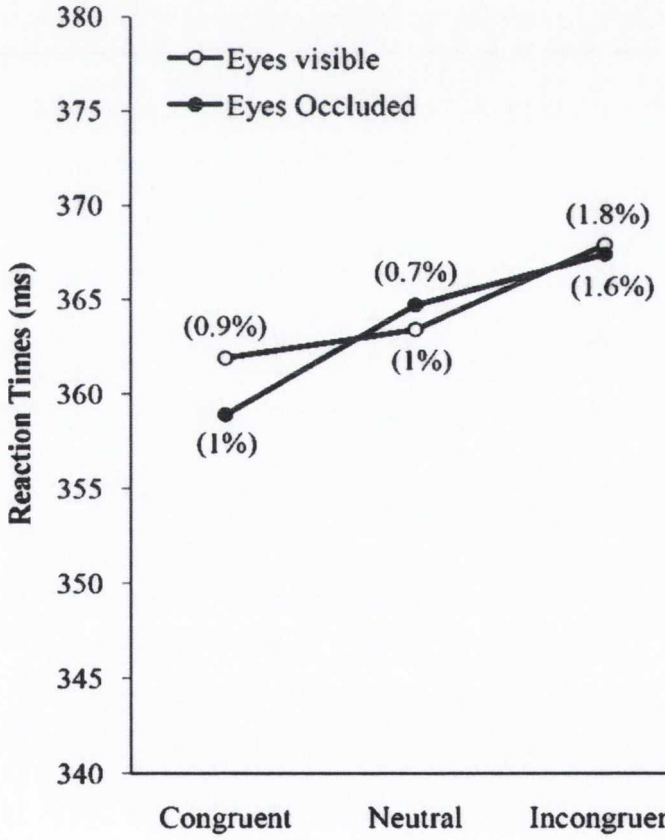


Figure 2.2. Mean reaction times (ms) and mean error rates (%) as a function of congruency of head and body orientation and eye visibility in Experiment 1.

The mean percentage error was 1.18 %. A within-subjects analysis of variance revealed no main effect of eye visibility ($F < 1$). The main effect of congruency almost reached significance, $F(2, 22) = 3.123$, $MS_e = .00013$, $p = .064$. Error rates in the congruent, neutral, and incongruent conditions were 1.0 %, 0.9%, and 1.7% respectively, thus mirroring the RT-data and revealing no evidence for a trade-off between speed and accuracy. The factors eye visibility and congruency did not interact ($F < 1$).

2.2.3. Discussion

The results of Experiment 1 first of all show that body orientation, even when task-irrelevant, influenced the speed at which the looking direction was judged. This implies that judgments of gaze or head directions are not solely driven by the face region but that body information (i.e., trunk, arms, and legs) is also processed. Second, congruent head-body orientations resulted in faster responses compared to incongruent head-body orientations. This observation is in line with Langton's (2000) *positive congruency model*, which suggests that another individual's posture signals the direction of their attention most efficiently when the eye-gaze, the head and the body are aligned. Yet, this result is at odds with Seyama and Nagayama (2005) who observed a reverse congruency effect for the head-body relationship based on a Stroop task, and Hietanen (2002) who observed a similar reverse congruency effect on attentional shifts in a Posner task. Third, the general speed of the direction judgment was not affected by the visibility of the eyes, nor was congruency affected by the visibility of the eyes. In line with Nuku and Bekkering (2008), these results suggest that the visibility of the eyes is not essential for signalling the direction of an observed person's attention (at least not in the present task). However, the fact that the presence of the eyes did not facilitate processing should not be interpreted as evidence against such facilitation, in general, because the size of the eye information was relatively small in the present experiment (i.e., roughly corresponding to viewing a person at a distance of approximately 8 meters).

The positive congruency effect, which was obtained with relatively easy stimuli (i.e., as reflected in the fast reaction times and low percentage of errors), may also be understood with respect to recent results obtained by Ricciardelli and

Driver (2008). They argued that the factor determining whether positive or reverse congruency effects between social cues can be observed is dependent on processing time. As mentioned in the introduction, positive congruency effects have mostly been revealed in speeded tasks (e.g., Langton, 2000; Ricciardelli & Driver, 2008, Experiment 1 & 3; though see Seyama & Nagayama, 2005 for further qualifications). In contrast, the strongest support for a reversed congruency effect seems to come from relatively unspeeded tasks (e.g., Anstis et al., 1969; Ricciardelli et al., 2000; Ricciardelli & Driver, 2008, Experiment 2). Ricciardelli and Driver (2008) argued that the congruency effect (a *positive congruency effect* reflecting a *towing* account or a *reverse congruency effect* representing the *overshooting* account) might in fact depend on the speed of response while judging gaze direction: with more speeded decisions (e.g., under time pressure), head orientation and gaze direction may be encoded briefly and in parallel producing positive congruency effects (Langton, 2000). Reverse congruency effects on the other hand presumably result from more temporally extended visual processing, which may be required for the perceptual integration of head, gaze and body cues within a detailed geometry of complex social stimuli (Ricciardelli & Driver, 2008; though see Doi, Ueda, & Shinohara, 2009). If the positive congruency effect observed in Experiment 1 is due to the relatively easy task, and thus fast and parallel processing of head and body information, then this effect should be reversible (i.e., into a reverse congruency effect) when task difficulty (and as a result processing time) is increased. This hypothesis was tested in Experiment 2.

2.3 Experiment 2

To test the hypothesis that extended processing time may lead to a reverse congruency effect, we increased task difficulty in Experiment 2 relative to Experiment 1. To this end, head orientations of 5° instead 30° were employed, while keeping all other aspects of the experiment identical. If, consistent with Ricciardelli and Driver (2008), extended processing time is needed to integrate head and body information, and that this integration is a necessary condition for obtaining the reversed congruency effect, we expected to find such a reversal with the more difficult task of judging head orientations of 5°.

With respect to the manipulation of eye visibility we assumed that concealing the observed person's eye gaze could, unlike Experiment 1, affect the direction judgments because the eyes are more visible in images where the head is averted by only 5° instead of 30°.

2.3.1. Method

Participants

Eight undergraduate students and staff members of the University of Leuven, 3 males and 5 females (age 27 to 36) volunteered to participate in the experiment. All reported normal or corrected-to-normal vision and were naïve as to the purpose of the experiment.

Apparatus, stimuli, design and procedure

Experiment 2 was identical to Experiment 1 with the exception that now the head orientation of the human characters was oriented 5° away from a frontal view instead of 30° (see Figure 2.3). The orientation of the body was maintained at 30° left or right, as in Experiment 1. Furthermore, we did not include the condition with a neutral (i.e., frontal) body orientation. The visual angles subtended by the human characters were the same as those reported in Experiment 1.

2.3.2. Results

The mean RTs, and associated error rates, were derived for each of the four conditions (2 eye visibility x 2 congruency) for every participant. Individual trials were removed if response times exceeded 2.5 SD of each participant's mean reaction time. 5.87 % of trials were excluded in this way. A two-way, within-subject analysis of variance was carried out on the remaining, correct RT data and error rates.

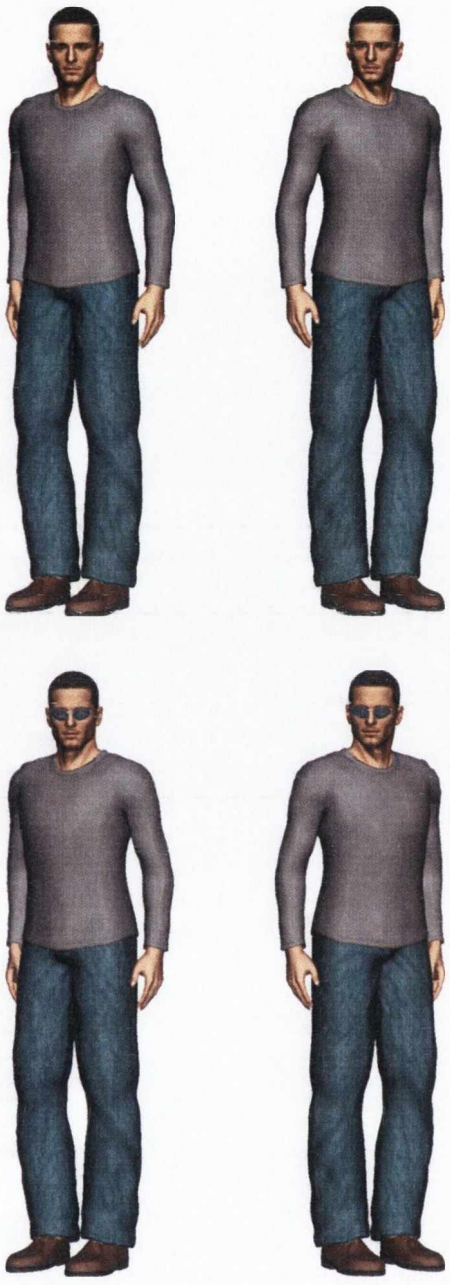


Figure 2.3. Examples of stimuli used in Experiment 2. Human figures with body orientated by 30°, congruently (left column) or incongruently (right column) relatively to the head oriented by 5° to the left. In rows the characters are depicted with eyes visible (top) or eyes occluded (bottom).

The analysis of the correct RT data revealed a main effect of eye visibility, $F(1, 7) = 7.417$, $MS_e = 52.595$, $p < .05$. Responses to head orientation with occluded eyes were generally slower than when the eyes were visible (395 versus 388 ms respectively). There was a main effect of congruency, $F(1, 7) = 9.894$,

MS_e = 179.231, p < .05. As shown in Figure 2.4, discrimination of head orientation was faster in the incongruent body orientation condition compared to the condition with a congruent body orientation (385 versus 400 ms). There was no interaction between congruency and eye visibility (F < 1).

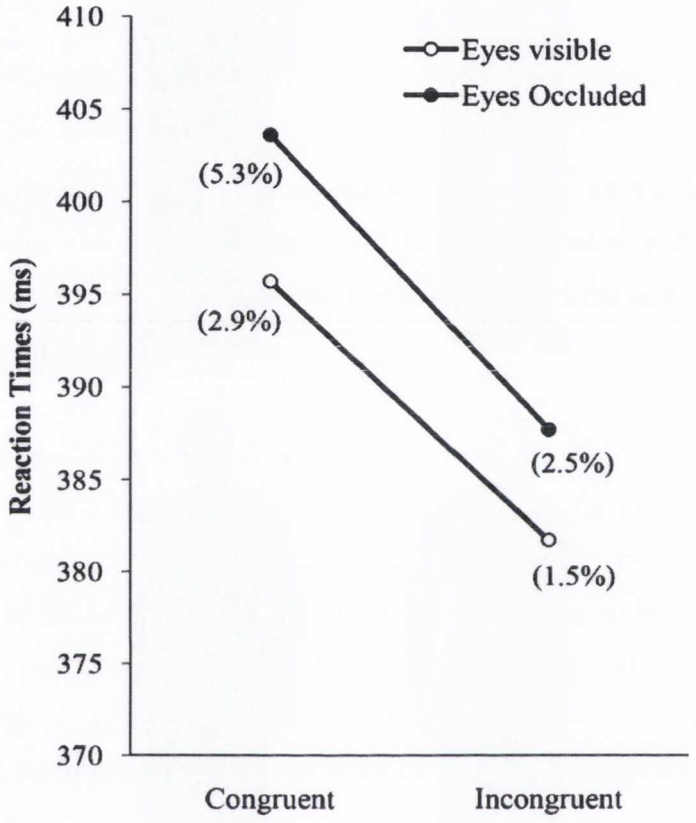


Figure 2.4. Mean reaction times (ms) and mean error rates (%) as a function of congruency of head and body orientation and eye visibility in Experiment 2.

The mean percentage error was 3.28%. A two-way within-subjects analysis of variance revealed a marginal effect of congruency [F(1, 7) = 5.149, MS_e =.000592, p = .06], with lower error rates in incongruent than in congruent conditions (2.1 % vs. 4.1%). Hence there was no evidence for a speed-accuracy trade-off. A trend for an eye visibility effect was revealed [F(1, 7) = 5.271, MS_e =.0006, p = .06], with lower error rates in the conditions with the eyes visible than in the conditions with eyes occluded (2.2 % vs. 3.9%). The interaction between both factors did not reach significance (F < 1).

2.3.3. Discussion

The results of Experiment 2 show that under conditions of higher task difficulty (evidenced by a significant increase in error rate relative to Experiment 1 [3.1 % vs. 1.3 %; $F(1, 18) = 5.093$, $MS_e = .001$, $p < .04$], and somewhat, though not significantly longer RTs [392 ms vs. 364 ms; $F(1, 18) = 2.225$, $MS_e = 6844.725$, $p = .15$]), the positive congruency effect observed in Experiment 1 changes into a reversed congruency effect. In other words, reaction times were faster and more accurate in the incongruent condition in which the head was oriented 5° to the left (right) and the body was oriented 30° to the right (left) compared to the congruent condition in which the head was oriented 5° to the left (right) and the body 30° to the left (right). Following Ricciardelli and Driver (2008), this reversal may indeed be due to more extensive processing and thus revealing effects of an integration process of head and body information that requires additional processing time.

Unlike Experiment 1, the present experiment also revealed an effect of eye visibility; reaction times were significantly faster when eye information was present, but its presence did not interact with congruency. Though other explanations are possible, the additional benefit of eye information may be the result of eye information being more visible with the head averted by only 5° instead of 30°.

The main reason for conducting Experiment 2 was to assess the effect of increased task difficulty and thus processing time in relation to Experiment 1 (which adopted a relatively easy head orientation discrimination task). Despite the fact that we observed a reversal of the congruency effects, a direct comparison between the results of both experiments may not be warranted. In Experiment 1, a congruent head-body relationship was operationalized as head and body being oriented in the same direction relative to the viewer (i.e., both to the left or right) and with an identical angle of orientation (e.g., both head and body were oriented 30° to the left). However in Experiment 2, while congruent head-body postures had both head and body oriented in the same direction (i.e., both to the left or right), the angle of orientation was never identical (e.g., the head was oriented 5° to the left whereas the body was oriented 30° to the left). Thus, strictly speaking, the congruent conditions of Experiment 1 and 2 may not allow a direct comparison. This shortcoming was addressed in Experiment 3.

2.4 Experiment 3

In order to confirm the results obtained in Experiment 2 with the more difficult task, and to allow a better comparison with Experiment 1 (with the relatively easy task), a third experiment was carried out. Experiment 3 was identical to Experiment 2 except that we now also included congruent and incongruent head-body stimuli where both the head and body were oriented by 5°. Thus, in Experiment 3 body orientation of the human figures was set at 30° or 5°, while head orientation remained at 5°. The inclusion of conditions with head and body oriented at 5° allowed for a better comparison with Experiment 1 because in these conditions the congruent condition has an identical head and body orientation, namely 5°. In order to keep the duration of the experiment manageable, we did not include conditions with occluded eyes. If increased task difficulty and, as a consequence, extended processing time was indeed responsible for reversed congruency effects, we expected reverse congruency effects for both the conditions with the body oriented either by 5° (new conditions) or by 30° (i.e., a replication of Experiment 2) relative to the head oriented at 5°.

2.4.1. Method

Participants

Ten undergraduate students and staff members of the University of Leuven, 4 males and 6 females (age 27 to 36) participated in the experiment. They were rewarded with 5 euro for a 25 minute participation session. All reported normal or corrected-to-normal vision and were naïve as to the purpose of the experiment.

Apparatus, stimuli and procedure

Experiment 3 was identical to the previous experiments except that here the body orientation of the human figures was oriented by either 30° or 5°, while head orientation remained at 5°. Furthermore, we did not include the eye visibility manipulation keeping the character's eyes visible in all conditions.

Design

There were two within-subjects factors: the congruency of head and body orientations, (i.e., both either oriented to the left, or to the right), and the angle of the body orientation (i.e., 5° or 30°).

2.4.2. Results

The mean RTs, and associated error rates, were derived for each of the four conditions (2 body-head congruency x 2 body angle orientation) for every participant. Individual trials were removed if responses were made in excess of 2.5 SD of each participant's mean reaction time. 5.03% of trials were excluded in this way. A two-way, within-subject analysis of variance was carried out on the remaining correct RT data and error rates.

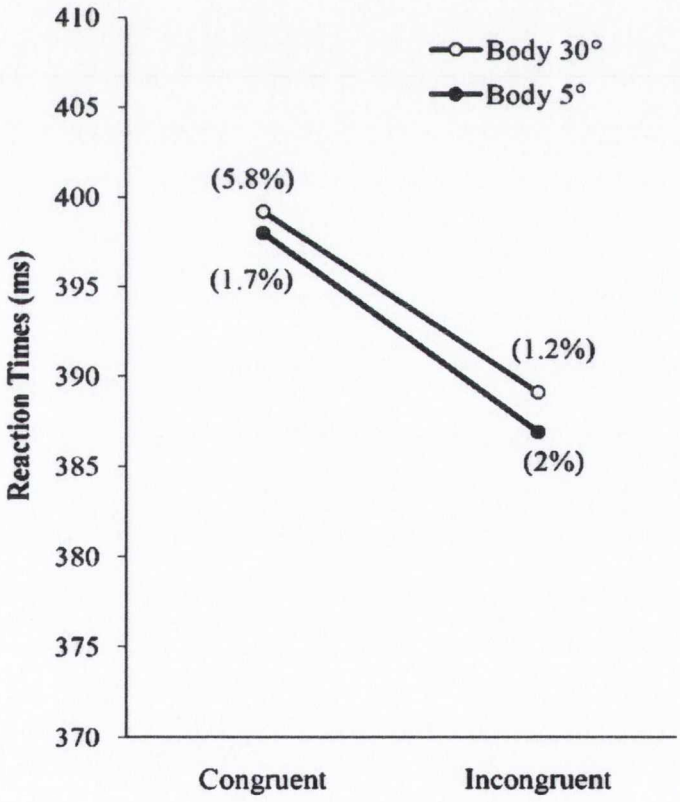


Figure 2.5. Mean reaction times (ms) and mean error rates (%) as a function of congruency of head and body orientation and body angle in Experiment 3.

The analysis of the correct RT data revealed a main effect of congruency, $F(1, 9) = 12.143$, $MS_e = 93.234$, $p < .01$. As shown in Figure 2.5, discrimination of head orientation was faster when the body orientation was incongruent with the head compared to when body and head orientations were congruent (388 ms versus 398 ms). There was no main effect of body angle (5° versus 30°; $F < 1$), nor was there a significant interaction between congruency and body angle ($F < 1$).

The overall mean percentage error was 2.72 %. The within-subjects analysis of variance revealed main effects of body angle [$F(1, 9) = 6.802$, $MS_e = .000384$, $p < .05$], with better performance at the 5° body angle than at the 30° body angle condition. There was a main effect of congruency [$F(1, 9) = 6.817$, $MS_e = .000586$, $p < .05$], with better performance when head and body orientation were incongruent. In addition, a significant interaction between both factors was observed, $F(1, 9) = 15.336$, $MS_e = .000408$, $p < .005$. Following up on this interaction, post hoc comparisons with Bonferroni correction showed that error rates between the congruent and incongruent conditions did not differ significantly for body orientations of 5° (1.7 % versus 2.0 %; $p = .72$), whereas, with the body oriented by 30°, significantly more errors were made in the congruent than in the incongruent condition (5.8 % versus 1.2 %; $p < .01$). For both the conditions with 5° and 30° body orientations no evidence for a speed/accuracy trade-off was present.

2.4.3. Discussion

The results of Experiment 3 confirmed those obtained in Experiment 2. In both experiments, the more difficult task (i.e., 5° head orientation) resulted in a reverse congruency effect. Furthermore, the present experiment showed that even small incongruent angles between the orientation of the body and head (i.e., 10 degrees as opposed to 35 degrees) result in a reverse congruency effect. Together, a comparison of the results of Experiment 1 with those of Experiment 2 and 3 provide strong evidence that task difficulty predicts the occurrence of either positive (easy task) or reverse congruency effects (the difficult task).

2.5 General Discussion

The present study examined whether and how the orientation of an observed person's body (i.e., trunks, arms, and legs) relative to their head affects the processing of the direction of that individual's social attention. To examine this issue, we adopted a Stroop-type interference paradigm, in which the orientation of the body (the task-irrelevant dimension) was manipulated independently from that of the head (i.e., the direction at which the head and body were oriented could be congruent or incongruent). When available, eye gaze direction was always aligned with the direction of the head. Participants judged the direction in which full-body computer-generated human figures were looking by making speeded key press responses contingent on the direction of the head.

A first observation was that the direction, in which the body was oriented, although irrelevant to the task, influenced the time it took to judge that direction. Consistent with previous research (e.g., Hietanen, 2002; Seyama & Nagayama, 2005), this finding demonstrates that gaze and head direction judgments are not solely driven by the face region but can also be affected by orientation information from the body (i.e., from the trunk, arms, and legs). Furthermore, it suggests that body information is automatically processed when judgments of the direction of attention based on head/gaze direction have to be made.

The main finding, however, was that the effect of body orientation relative to head orientation varied qualitatively with task demands. In particular, when the judgment of head orientation was relatively easy (i.e., head oriented 30° left or right of a frontal view; Experiment 1), a positive congruency effect between head and body cues was obtained. When the body orientation was aligned with the head (i.e., congruent), the time to judge the direction of attention was significantly faster than when the body was oriented in a direction opposite to that of the head (i.e., incongruent). In contrast, when task difficulty was increased by using stimuli with a head orientation of 5 instead of 30 degrees away from a frontal view (Experiment 2 and 3) this effect was reversed: the time to judge the direction of attention from stimuli with incongruently oriented head and body was faster relative to the time it took to judge the direction of attention from congruently oriented head-body stimuli.

The observation that the effect of body orientation relative to head orientation varies qualitatively with task demands is in general accord with recent findings on the relationship between eye and head positions. Based on a similar Stroop paradigm with gaze direction judgments, Ricciardelli and Driver (2008) observed positive congruency effects of the eye-head relationship when responses had to be made under time pressure, and reverse congruency effects in the absence of time pressure. To explain these results, they argued that with more speeded decisions under time pressure, only gross head orientation and gaze direction may be encoded, in parallel, to produce a positive congruency effect (also see Langton, 2000). On the other hand, the perceptual integration of head and gaze cues requires some temporally extended visual processing resulting in a reverse congruency effect. Though Ricciardelli and Driver (2008) did not spell out precisely how the integration process may result in a reverse congruency effect, we suggest that it may be a consequence of the activation of implied motion signals during later processing stages (see also Freyd, 1983, 1987; Jellema & Perrett, 2003a, 2003b; Seyama & Nagayama, 2005). Jellema and Perrett (2003a, 2003b) pointed out that incongruently oriented body parts can induce the perception of a twisting action through a process involving the referential coding of the orientation of the head and body. For example, an observed pose with the head oriented to the left and body oriented to the right (relative to the viewer), may induce the perception of implied motion of the head from right to left. When both the head and body are identically and congruently oriented to the left then no such motion is implied. Consistent with this account, several lines of research point towards slower activation of implied motion signals. It has been shown that the latency of the cortical response to implied motion (240–300 ms) is usually longer than that to real motion by about 100 to 150 ms (Bach & Ullrich, 1994; Heinrich, van der Smagt, Bach, & Hoffmann, 2004; Hoffmann, Unsold, & Bach, 2001; Lorteije et al., 2006), which means that implied motion is not processed along the dorsal visual path, as real motion is, but arrives at motion processing areas via a longer route, possibly as a projection from temporal form areas (Lorteije et al., 2007). Also Kourtzi, Krekelberg, and van Wezel (2008) confirmed that human visual evoked potentials resulted in the largest difference between 260 and 320 ms after stimulus onset to static images of human figures displaying an action versus standing still, which is 100 ms later than the evoked response to a

real motion stimulus. To summarize, reverse congruency effects may be a result of implied motion processing which may require extended processing time.

Although time pressure was not manipulated in the present study (as in Ricciardelli & Driver, 2008), processing time was indirectly manipulated by task difficulty. However, despite the fact that reaction times were somewhat, however not significantly, slower when task difficulty was increased (Experiments 2 and 3 compared to Experiment 1), we cannot conclude with absolute certainty that processing time per se was responsible for the observed shift from positive (Experiment 1) to reverse congruency effects (Experiment 2 and 3). Increased task difficulty (as evidenced by a significant increase in error rates) may have initiated additional or different processes necessary to carry out the more difficult task of judging the direction of attention, which would not be initiated in the easy task (Experiment 1) even with extended processing time. To disentangle the effects of processing time and task difficulty, further research could be carried out using the same stimuli as in Experiment 1 (i.e., head angles which are easy to discriminate), but artificially delaying responses (e.g., by inserting a sound at different moments following visual stimulus onset, signalling that a response may be given from that moment onwards). If such an experiment would reveal positive congruency effects with undelayed responses and reverse congruency effects with postponed responses, this would be evidence that the referential coding of head and body parts is not a special process limited to difficult head orientations (as in Experiment 2 and 3), but that it occurs routinely and requires extended processing time to affect response selection in the present head direction judgment task. The absence of a reversal of the congruency effect with increased response delays on the other hand, would suggest that referential coding of head and body information may only be triggered when head orientation is difficult to assess in order to facilitate judgements of head direction. However, in terms of our implied motion interpretation of the reversed congruency effect in Experiment 2 and 3, the latter result is unlikely, as it would suggest that activation of implied motion signals would be restricted to body poses in which the direction of the head relative to the viewer is difficult to discriminate. Further research is required to clarify these issues.

The present results have further implications for a number of issues within the literature. First, the fact that we observed effects of body orientation in a task

in which head direction had to be judged, adds to the growing body of evidence (e.g., Anstis et al., 1969; Bayliss, di Pellegrino, & Tipper, 2004; Cline, 1967; Gibson & Pick, 1963; Hietanen, 1999, 2002; Langton, 2000; Langton & Bruce, 1999; Langton et al., 1996; Nummenmaa & Calder, 2009; Seyama & Nagayama, 2005) that the inhibitory hierarchical model proposed by Perrett et al. (1992), which is based on neurophysiological findings in macaques, does not generalize to observable behaviour in humans. Whereas Perrett et al. found that social cues higher up the hierarchy, which are involved in the perception of social attention, actively inhibit activation of cues lower in the hierarchy (i.e., gaze relative to head direction, and head relative to body direction), even to the extent that these would be rendered irrelevant to the attention system, the present results do not support such a hierarchical model. Thus, consistent with a large set of studies showing that the processing of gaze direction can be influenced by head direction, the present results add to the few studies showing influences of body orientation on the perceived direction of the head or gaze (i.e., Hietanen, 2002; Seyama & Nagayama, 2005).

Second, the results of the present study have implications for Langton's (2000) *positive congruency model* of social cue processing, according to which the direction of attention is signalled most efficiently when gaze, head and body cues are oriented in the same direction. The model suggested that directional information from multiple cues is analyzed in parallel and that these cues have independent and additive effects on the discrimination of the direction of social attention. Contrary to this view, we provided evidence that increased task difficulty (and presumably increased processing time) can reverse the congruency effect of head and body cues in a head direction judgment task in much the same way as has been shown by Ricciardelli and Driver (2008) for the relationship between the direction of gaze and head cues in a gaze direction judgment task under conditions that do or do not require highly speeded responses. As such, the picture that emerges is more complex than that provided by the *positive congruency model*, with temporal processing constraints and/or task difficulty affecting the qualitative nature of the compatibility effects. In this respect it is interesting to note that Langton (2000) observed a "curious" reverse congruency effect of head and gaze direction in an experiment (see Experiment 1, gaze direction judgment task, p. 834) in which the overall reaction times were slower

compared to subsequent experiments in that same study which all showed positive compatibility effects.

Third, to explain the difference between the positive congruency effects obtained by Langton (2000) derived from a series of Stroop-type experiments, and reverse compatibility effects of gaze-head direction (Hietanen, 1999) and head-body direction (Hietanen, 2002) derived from a Posner attentional cueing paradigm, Hietanen (2002) suggested that visual information may be processed and integrated differently for the purpose of overt direction discrimination of social directional cues than for covert visual attention orienting. However, the reversal of the compatibility effects shown in the present study in which an overt discrimination of a social directional cue was required casts doubt over this explanation, instead pointing towards other factors as elaborated on above.

Finally, Seyama and Nagayama (2005) showed that different relationships between the cues may generate different compatibility effects in a task requiring the judgement of gaze direction, with directional gaze and head cues producing positive compatibility effects and directional gaze and body cues producing reverse compatibility effects. Again, the reversibility of the compatibility effect of head and body cues observed in the present experiment, in which eye gaze and head were always identically oriented, seem to suggest that Seyama and Nagayama's explanation for the qualitatively different compatibility effects may be an oversimplification.

Although further research will be required to examine the precise circumstances under which positive compatibility effects of directional head and body cues can be reversed (i.e., increased task difficulty and/or increased processing time) for the computation of where another person is looking, the present study demonstrates that body orientation, as a directional social cue, is automatically processed. Furthermore, the reverse compatibility effect suggests that when the encoding of head direction is more difficult such that processing time is increased, referential coding of the head relative to the body is initiated, which we argue may be related to the processing of implied motion. This additional coding process seems to follow an initial parallel processing of the head and body direction of the observed person.

CHAPTER 3

AUTOMATIC ACTIVATION OF DIRECTIONAL SPATIAL CODES BY BODY ORIENTATION IN A SIMON TASK

Autorship

Results from the following chapter were presented at the Annual Conference of The British Psychological Society (BPS) 2008:

Pomianowska, I., Germeys, F., & Newell, F. N. (2008, April). *Social perception from visual cues: The role of body orientation in the computation of attention direction.* Poster session presented at the Annual Conference of The British Psychological Society (BPS), Dublin, Republic of Ireland.

Abstract

In this study we investigated whether the direction of body orientation (i.e., trunk, legs, and arms in the absence of directional gaze and head cues) automatically activates a spatial code, which in turn can trigger shifts of attention. To this end, we adopted a Simon task with centrally presented body poses (with their head occluded) in which the left/right orientation direction of the body was irrelevant to the task that had to be performed. The task was to determine either the action displayed by the human character (Experiment 4) or the sex of the character (Experiment 5). In both experiments observers responded to the task-relevant dimension by pressing one of two lateralized response keys. Although completely irrelevant to the task, body orientation influenced reaction times in these spatially selective discrimination tasks. Faster reaction times were observed when the body pose was oriented in the same direction as the required response location (i.e., compatible S-R pairings) than when the body pose was oriented in the opposite direction (i.e., incompatible S-R pairings). These results provide evidence that, similar to studies on the direction of eye-gaze (Ansorge, 2003a; Zorzi, Mapelli, Rusconi, & Umiltà, 2003), the direction in which a body is oriented (in the absence of directional gaze and head cues) is automatically processed and activates a directional spatial code.

3.1 Introduction

A large number of studies have demonstrated that the spatial location of objects is automatically coded even when it is irrelevant to the task to be performed. These effects have been studied extensively with a classic behavioural paradigm called the Simon task (Lu & Proctor, 1995; Simon & Craft, 1970, Umiltà & Nicoletti, 1990). In a typical Simon task, participants are presented with one of two different patterns (e.g., two colours) in peripheral vision (on the left or right of fixation) and are required to press the left key in response to one pattern and the right key in response to the other. Even though the stimulus location is irrelevant for performing the task (e.g., colour discrimination) and participants are instructed to select the response exclusively on the basis of the relevant, non-

spatial stimulus dimension (e.g., colour), irrelevant information concerning stimulus location is nevertheless processed. This is supported by faster and often more accurate responses to patterns presented in a position which corresponds to the position of the required response key (e.g., stimulus position right and response side right or vice-versa and is known as compatible or corresponding S-R pairings) compared to when they are positioned differently (e.g., right-left which are incompatible or noncorresponding S-R pairings). These results demonstrate that a spatial code is generated for the irrelevant stimulus dimension (i.e., location), which in turn affects response selection (Lu & Proctor, 1995; Zorzi & Umiltà, 1995).

Further research, which was based on adopting a variant of the Simon task with centrally presented stimuli suggested that stimulus position is not the only dimension capable of automatically activating spatial codes. For example, in a task which required subjects to discriminate the colour of centrally presented arrows with compatible or incompatible S-R mappings, Masaki, Takasawa, and Yamazaki (2000) also observed a Simon effect. Likewise, but more closely related to the present study, Ansorge (2003a), and Zorzi et al. (2003; also see Ricciardelli, Bonfigloli, Iani, Rubichi, & Nicoletti, 2007) showed that a centrally presented social cue, namely the direction of eye gaze, automatically activated a directional spatial code, which in turn affected response selection[7]. Even though gaze direction was task-irrelevant, it influenced reaction times in a task that required participants to discriminate eye colour (i.e., faster responses when gaze was oriented to the same side as the required response side). Zorzi et al. (2003) argued that the automatic activation of a spatial code based on gaze direction (as observed in their version of the Simon task) is very likely to drive subsequent attentional shifts of the observer. This finding is consistent with the observation that

[7] In this study, participants were shown simple drawings of schematic eyes with coloured irises that were either presented looking centrally or oriented to the left or right. The participants' task was to respond to the colour of the irises (blue or green) by pressing one of two response keys, each located left or right of the body midline. Even though the stimuli were not lateralised as in the regular Simon paradigm and gaze direction was task-irrelevant, participants were faster to respond to the colour of the eyes when the side of the response key corresponded with gaze direction than when it did not. Thus, task-irrelevant gaze direction automatically generated a directional spatial code, which in turn affected response selection (Lu & Proctor, 1995; Zorzi & Umiltà, 1995).

central gaze cues in a version of the Posner (1980) cueing paradigm automatically trigger reflexive attention shifts in the direction of gaze (e.g., Driver et al., 1999; Friesen & Kingstone, 1998). These shifts of attention in the direction of the gaze of the observed person may be critical for a number of adaptive (social) behaviours and our understanding of what goes on in the mind of others (Baron-Cohen, 1995a). For example, autistic individuals exhibit many difficulties in reading of social signs, especially an eye contact (Kanner, 1943; Neumann, Spezio, Piven, & Adolphs, 2006), gaze following (Leekham et al., 1998), and joint attention (Charman, Swettenham, Baron-Cohen, Cox, Baird, & Drew, 1997). These social impairments reflect an inability or difficulty to understand the minds of others or to read someone's behaviour in terms of intentions, mental states, desires and beliefs (see e.g., Baron-Cohen, 1995a; Frith, Morton, & Leslie, 1991). An understanding of the mechanisms of gaze following, and establishing of joint attention is essential in order to comprehend social perception in healthy adults as well as in individuals with potential social development disorders.

While eye direction is an important cue for inferring the direction and location of another person's locus of attention, other cues such as head and body information (i.e., the direction of torso, arms and legs) also contribute to this process (for a review, see Frischen, Bayliss, & Tipper, 2007). The aim of the present study was to investigate whether the direction in which the body is oriented can, in itself (i.e., in the absence of directional gaze and head cues), automatically activate a spatial code, which in turn can trigger shifts of attention. To this end, we adopted a Simon task with centrally presented body poses (with their heads occluded) in which the orientation direction of the body was irrelevant to the task that had to be performed. The task relevant dimension was either the action displayed by the body pose (Experiment 4) or the sex of the displayed body (Experiment 5).

3.2 Experiment 4

On each trial, participants were presented with an image of a human character with its head occluded by a black square. The observer's task was to discriminate between static images of two types of actions, waving and walking,

by responding with a right or left key press respectively. Stimulus-response compatibility was manipulated by presenting the body poses in profile, either facing to the left or right of the observer. Thus, on trials with compatible stimulus-response pairings, the body pose was oriented to the left (or right) and correct responses required a left (or right) key press, and on trials with incompatible stimulus-response pairings, the body pose was oriented to the right (or left) and correct responses required a left (or right) key press.

In the present experiment, left-right responses were made unimanually by using the index and middle finger of one hand (i.e., the dominant hand, which was right for all participants). The reason for adopting a unimanual rather than a bimanual response mode (e.g., left and right index finger) was grounded in the idea that any compatibility effect observed could be ascribed to the activation of a more generalized or abstract spatial code rather than a specific lateralized motor response tied to the left or right hand (Phillips & Ward, 2002; Tucker & Ellis, 1998; Shulman & McConkie, 1973).

3.2.1. Method

Participants

Eight undergraduate students and staff members from the Institute of Neuroscience, Trinity College Dublin (3 males and 5 females, with a mean age of 28.1 years) took part in the experiment. All reported that they were right-hand dominant, had normal or corrected-to-normal vision and were naïve with respect to the purpose of the study. The study was approved by the Ethics Committee of the School of Psychology at Trinity College Dublin, accordingly, all participants provided informed consent prior to the experiment.

Apparatus and stimuli

Stimuli were displayed on a 21-inch CRT colour monitor with a refresh rate of 60 Hz and resolution 1024 x 768 pixels, driven by a HP Compaq dc5750 Microtower (with processor AMD Athlon (tm) 64X2 Dual Core Processor 4000+ 984 MHz; 896MB RAM). The experiment was designed using E-prime software (version 1.2). Participants sat in a darkened room, with their head stabilized on a

chin-rest, which was positioned 80 cm from the monitor. Responses were collected using a serial Response Pad Model RB – 830 (Cedrus Corporation), which was placed in front of the participant and was aligned with the horizontal midpoint of the screen and the participant's body midline.

Stimuli consisted of digital photographs of four human models, two male and two female, each wearing the same neutral, homogenous clothing (black t-shirt and blue jeans). Using Adobe Photoshop computer graphics software (version CS3), the head of each model was covered with a black square subtending 1.5° x 1.5°, so that the information about the direction of the head was not available to the viewers. The images of the characters subtended a visual angle of 7° vertically, and were presented in colour, without external shadows, against a white background. The models were presented in profile (oriented to the left or right) and in two possible body poses: waving or walking. Thus, four different images were created for each model by combining two profile orientations with four different body poses, resulting in a total of 16 stimuli. Examples of a waving and walking stimulus are shown in Figure 3.1.

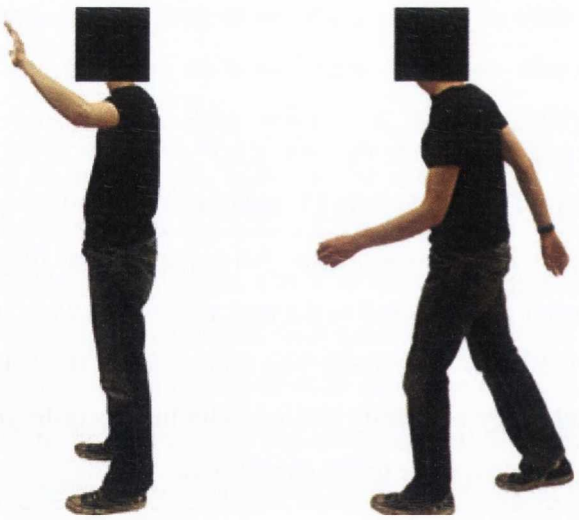


Figure 3.1. Examples of stimuli used in Experiment 4. Male model with body orientation to the left in waving and walking pose.

Stimuli were presented in the centre of the screen with the midline of the body aligned with the vertical axis of the screen. A fixation cross, centred in the middle of the screen, was presented prior to each stimulus image.

Design

The protocol of the experiment was based on a *Simon task*. Participants had to discriminate the action (waving or walking) of the image of the human character (i.e., the task-relevant dimension) by manually pressing the left or right response button with the index finger or middle finger of their dominant hand (all participants were right handed). The left/right location of the required response was pitted against the left/right direction in which the body was oriented (i.e., the task-irrelevant dimension).

The experiment was based on a fully factorial, two-way, within-subjects design in which stimulus-response compatibility (body orientation compatible with response location vs. incompatible) and body pose (waving vs. walking, which coincided with a left vs. a right response) were manipulated. The manipulation of stimulus-response compatibility (the combination of body orientation and the location of the required response) resulted in half of the trials with a compatible stimulus-response (S-R) pairing and half of the trials with an incompatible S-R pairing.

Procedure

Each trial began with the presentation of a fixation cross for 1000 ms, followed by the stimulus. Participants were instructed to keep their eyes on the fixation cross and to respond to the displayed action (waving or walking) as rapidly and accurately as possible once the model appeared on the screen. Participants were instructed to press the left button if the model displayed a waving action, and to press the right button if the model displayed a walking action. The stimulus remained present until a button press was recorded. Feedback was provided following each response: correct responses were followed by a green plus sign (0.5° x 0.5°) and incorrect responses were followed by a red minus sign, and these symbols were presented at the location of the previous fixation cross for 680 ms. No inter-trial interval was provided.

Participants first completed a set of 32 practice trials, followed by 25 blocks of 16 experimental trials. Each experimental block included a random presentation of the 4 models, in 2 body profile orientations and 2 poses. Participants were given the opportunity to take a one-minute rest every four blocks. The entire experiment lasted approximately 15 minutes after which participants were debriefed and thanked.

3.2.2. Results

The median reaction times (RTs) for correct responses and associated error rates were derived for the four conditions as a function of stimulus-response compatibility (body orientation compatible with response location vs. incompatible) and body pose (waving vs. walking, which coincided with a left vs. a right response). We conducted separate two-way, within-subject analyses of variance (ANOVA) on these RT and error data.

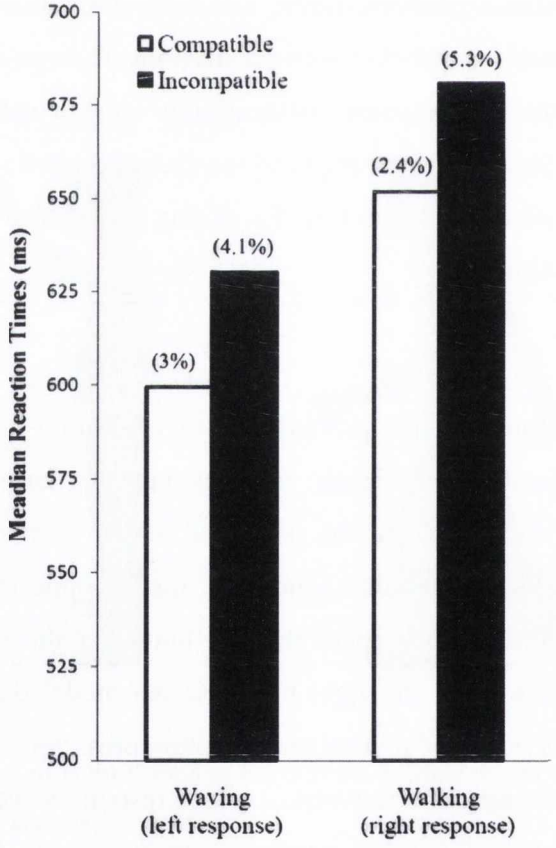


Figure 3.2. Median reaction times (ms) and associated error rates (%) in Experiment 4 as a function of response-compatibility and body pose (equivalent to response location).

The analysis of the correct RT data revealed a main effect of body pose [$F(1, 7) = 7.701$, $MS_e = 2755.143$, $p < .03$], with faster RTs to the waving body pose than the walking body pose. There was also a main effect of stimulus-response compatibility, $F(1, 7) = 11.003$, $MS_e = 643.5$, $p < .02$. As shown in Figure 3.2, participants were approximately 30 ms faster at discriminating the body pose when it was oriented in the same direction as the required response location than when it was oriented in the opposite direction, and this was true for both the waving pose (i.e., left responses) and the walking pose (i.e., right responses). On average, responses to waving poses were 52 ms faster than responses to walking poses. The interaction between body pose and stimulus-response compatibility did not reach significance ($F < 1$).

The overall mean percentage of error across participants was 3.69 %. The within-subjects ANOVA revealed a significant main effect of stimulus-response compatibility [$F(1, 7) = 8.00$, $MS_e = 4.000$, $p < .03$], with fewer errors made to the compatible condition than the incompatible condition. The main effect of body pose ($F < 1$) and the interaction between body pose (equivalent to response location) and stimulus-response compatibility did not reach significance ($p = .34$). Importantly, conditions with compatible stimulus-response pairings showed lower mean error rates than those with incompatible stimulus-response pairings. Thus, the effects of compatibility found in the analyses of the RT data cannot be explained by a speed-accuracy trade-off.

3.2.3. Discussion

The results of the present experiment show that body orientation, although it was irrelevant to the task, was automatically processed and generated a spatial code which influenced reaction times and error rates in the discrimination of the two types of body poses, waving or walking. When the body poses were oriented in a compatible direction relative to the required action discrimination response (i.e., left (or right) oriented pose requiring a left (or right) response), reaction times were faster and errors were less frequent than when the body pose was oriented in an incompatible direction relative to the required response (i.e., right (or left) oriented pose requiring a left (or right) response).

The Simon effect observed here is very similar to that observed for eye gaze (Ansorge, 2003a; Zorzi et al., 2003; also see Ricciardelli et al., 2007) and adds to the growing body of evidence that multiple social cues, such as eye-gaze, head, and body direction may activate spatial codes which in turn may contribute to the triggering of shifts in spatial attention. Furthermore, the observed Simon effect was obtained using a unimanual response mode, which differs from the above-mentioned studies in which responses were made bimanually. This suggests that the observed compatibility effect can be ascribed to the activation of a more generalized or abstract spatial code rather than perhaps a more specific lateralized motor response tied to the left or right hand (Phillips & Ward, 2002; Shulman & McConkie, 1973; Tucker & Ellis, 1998).

The finding that responses to waving poses were significantly faster than responses to walking poses does not necessarily reflect slower processing of walking poses but may instead be due to different fingers being used for both responses (i.e., index finger for a left/waving response, and middle finger for a right/walking response). Slower responses of the middle versus the index finger have been observed frequently (e.g., see Experiment 2 in Tucker & Ellis, 1998).

3.3 Experiment 5

The aim of the second experiment was twofold. First, we wished to explore whether the Simon effect induced by the task-irrelevant body orientation would also apply to an image of a body pose in which motion or an action was not implied. Note that in Experiment 4, the walking pose signalled an implied motion in the direction in which the body was oriented, and the waving pose carried a clear action direction in the direction in which the body was oriented (i.e., waving towards a potential other person). In the following experiment, we added a third body pose in which the model was simply standing in a relaxed way with the arms held loosely next to the body. We hypothesized that if the action implied in the poses used in Experiment 4 was responsible for the activation of a spatially directed code and thus the Simon effect, such activation would be less pronounced or even absent for a pose in which no action was implied, and consequently would at least reduce the magnitude of the Simon effect. If, on the other hand, a Simon effect of similar magnitude was observed, then this would suggest that it is the

orientation of the body rather than the direction of the implied action of the body pose that was responsible for the observed Simon effect in Experiment 4. Second, and consistent with this first aim, we wished to assess the effect of body orientation in a task in which the type of action would not have to be deliberately processed. One could argue that the task of discriminating the action displayed by the two poses in Experiment 4 may have affected the processing of the implied action of these poses, thus increasing the possibility that the direction in which the action was performed was processed and subsequently activated a spatial code. To avoid this, observers were asked to perform a sex discrimination task (male/female) instead of the action discrimination task that was adopted in Experiment 4.

A final difference with the previous experiment was that instead of a unimanual response mode, the classical bimanual response mode was used in order to avoid possible motor speed differences between the fingers, as in Experiment 4. Thus, participants responded with their left and right index fingers. In all other respects, Experiment 5 was identical to Experiment 4.

3.3.1. Method

Participants

Eight undergraduate students and staff members from the Institute of Neuroscience, Trinity College Dublin (2 males and 6 females, with a mean age of 28.7 years) took part in the experiment. All reported normal or corrected-to-normal vision and were naïve with respect to the purpose of the study. The study was approved by the Ethics Committee of the School of Psychology at Trinity College Dublin, accordingly, all participants provided informed consent prior to the experiment.

Apparatus and stimuli

The apparatus and stimuli were identical to Experiment 4 with the exception that an additional third *standing* body pose (oriented to the left or right) was added. Thus, six different images were created for each model by combining two profile orientations with three different body poses (standing, waving, and

walking), resulting in a total of 24 stimuli. An example of the standing pose is shown in Figure 3.3.



Figure 3.3. Example of male with body orientation to the right in standing pose used in Experiment 5.

Design

The protocol of the experiment was identical to Experiment 4 with the following exceptions. Participants now had to discriminate the sex (male/female) of the presented model (i.e., the task-relevant dimension) by manually pressing the left or right response button with their left or right index finger, respectively. The left/right location of the required response was pitted against the left/right direction in which the body was oriented (i.e., the task-irrelevant dimension). The experiment was based on a fully factorial, two-way, within-subjects design in which stimulus-response compatibility (body orientation compatible with response location vs. incompatible), and the body pose (standing, waving, or walking) were manipulated. Similar to Experiment 4, the manipulation of stimulus-response compatibility (the combination of body orientation and the location of the required response) resulted in half of the trials with a compatible stimulus-response pairing and half of the trials with an incompatible stimulus-response pairing.

Procedure

The procedure was identical to Experiment 4 with the following exceptions. Participants were now instructed to press the left button with the index finger of the left hand if the model was male, and to press the right button with the index finger of the right hand if the model was female.

Participants first completed a set of 48 practice trials, followed by 16 blocks of 24 experimental trials. Each experimental block included a random presentation of the 4 models, in 2 body profile orientations and 3 poses. Participants were given the opportunity to take a one-minute rest every 3 blocks. The entire experiment lasted approximately 20 minutes after which participants were debriefed and thanked.

3.3.2. Results

The median RTs for correct responses and associated error rates were derived for each of the six conditions as a function of stimulus-response compatibility (body orientation compatible with response location vs. incompatible) and body pose (standing, waving, and walking). We conducted separate two-way, within-subject analyses of variance (ANOVA) on these RT and error data.

The analysis of the correct RT data revealed a main effect of body pose, $F(2, 14) = 4.285$, $MS_e = 387.005$, $p < .05$. The main effect of stimulus-response compatibility did not reach significance, $F(1, 14) = 3.194$, $MS_e = 432.475$, $p = .12$. However, there was a significant interaction between body pose and stimulus-response compatibility, $F(2, 14) = 5.444$, $MS_e = 184.797$, $p < .02$. Post-hoc pairwise comparisons with Bonferroni correction revealed that the median RTs for compatible and incompatible stimulus–response pairings differed significantly for the standing ($p < .02$) and waving body pose ($p < .02$), but not for the walking body pose ($p = .52$). As shown in Figure 3.4, for the standing and waving pose, participants were faster in responding to the sex of the model when the body was oriented towards the same side as the required response location (574 vs. 595 ms, and 590 vs. 609 ms), while this was not the case for the walking pose (608 vs. 600 ms).

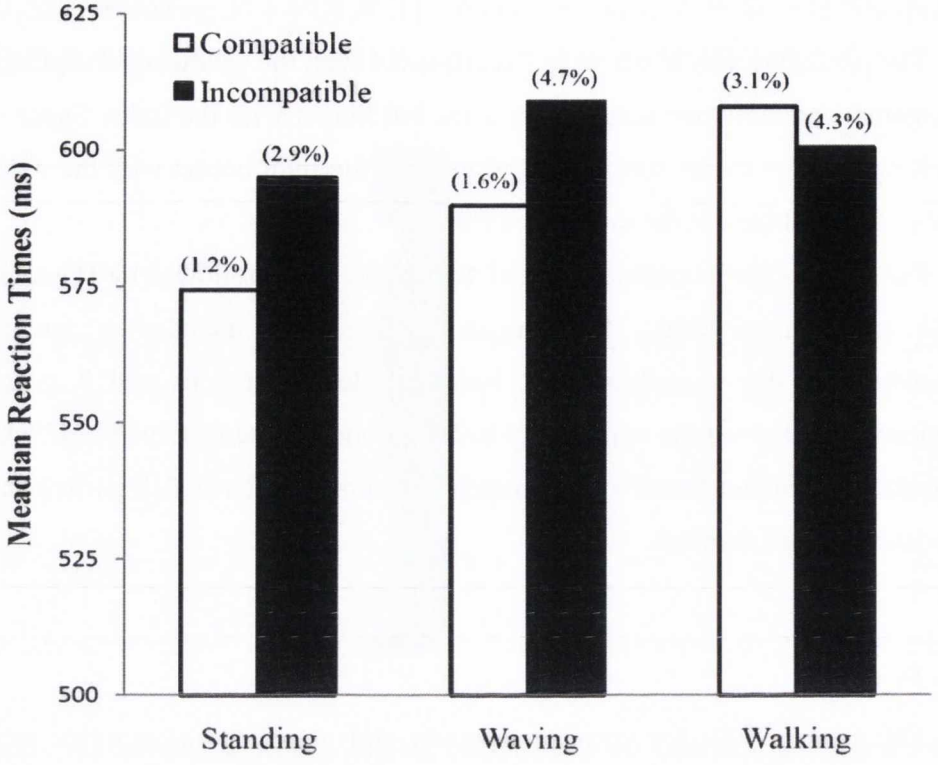


Figure 3.4. Median reaction times (ms) and associated error rates (%) in Experiment 5 as a function of response-compatibility and body pose.

The overall mean percentage error across participants was 2.96 %. The within-subjects ANOVA revealed no main effects of body pose (p = .18), or stimulus-response compatibility (p = .14), and the interaction between both failed to approach significance (F < 1). Although the effect of compatibility failed to reach significance, the mean error rates for compatible versus incompatible stimulus-response pairings for each of the three poses shows a tendency for fewer errors in the S-R compatible relative to the incompatible conditions. Thus, the effects of compatibility found in the analyses of the RT data cannot be explained by a speed-accuracy trade-off.

3.3.3. Discussion

The results of the present experiment only partially confirm those of Experiment 4. While a Simon effect was observed for the waving pose, unlike in Experiment 4 this was not the case for the walking pose. For the newly introduced standing pose, a Simon effect of similar magnitude (approximately 20 ms) as that for the waving pose was observed.

Disregarding the absence of a Simon effect for the walking pose for the moment, that a Simon effect of similar magnitude was found for the standing pose as for the waving pose, despite there being less of an action implied from the direction in which the body was oriented, suggests that the presence of implied action in the image of the body pose (e.g., the action of waving towards something or somebody) is not a necessary condition for obtaining a Simon effect. Instead, a body oriented in a certain direction seems to be sufficient by itself to activate a spatial code. Furthermore, the fact that a Simon effect was observed within a task in which the type of action displayed did not have to be deliberately processed (i.e., a sex discrimination task), strengthens the claim that body orientation is processed automatically and generates a directional spatial code.

At present it is unclear why we failed to observe a Simon effect for the walking pose in the present experiment although it was found in the preceding experiment. Although speculative, the difference on the one hand between the results of the walking pose and the two other poses (standing and waving) in the present experiment, and the difference between the results of the walking pose in the present versus the previous experiment on the other hand, may be related to a specific characteristic of the walking pose. In particular, for the stimuli displaying a walking pose, the model's arm was partly occluding the chest, and in addition, the chest was twisted somewhat away from the viewer due to the walking action (see Figure 3.1). Thus, in comparison to the waving and the standing pose, the most defining sex-specific features in the body shape, which were needed to perform the task in Experiment 5 were presumably harder to discriminate. These features on the other hand were not essential for the action discrimination task in Experiment 4. Therefore, one possibility is that an increase in the difficulty of encoding these sex-specific features may somehow have eliminated the Simon effect in Experiment 5, maybe due to prolonged processing of task-relevant aspects of the stimulus combined with a decaying activation of the spatial code that was triggered by body orientation[8]. However, even though comparison of the RT and error data of the walking pose with those of the waving pose in

[8] Hommel (1993, 1997) provided evidence for decreased Simon effects with increasing reaction times (though see Ansorge, 2003a, 2003b for evidence showing increased Simon effects with longer reaction times).

Experiment 5 does reveal somewhat longer RTs and higher error rates, these differences were not significant, thus questioning the hypothesis that encoding difficulty may have caused the absence of a Simon effect.

To further explore the hypothesis that the absence of a Simon effect for the walking pose may be due to prolonged processing of task-relevant aspects of the stimulus combined a with decaying activation of the spatial code that was triggered by body orientation, and to attain a better understanding of the time course of the Simon effect, we conducted additional analyses. For each individual, median reaction times were derived for the 50% slowest and 50% fastest responses and this separately for each of the six conditions (3 body pose x 2 S-R compatibility). These median RT data were analyzed by a three-way, within-subject analyses of variance (ANOVA), with the following factors: stimulus-response compatibility (body orientation compatible with response location vs. incompatible), body pose (standing, waving, and walking) and response speed (fast vs. slow responses).

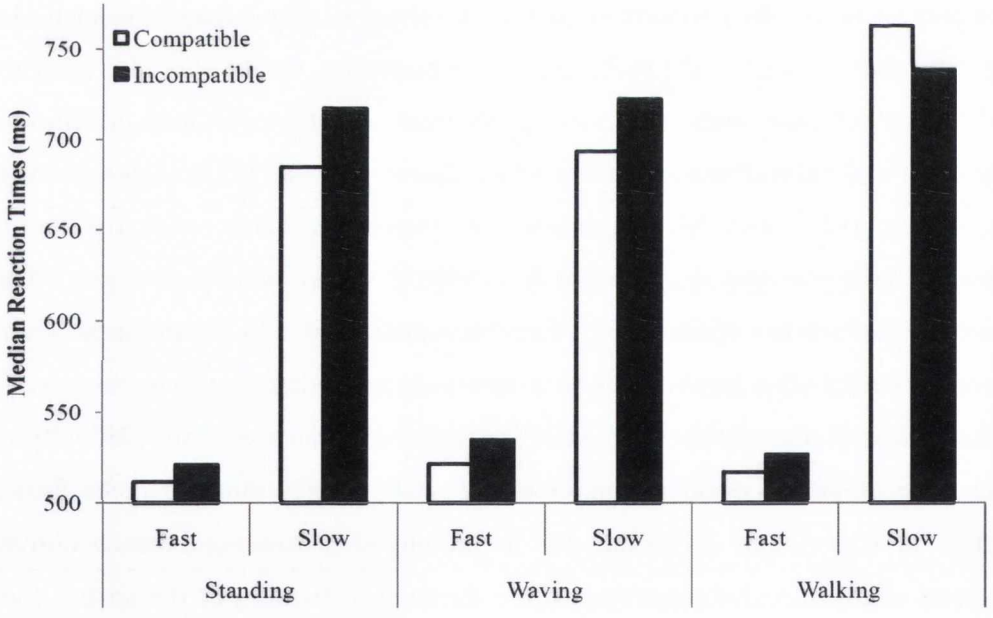


Figure 3.5. Median reaction times (ms) in Experiment 5 as a function of response-compatibility, response speed, and body pose.

As the analysis revealed a significant three-way interaction effect [$F(2, 14) = 5.795$, $MS_e = 326.149$, $p < .02$], it was followed up by separate compatibility x response speed analyses for each of the three body poses.

For the standing body pose, significant main effects of S-R compatibility [$F(1, 7) = 5.513$, $MS_e = 639.929$, $p < .05$], response speed [$F(1, 7) = 23.078$, $MS_e = 11784$, $p < .005$], and a significant interaction between these factors [$F(2, 14) = 5.788$, $MS_e = 182.786$, $p < .05$] were found. As shown in Figure 3.5, the compatibility effect (i.e., RT_{IC} versus RT_C) increased with slower RTs. Pair-wise comparisons (using Bonferroni correction) between compatible and incompatible conditions for slow and fast responses revealed a significant S-R compatibility effect for slow responses (33 ms; $p < .03$) but not for fast responses (10 ms; $p = .31$). For the waving body pose, significant main effects of compatibility [$F(1, 7) = 17.738$, $MS_e = 201.268$, $p < .005$], and response speed [$F(1, 7) = 36.851$, $MS_e = 7004.411$, $p < .001$] resulted, but no significant interaction between these factors, $F(2, 14) = 1.480$, $MS_e = 335.125$, $p = .27$. Although the interaction was not significant, a similar increase in the compatibility effect with slower RTs was present as was observed for the standing pose (i.e., an increase from 13 to 29 ms). Pair-wise comparisons between compatible and incompatible conditions for slow and fast responses revealed a significant S-R compatibility effect for slow responses (29 ms; $p < .001$) but not for fast responses (13 ms; $p = .15$). Finally, for the walking body pose, a significant main effect of response speed [$F(1, 7) = 24.204$, $MS_e = 17238.696$, $p < .005$], but no main effect of compatibility ($F < 1$) was observed. The interaction between these factors almost reached significance, $F(2, 14) = 4.752$, $MS_e = 472.357$, $p = .06$. As shown in Figure 3.5, a compatibility effect of 10 ms was present in the fast responses, but remarkably, this effect turned into a 24 ms reverse compatibility effect for the slow responses (i.e., faster responses when the body pose was oriented in the opposite direction as the required response location). However, both these effects did not reach significance (p's $> .29$).

Although the results of the analysis of compatibility effects as a function of response speed were not clear-cut, the Simon effect in the standing pose and waving pose conditions seemed to increase with longer RTs, and did not decrease with longer RTs. Thus, the suggestion that prolonged RTs may result in smaller Simon effects due to decaying activation of the spatial code that was triggered by body orientation is clearly not supported and hence does not seem to be able to explain the absence of a Simon effect for the walking pose. In fact, the results of the response speed x compatibility analysis of the walking pose seem to suggest a

reversal of the compatibility effect with increased RTs rather than a decrease of the compatibility effect for which there was some indication at the shorter RTs. At present we do not have an explanation for these results and further research will be needed to examine this issue.

3.4 General Discussion

The aim of the present study was to investigate whether the direction in which a body was oriented (i.e., trunk, legs, and arms in the absence of directional gaze and head cues) automatically activates a spatial code, which, in turn, can trigger shifts of attention. To this end, we adopted a Simon task with centrally presented body poses (with the head occluded) in which the direction in which the body was oriented was irrelevant to the task that had to be performed. The task relevant dimension was either the action displayed by the body pose (Experiment 4) or the sex of the displayed body (Experiment 5). With the exception of the results for the walking pose in Experiment 5, the present study provides evidence that, similar to eye gaze direction (Ansorge, 2003a; Zorzi et al., 2003), body orientation is automatically processed and generates a directional spatial code which in turn may trigger a shift in attention (Zorzi et al., 2003). Furthermore, the fact that we found a Simon effect with a body pose that did not signal implied motion (i.e., standing pose) suggests that the presence of an action implied by the body pose or an action direction indicted by the direction in which the body is oriented, is not a necessary condition for obtaining the effect. Instead, a body oriented in a certain direction seems to be sufficient to activate a spatial code. Finally, exploratory analyses of the relationship between response speed and the magnitude of the Simon effect seem to suggest that the activation of a directional spatial code based on body orientation is relatively long lasting and even seems to increase with longer RTs. This finding is in agreement with the time course of Simon effects induced by gaze direction (Ansorge, 2003a). Having studied the effects of body information in isolation, the results of the present study will serve as a reference to which the results of subsequent study involving full body stimuli with conflicting directional head and body information (Chapter 4) will be compared.

CHAPTER 4

THE ROLE OF SOCIAL CUES IN THE DEPLOYMENT OF SPATIAL ATTENTION: HEAD-BODY RELATIONSHIPS AUTOMATICALLY ACTIVATE DIRECTIONAL SPATIAL CODES IN A SIMON TASK

Autorship

Results from the following chapter were presented at the Annual Meeting of the Belgian Association for Psychological Science (BAPS) 2009:

Pomianowska, I., Newell, F. N., Kilianova, T., & Germeys F. (2009, June). *Processing of action components in human body poses: Incongruent head-body orientations automatically generate spatially defined codes in a Simon task.* Paper presented at the Annual Meeting of the Belgian Association for Psychological Science (BAPS), Brussels, Belgium.

The chapter has been submitted for publication:

Pomianowska, I., Germeys, F., Verfaillie, K., & Newell, F. N. (2010). The role of social cues in the deployment of spatial attention: Head-body relationships automatically activate directional spatial codes in a Simon task. Manuscript submitted for publication.

Abstract

Previous study (Chapter 3) showed that the direction in which a body is oriented (i.e., trunk, legs, and arms) automatically activates a spatial code even in the absence of directional gaze and head cues. It served as groundwork for the current study (Experiment 6), in which the effect of the relationship between the orientation of the head and body on the activation of directional spatial codes was investigated by means of a similar Simon task. Participants categorized the facial expression of forward facing, computer-generated human figures by pressing the right or left button, while the orientation of the body (trunk, arms, and legs oriented towards the left or right visual hemifield), which was the task-irrelevant feature of interest, was manipulated with respect to the spatial location of the required response. We found that when the orientation of the body was compatible with the required response location, responses were slower relative to when body orientation was incompatible with the response location. This reverse compatibility effect suggests that body orientation is automatically processed into a directional spatial code, but that this code is based on an integration of head and body orientation within an allocentric-based frame of reference. Moreover, we argue that this code may be derived from the motion information implied in the image of a figure when head and body orientation are incongruent. Our results have implications for understanding the nature of the information that affects attentional allocation for social orienting.

4.1 Introduction

It has been been mentioned in previous chapters that the human ability to infer where another person is directing his or her attention has an important, adaptive function. Moreover, it has been argued that there is a propensity for observers to orient their attention to the same object that other people are attending, a process referred to as *joint attention*, and that this process is automatic (Baron-Cohen, 1995a; Galantucci & Sebanz, 2009; Sebanz & Knoblich, 2009). Here we investigate the nature of the social information that contributes to this automatic deployment of attention, and specifically test the role of the relative orientation of head and body in this process.

As mentioned in Chapter 2, eye-gaze provides a particularly powerful cue to the direction and location of where another person is attending (e.g., Baron-Cohen, 1995a; Gibson & Pick, 1963; Langton et al., 2000; for recent reviews also see Becchio, Bertone, & Castiello, 2009; Frischen, Bayliss, & Tipper, 2007). For example, Driver et al. (1999) and Friesen and Kingstone (1998) used an adapted version of Posner's cueing paradigm (1980) with spatially unpredictive central gaze cues and reported evidence for reflexive attentional shifts in the direction of the eye-gaze. This automaticity strongly suggests that gaze direction is very likely to be transformed into a spatial code, which subsequently produces a shift in the allocation of attention (Zorzi, Mapelli, Rusconi, & Umiltà, 2003). Further evidence in support of the automatic generation of a spatial code was provided by Zorzi et al. (2003; also see Ansorge, 2003a) in a study involving a variant of the Simon task (Lu & Proctor, 1995; Simon & Craft, 1970; see Chapter 3).

Since eye gaze direction does not necessarily coincide with the direction of the head, it can be predicted that attentional allocation on the basis of gaze cueing is also affected by head orientation. Hietanen (1999) manipulated gaze direction and head orientation independently in a Posner (1980) cueing paradigm and found that reflexive orienting of attention was induced only when eye and head direction did not coincide. First, a central, non-predictive cue with a frontal face and averted gaze facilitated responses to targets appearing at the gazed at location (see e.g., Figure 4.1A for an adapted version of the stimulus). This suggests that the direction of gaze automatically triggered a shift of attention, activating a motor program, which in turn influenced the response. Second, a lateral face with gaze oriented in the same direction (Figure 4.1B) did not result in attentional cueing effects. According to Hietanen, this could be due to the fact that an averted head with a congruently averted gaze is a less powerful social signal in that the observed person is interpreted to be completely unrelated to the observer. Third, and most pertinent to the present study, when presented with a lateral head and a frontal gaze (averted back to the observer as shown in Figure 4.1C), there was a reverse validity effect: Observers were fastest when the head was oriented in a direction which was opposite (egocentric) to the location of the target stimulus. To explain this counterintuitive result, Hietanen suggested that, in the orienting of social attention, the direction of the observed person's gaze or head is not directly encoded relative to an observer-based (or egocentric) frame of reference. Instead,

gaze and head direction cues are combined into an allocentric frame of reference centred on the observed person (see step 1 in Figure 4.1), and only then is the direction of attention related to the observer's own egocentric frame of reference (step 2 in Figure 4.1). More specifically, a head oriented to the right of the observer with the gaze directed towards the observer (e.g., Figure 4.1C) would be coded as "a person attending to his/her right" in an allocentric reference frame centred on the observed person and this shifts the attention of the observer to the left (just like a head oriented straight with the eyes averted to the left of the observer is coded as "a person looking to his right" allocentrically, inducing an attention shift to the observer's left). Indeed, with two interacting persons facing each other, a leftward direction in an allocentric reference frame corresponds to a rightward direction in an observer-centred reference frame and vice versa.

Whilst it is clear that perceived eye and head direction are important cues for determining the direction and location of another person's attention, and have been studied quite extensively (for a review, see Frischen et al., 2007), the role of body information (i.e., the direction of the torso, arms, and legs) on reflexive attentional shifts is less well understood. In an experiment similar to the 1999 study, Hietanen (2002) again used a Posner paradigm in which spatially unpredictive cues of a person's head and upper part of the torso were displayed centrally. A cue containing head and upper-body oriented in different directions (i.e., head rotated towards the target but a front-facing upper-body, as shown in Figure 4.1D) facilitated reaction times while a cue with identical head and upper-body direction (i.e., both head and upper-body rotated towards the target, e.g., Figure 4.1E) did not.

These results, together with those mentioned earlier on eye and head direction (Hietanen, 1999), provide support for the suggestion that in social attention orienting, different cues are initially used to derive the other person's direction of attention in an allocentric reference frame and only after this, the other person's direction of attention is related to the observer's egocentric frame of reference (Hietanen, 2002). Based on the *reverse validity effect* (see e.g., Figure 4.1C), a model in which social attention orienting uses a hierarchy of social attention cues was proposed (Hietanen, 1999, 2002). According to the model, gaze direction is inferred relative to head orientation, and head orientation in turn is inferred relative to body orientation.

	Hietanen (1999)		
	A	B	C
			
Step 1: allocentric coding (observed person attends to his…)	left	straight	Right
Step 2: allocentric coding is related to the observer's frame of reference	right	straight	Left
Step 3: automatic attention shift observer	right	no	Left

	Hietanen (2002)		Present study
	D	E	F
			
Step 1: allocentric coding (observed person attends to his…)	left	straight	right
Step 2: allocentric coding is related to the observer's frame of reference	right	straight	left
Step 3: automatic attention shift observer	right	no	left

Figure 4.1. Automatic attention shifts based on referential coding of body parts in an allocentric-based frame of reference. (A) frontal head with gaze averted (B) lateral head with straight gaze in the same direction, (C) lateral head with gaze towards observer, (D) frontal body with head averted (E) sideways body with head in the same direction, and (F) sideways body with head facing the observer.

If the derived relationships between these cues suggest that the other person has a laterally averted attention direction, a spatially defined directional code is

then activated which may trigger an automatic shift of the observer's own attention in that direction (step 3 in Figure 4.1)[9].

4.2 Experiment 6

The most direct evidence for Hietanen's hypothesis that gaze, head, and body cues in social orienting are combined in an allocentric coordinate system centred on the observed person (rather than in an egocentric frame of reference) comes from the finding that, when the head is averted and the person is gazing at the observer (as shown in Figure 4.1C), a reverse validity effect is observed in a Posner paradigm. The aim of the present study was to extend this evidence in two ways.

First, we wanted to investigate the role of body orientation (i.e., trunk, arms, and legs) on the orienting of social attention in general and allocentric allocation of attention in particular. As discussed in the Introduction, Hietanen (2002) already manipulated the relationship between torso and head direction and he observed that cues with a body oriented towards the viewer and the head averted produced facilitation on valid trials (e.g., Figure 4.1D). Hietanen interpreted this as evidence for allocentric coding. However, while not in contradiction with such an account, this observation can be interpreted as evidence for egocentric coding as well (faster right (left) responses when the figure is looking to the observer's right (left)). More specifically, we reasoned that the generation of an allocentrically based spatial directional code should not be limited to situations in which an observed person's head (and gaze) is averted to one side, with the body in frontal view (i.e., different head/body orientations, e.g., Figure 4.1D), but

[9] Note that an alternative to the hierarchical model has been proposed. In contrast to Hietanen's (1999, 2002) studies, a paradigm which required a more explicit discrimination of gaze direction (i.e., an adapted Stroop paradigm in which participants had to respond either to the direction of gaze or to the orientation of the head and gaze and body information were placed into conflict or not) provide evidence for a facilitation of congruent eye gaze and head direction on performance and inhibition of incongruent eye-head directions (e.g., Langton, 2000; Langton, Watt & Bruce, 2000; Seyama & Nagayama, 2005). On the basis of these findings, Langton and colleagues proposed a model in which the directional information provided by different social cues is processed in parallel (even if some cues may be completely task irrelevant) and these cues have independent and additive effects on the discrimination of the perceived direction of social attention. We will come back to this alternative model in the Discussion of this Chapter.

should generalize to situations in which the body is oriented away and the person is facing the observer. For example, in the case of a frontal view of the head (with straight gaze) combined with a body oriented to the right of the observer (as shown in Figure 4.1F) the predicted spatial directional code should be in the opposite direction of the body orientation. Indeed, such a combination of head/body orientations would, if coded in an allocentrically based frame of reference, activate a spatial code directed to the observed person's right (see Figure 4.1, step 1; and, therefore, the observing person's left in an egocentrically frame, step 2), despite the fact that head and eye gaze are oriented directly towards the viewer.

Second, based on the concept of convergent operations (Garner, Hake, & Eriksen, 1956), we intended to extend the evidence collected with a Posner cueing paradigm to data gathered with another experimental paradigm. Specifically, we used an adapted Simon paradigm similar to Zorzi et al. (2003; see also Ansorge, 2003a), which required processing of a feature of the stimulus cue, namely the facial expression of a figure (i.e., the task-relevant feature). The figure was presented in full body and the orientation of the body, facing either the left or right hemifield vis-à-vis the head, was manipulated. The face was always presented and facing forward (i.e., towards the participant) and only the face contained information relevant to discriminate the emotional state of the person, rendering body orientation task-irrelevant. Note that, by focusing the task on the face of the figure, the body was, at least in retinal terms, presented outside of foveal vision although perhaps not outside of attentional focus (because attention may spread to the body in an object-based manner; Mozer & Vecera, 2005; Scholl, 2001). The leftward or rightward body orientation was pitted against the spatial location of the required response (i.e., left or right button), with the orientation of the body being either compatible or incompatible with the required response location[10].

[10] To avoid confusion, here and in the remainder of this chapter, we will use the terms *compatible* and *incompatible* to refer to the relationship between the required response location (based on the emotional expression displayed) and the task-irrelevant stimulus attribute, body orientation. The terms *congruent* and *incongruent* will be used to refer to the relationship between head (gaze) and body orientation.

We predicted that if body orientation is automatically processed and activates a directional spatial code then it should induce a *Simon effect*. Moreover, if attentional allocation on the basis of social cues is based on direct egocentric coding (centred on the observer), performance to compatible response locations should be facilitated relative to incompatible response locations. For example, a body oriented towards the right visual hemifield should facilitate responses made within that same hemifield in comparison to those made in the other hemifield. In contrast, however, Hietanen's model predicts that the directional spatial code is derived from an integration of head and body orientation coded in an allocentric frame of reference (centred on the observed person). If this is the case, then reaction times to facial expressions requiring a right response should be faster when the figure's body is oriented to the left than to the right. In other words, this model predicts a *reverse compatibility effect* (similar to the *reverse validity effect* reported by Hietanen, 1999).

4.2.1. Method

Participants

Eleven undergraduate students and staff members from the University of Leuven (6 male and 5 female, with a mean age of 26.8 years) participated in the experiment. All reported normal or corrected-to-normal vision and were naïve with respect to the purpose of the study. Our study was approved by the Department of Psychology Ethics Committee, University of Leuven and, accordingly, all participants provided informed consent prior to the experiment.

Apparatus and stimuli

Stimuli were displayed on a 19-inch CRT colour monitor with a refresh rate of 75 Hz, driven by a Dell XPS 420 PC using E-prime software (version 2.0). Participants sat in a darkened room, with their head stabilized on a chin-rest, which was positioned 80 cm from the monitor. Responses were collected using a serial response box, model 200A (Psychology Software Tools), which was placed in front of the participant and was aligned with the horizontal midpoint of the screen.

Stimuli consisted of computer-generated human figures, which were presented against a white background. The images of the figures subtended a visual angle of 9° in the vertical direction and the image of the head subtended a visual angle of approximately 1.1° x 0.7°. Images of human figures were presented in the centre of the screen with the midline of the face aligned with the vertical axis of the screen. A fixation cross, centred on the mouth of the subsequent figure, was presented prior to each stimulus image.

The images of the human figures were generated using the 'Poser'™ computer graphics software (version 7.0, E-Frontier Inc.). Four different models were used, two male and two female, and each wore different clothing. Each was illuminated by three infinite light sources (a frontal light and two lights positioned 30° left and right of the figure from an angle of 45° above the viewer), which created smooth shading on the models. Images were rendered in colour without external shadows. The models were presented in a standing position with their heads facing towards the participant. Eight different images were created from each computer-generated character by combining two different facial expressions (happy and sad) with four different body orientations (60° left, 30° left, 30° right, and 60° right). The direction of the eye gaze and the head remained fixed for all images. Examples of the stimuli are shown in Figure 4.2.

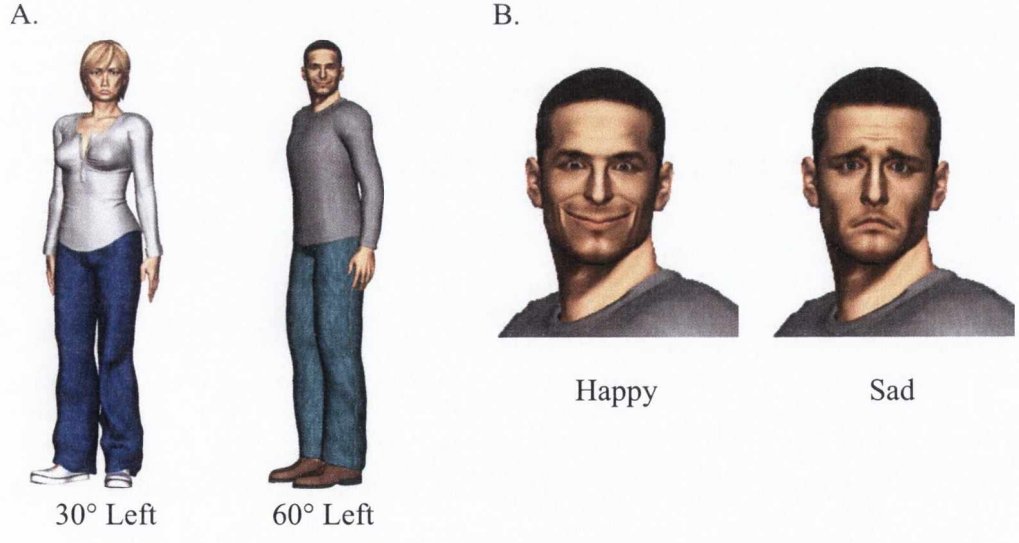


Figure 4.2. Examples of stimuli used in Experiment 6. (A) A female with body orientation to the left with an angle of 30 degrees (sad facial expression) and a male with body orientation to the left with an angle of 60 degrees (happy facial expression). (B) Close-up of happy and sad facial expressions of a male figure.

Design

The protocol of the experiment was based on a *Simon task*. Participants had to discriminate between happy and sad facial expressions of the figure (the relevant dimension) by manually pressing the left or right response button. Half of the participants pressed the left response button to indicate a happy face and the right button for a sad face, and vice versa for the remaining participants. The location of the response keys for the task was pitted against the hemifield location to which the body of the figure was facing (the task-irrelevant dimension). The experiment was based on a fully factorial, three-way, within-subjects design in which overall body orientation (left or right), angle of the body orientation (30° or 60°), and the location of the response key (left or right) were manipulated.

Procedure

Each trial began with the presentation of a fixation cross for 760 ms, followed by an 80 ms blank interval, and then the stimulus. Participants were instructed to keep their eyes on the fixation cross and to respond to the facial expression as rapidly and accurately as possible once the human figure appeared. Participants responded with the index finger of their right or left hand (i.e., left index finger on left button for a happy face, right index finger on right button for a sad face or vice versa). The stimulus remained present until a button press was recorded. Feedback was provided following each response: Correct responses were followed by a green plus sign (0.5° x 0.5°) and incorrect responses were followed by a red minus sign, and these symbols were presented at the location of the previous fixation cross for 240 ms. The inter-trial interval was set at 1000 ms.

Participants first completed a set of 32 practice trials, followed by six blocks of 96 experimental trials. Each experimental block included three repetitions of the 32 stimuli (4 models, 2 facial expressions, 2 directions of body orientation, and 2 angles of the body orientation), which were presented in a random order. After each block, participants were encouraged to take a one-minute rest. The entire experiment lasted approximately 30 minutes after which participants were debriefed.

4.2.2. Results

The median reaction times (RTs) for correct responses and associated error rates to each of the eight conditions as a function of response location (left or right), hemifield orientation of the body (left or right), and angle of body orientation (30° or 60°) are presented in Table 4.1.

Table 4.1. Average median reaction times (ms) and error rates (%) as a function of response location, body orientation, and angle of body orientation in Experiment 6.

	Left body orientation			Right body orientation		
	30°	60°	Mean	30°	60°	Mean
			Reaction times			
Left response	608	610	609	597	596	596
Right response	597	602	599	604	612	608
			Errors			
Left response	3.3	4.4	3.9	3.4	4.2	3.8
Right response	3.3	5.3	4.3	4.4	5.9	5.1

We conducted separate three-way, within-subject analyses of variance (ANOVA) on these RT and error data. The analysis of the correct RT data revealed no main effects of response location, direction of body orientation, or angle of body orientation (all *F-values* < 1). However, the interaction between response location and direction of body orientation was significant, $F(1, 10) = 14.756$, $MS_e = 171.432$, $p < 0.01$. None of the other interactions reached significance (all *F-values* < 1). As shown in Figure 4.3, participants were faster in deciding which emotional expression was expressed by the character when the body of the character was oriented towards the hemifield opposite to that of the required response. For example, when a happy face required a right response, participants were faster when the body of the computer-generated character was oriented to the left than when it was oriented to the right. This reverse stimulus-response compatibility effect by a task-irrelevant stimulus attribute, namely body orientation, was 11 ms on average.

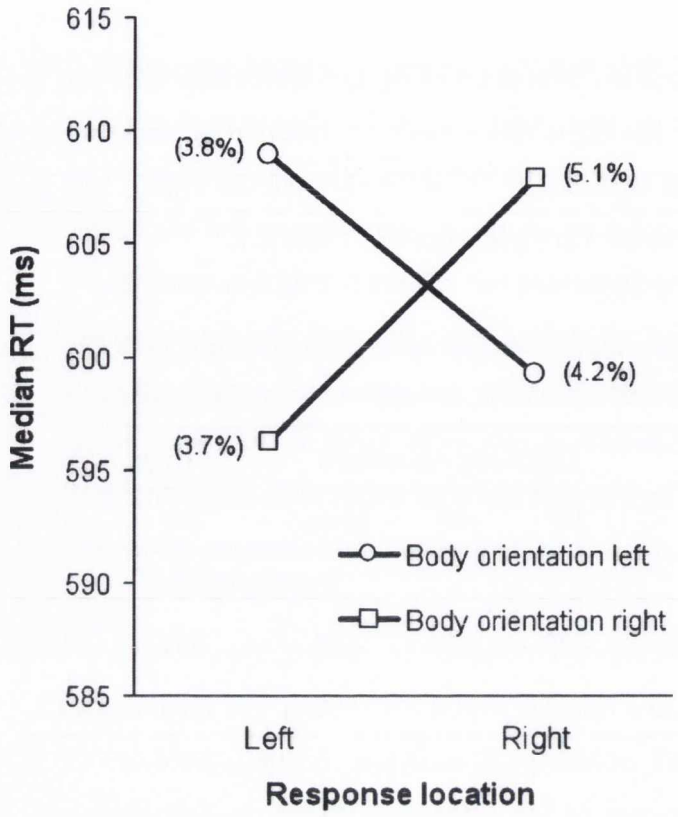


Figure 4.3. Median reaction times (ms) as a function of response location and body orientation in Experiment 6. Mean error rates (%) are shown between brackets.

The overall mean percentage error across participants was 4.28 %. The within-subjects ANOVA revealed no main effects of response location (p = .23) or direction of body orientation (F < 1). However, a significant main effect of angle of body orientation was observed, $F(1, 10) = 12.460$, $MS_e = 3.253$, $p < 0.01$. Errors were more frequent when the angle of the body was oriented by 60° compared to 30° ($M_{60°}$ = 4.96% versus $M_{30°}$ = 3.60%). All interactions failed to even approach significance (all *F-values* < 1). The mean error rates associated with the nonsignificant response location x direction of body orientation interaction found in the RT data are shown in Figure 4.3. Importantly, these findings imply that the significant interaction between response location and direction of body orientation in the RT data cannot be explained by a speed-accuracy trade-off (error rates for compatible body-orientation / response-location trials were 4.51 % on average, and 4.04 % for incompatible trials).

4.3 Discussion

The present study examined whether the orientation of the body (i.e., trunk, arms, and legs) is automatically processed and generates a directional spatial code. To examine this issue, a Simon paradigm was adopted in which the task required processing of a non-spatially oriented feature of the stimulus, namely its facial expression, while at the same time the (task-irrelevant) direction in which the body was oriented was manipulated and this direction was either compatible or incompatible with the location of the response key. We found a systematic reverse compatibility effect: When the categorization of the facial expression required a left (right) response, reaction times were faster when the body was oriented to the right (left) compared to when it was oriented to the same side as the response location. Even though the direction of the body was task-irrelevant, and presented in parafoveal/peripheral vision, it nevertheless generated a directional spatial code, which subsequently affected response selection (Lu & Proctor, 1995; Zorzi & Umiltà, 1995). This Simon effect suggests that processing of body direction is automatic.

In line with the *reverse validity effect* observed by Hietanen (1999), the *reverse compatibility effect* observed here suggests that the orientation of the trunk does not generate a spatial code in an observer-based frame of reference but rather in an allocentric frame of reference centred on the observed person. In this sense, the present study provides further evidence in support of Hietanen's model (1999, 2002) on the orienting of social attention in which spatially defined directional codes which automatically trigger attention shifts are activated based on referential coding of body parts (i.e., in an allocentric-based frame of reference). In particular, Hietanen suggested a hierarchical referencing scheme in which gaze direction is referenced to head orientation, and head orientation in turn is referenced to body orientation. Accordingly, in the present experiment, the combined hierarchical coding of head orientation relative to body orientation activated a spatial code in the opposite direction of the body orientation (even though the head of the figure was facing towards the observer), producing the observed reverse compatibility effect.

Furthermore, these findings are in contrast to those predicted by a model in which different social cues (e.g., eye, head, and body direction) are processed in

parallel, and have independent and additive effects as suggested by Langton and colleagues (Langton, 2000; Langton et al., 2000). According to their model, a spatial code consistent with the direction of the body from the observer's point of view should have been activated, predicting a compatibility effect (i.e., faster reaction times when response location and body orientation are in agreement), which was not what was found.

We speculate that one reason why allocentric coding may be important is that, when body and gaze are not oriented congruently, perception of implied motion may be induced (Freyd, 1983; Jellema & Perrett, 2003a, 2006). For example, a human figure with its trunk and legs oriented to the left (of the viewer) and a head facing front, may imply a rotating action of the head from a resting posture with congruent head and body direction (to the left of the viewer) to the figure's allocentric left (to the right of the viewer). Thus, the incongruently oriented head and body may have induced some form of implied motion perception, which activated a dynamically based directional spatial code as a result of allocentric coding of body parts.

Neurophysiological and neuroimaging studies have provided evidence that the superior temporal sulcus (STS) region of the brain, which is known to be activated by images of the face and body, is also activated by images which imply body-part motion and more generally to stimuli that signal the actions of another individual (for a discussion of these studies see for example, Allison, Puce & McCarthy, 2000; Kourtzi, Krekelberg & van Wezel, 2008). Human fMRI (e.g., Beauchamp, Lee, Haxby, & Martin, 2003; Grossman & Blake, 2002; Peuskens, Vanrie, Verfaillie, & Orban, 2005; Thompson, Clarke, Stewart, & Puce, 2005) and rTMS studies (Grossman, Batelli, & Pascual-Leone, 2005) documented that STS regions show a strong specialization for the perception of actions and body postures. This was confirmed in single-cell recording studies in monkeys (e.g., Barraclough, Xiao, Oram, & Perrett, 2006; Jellema & Perrett, 2003a, 2003b, 2006; Jellema, Baker, Wicker, & Perrett, 2000; Vangeneugden, Pollick, & Vogels, 2009). Moreover, of the cells that respond to static images of human figures, approximately 60% are sensitive to the degree of articulation shown by the human. Furthermore, about half of the cells sensitive to images of human figures prefer implied motion (Barraclough et al., 2006). Jellema and Perrett (2003a) found cells in the anterior part of the STS coding for a particular

articulated[11] action both when actually presented and when implied in a still image. Furthermore, the cells studied did not respond to the sight of a non-articulated static posture, which formed the starting-point of the action, but responded vigorously to the articulated static posture formed by the end-point of the action. It is worth noting that the stimuli of articulated static postures, which formed the end-point of the actions in that study were very similar to the stimuli used in the present study. The activated directional spatial code causing the reverse compatibility effect in the present study may reflect the influence of processes related to implied motion processing in STS. However, although it is known that reciprocal connections between STS and the inferior parietal lobule exist (Harries & Perrett, 1991; Rizzolatti & Matelli, 2003; Seltzer & Pandya, 1994), a link between STS implied motion processing and attentional functions remains speculative (Jellema & Perrett, 2006) until further investigations are conducted.

[11] Following Jellema and Perrett (2003a) we define articulated actions as actions where one body part (e.g., head) moves with respect to the remainder of the body, which remains static. Non-articulated actions are actions where the equivalent body parts do not move with respect to each other, but move as a whole. Similarly, articulated static body postures contain a torsion or rotation between parts, while non-articulated postures do not.

CHAPTER 5

VOLUNTARY AND REFLEXIVE VISUAL ORIENTING IN RESPONSE TO BODY ORIENTATION OF OTHERS

Autorship

Results from the following chapter were presented at the Annual Conference of The British Psychological Society (BPS) 2008:

Pomianowska, I., Germeys, F., & Newell, F. N. (2008, April). *Social perception from visual cues: The role of body orientation in the computation of attention direction.* Poster session presented at the Annual Conference of The British Psychological Society (BPS), Dublin, Republic of Ireland.

Abstract

A growing body of research suggests that an image of the human body influences our perception and deployment of attention. However, it remains unknown how body cues affect the orienting of visuospatial attention. In two experiments we investigated the propensity of a centrally presented body stimulus to induce voluntary and reflexive orienting of an observer's spatial attention. Participants were required to perform a categorization response of a target letter L or T, which could appear to the left or the right of a centrally presented body image. Prior to the presentation of the target, one of these possible locations was cued by the orientation of the image of the human body (which was presented with head occluded by a black square). The human body cue (representing a standing or walking pose) triggered faster target detection latencies at cued relative to uncued locations when the cues were informative about the target location (Experiment 7). This result suggests that observers may use strategic, predictive simulations of the future direction of motion/action of another person. However, contrary to expectations, a reflexive cueing effect by an uninformative and to-be-ignored body cue was observed only with a standing pose and not with poses in which motion was implied (Experiment 8). In general the results of this study show that a directional, centrally presented human body can trigger voluntary and reflexive, covert shifts of attention to peripheral locations. It is suggested however, that further research should be pursued in order to reveal the differences in the propensities of static and dynamic body poses to cue our attention to the direction of another individual's focus of attention.

5.1 Introduction

It has been stated in previous chapters that humans reveal a strong inclination to look where other people look (Argyle & Cook, 1976; Shepherd, 2010; Tomasello, Carpenter, Call, Behne, & Moll, 2005; van Hoof, 1967). However, before a state of *joint attention* is established, that is when two individuals are attending to the same object (Emery, 2000, p. 588), an observer must perform a gaze-following behaviour to a relevant object indicated by another agent's deictic gaze (e.g., Bruner, 1983; Moore & Dunham, 1994; for a review,

see Shepherd, 2010). Yet still, prior to an overt eye movement to the direction of another's focus of attention, a covert shift in social attention needs to take place (Deubel & Schneider, 1996; Hoffman & Subramaniam, 1995; Kowler, Anderson, Dosher, & Blaser, 1995; Peterson, Kramer, & Irwin, 2004). It has already been demonstrated in numerous behavioural studies that social cues (e.g., as eye-gaze, head, tongue pointing direction) can trigger a reflexive, covert orienting of an observer's visual attention (Downing, Dodds, & Bray, 2004; Driver, Davis, Ricciardelli, Kidd, Maxwell, & Baron-Cohen, 1999; Friesen & Kingstone, 1998; Hietanen, 1999; Kingstone, Friesen, & Gazzaniga, 2000; Kingtson, Tipper, Ristic, & Ngan, 2004; Langton & Bruce, 1999). In mentioned already Stroop-type interference paradigm (see Chapter 2), Langton and colleagues demonstrated that information from hand gestures can be equally important in indicating the direction of social attention as eyes and head cues (Langton, O'Malley, & Bruce, 1996; Langton, Watt, & Bruce, 2000). This suggests that directional information derived from other body parts also affects the computation of direction of social attention. Hietanen (2002), on basis of his results, suggested that reflexive shifts of attention in the direction signalled by a directional social cue (e.g., eye-gaze, or head) are only triggered when information about the relationship between this cue and other available cues (e.g., trunk orientation) is combined and signals the direction of an averted attention within the observed person's own frame of reference.

These observations are in line with the fact that the range of human eye movements constrains the range of visual attention much more than the ranges of head and body orientations (Shepherd, 2010). Therefore, while shifting the focus of attention to another location in the environment, human's eyes lead the head, which in turn leads the body posture, according to the inertia rule (Suzuki, Izawa, Takahashi, & Yamazaki, 2008). For that reason, it can be assumed that body posture as well as head or gaze orientation can effectively signal the direction to which another individual is attending and therefore guide our spatial attention to that person's action-relevant spatial location (see also Hietanen, 2002; Langton & Bruce, 1999).

An important extension to this field of investigation is the question whether attentional responses to body orientation differ from attention orienting responses triggered by the head and eyes. Most of the above mentioned studies concerning

the establishment of joint attention through shifts of social attention, typically used the cueing method for studying spatial orienting that was popularized by Posner (1978, 1980) and his colleagues[12]. This methodology is used to show that centrally presented directional social stimuli trigger voluntary or/and automatic shifts of a viewer's visual attention (e.g., faster discrimination of targets presented at a location in the direction of gaze as opposed to non-gazed-at locations even when eye-gaze is completely uninformative regarding the location of the upcoming target, e.g., Driver et al., 1999). The methodology used in the experiments reported here is also based on a classical Posner central cueing paradigm, especially on an adapted version used in the study of Driver et al. (1999). These authors used the established cueing method in order to investigate mechanisms involved in the perception of gaze direction, introducing at the same time more social questions about spatial orienting onto the agenda of mainstream attention research.

Present study

The primary objective of the present study was to examine the mechanism of attention orienting in response to a viewed image of a body in order to assess the contribution of body orientation to the computation of the direction of attention. For this purpose, voluntary as well as automatic attention orienting were both of interest. Therefore, two existing variations in the cueing methodologies were introduced and the associated distinction between two kinds of spatial orienting. In particular, we first sought to determine whether the human body image as an informative cue is able to orient our attention voluntarily[13]

[12] In a typical study participants perform a speeded detection task. Their attention would be cued either by a brief but uninformative flash on one side, or by an instruction that targets are most likely to appear on one of the sides. The usual outcome is a robust advantage in latencies of responses to targets appearing at the cued than on the uncued side, due to the orienting of attention in this direction.

[13] Voluntary orienting takes place when a person bases his expectancy regarding the target position according to the direction of an informative cue (Posner, 1980). On the other hand, reflexive cueing is an effect obtained with a non-predictive cue to where the target is likely to appear. The characteristic feature of such effect is that it cannot be ignored, despite a person's intention to do so (Jonides, 1981; Müller & Rabbitt, 1989a, 1989b). Voluntary orienting emerges as a slower process, however it is more durable. As it is based on the participant's expectancy about where the target will appear, the cueing effect is present as long as such expectancy holds.

(Experiment 7). Next, we examined whether such an attention orienting effect can arise automatically (Experiment 8), thus it investigated whether reflexive attention orienting in the direction of a seen human body can arise even when that direction is entirely uninformative for the prescribed target task. If body orientation automatically generates a directional spatial code, which was demonstrated previously based on a Simon task (see Chapters 3 & 4), it might drive subsequent attentional shifts into the side corresponding with its orientation (e.g., a body oriented left should trigger a shift of attention to the left).

5.2 Experiment 7

The first experiment in this chapter examined, whether directional body information can serve as a cue for voluntary attention shifts. To this end, we adopted Posner attentional cueing paradigm with an informative centrally presented cue, i.e., an image of a human body presented in one of three postures (standing, waving, or walking), oriented to the left or right or straight ahead towards the viewer. This was followed by a target presented to the left or to the right of the central figure (at different SOAs, i.e., 100, 300, 700 ms). Reaction times to congruent[14], neutral and incongruent cue-target combinations were assessed at three different SOA in order to investigate the time-course of the potential cueing effect.

5.2.1. Method

Participants

Twenty-four undergraduate students and staff members from the Institute of Neuroscience, Trinity College Dublin (7 males and 17 females, with a mean age of 27.2 years) participated in the experiment. All reported normal or corrected-to-normal vision and were naïve with respect to the purpose of the study. The study was approved by the Ethics Committee of the School of Psychology at Trinity

[14] Please, note that here and in the remainder of this chapter, the term congruency will be used to refer to the relationship between body orientation and target location (i.e., a congruent relationship refers to the body being oriented towards the target location, while an incongruent relationship refers to the body being oriented in an opposite direction).

presentation of a fixation cross for 1000 msec (participants were instructed to keep their eyes on it), followed by a centrally presented image of a human model. After 100, 300 or 700 ms (SOA), a target letter appeared on the left or right side of the model. The target letter disappeared after 100 ms, while the picture of the model remained present until a response was recorded. Participants were required to discriminate the target letter ("T" or "L") as fast and as accurately as possible, by manually pressing the upper-key on the response box with the index finger of their preferred hand to indicate the letter "T", or by pressing the lower-key with the thumb of the same hand to indicate the letter "L". Feedback was provided following each response: correct responses were followed by a green plus sign (0.5° x 0.5°) and incorrect responses were followed by a red minus sign. These feedback symbols were presented at the location of the previous fixation cross for a duration of 680 msec. No inter-trial interval was provided and the whole cycle of events was directly repeated to produce the next trial. Participants were explicitly informed that "Although the direction in which the body faces does not always predict the location of the target, your performance will generally be better if you take notice of this direction".

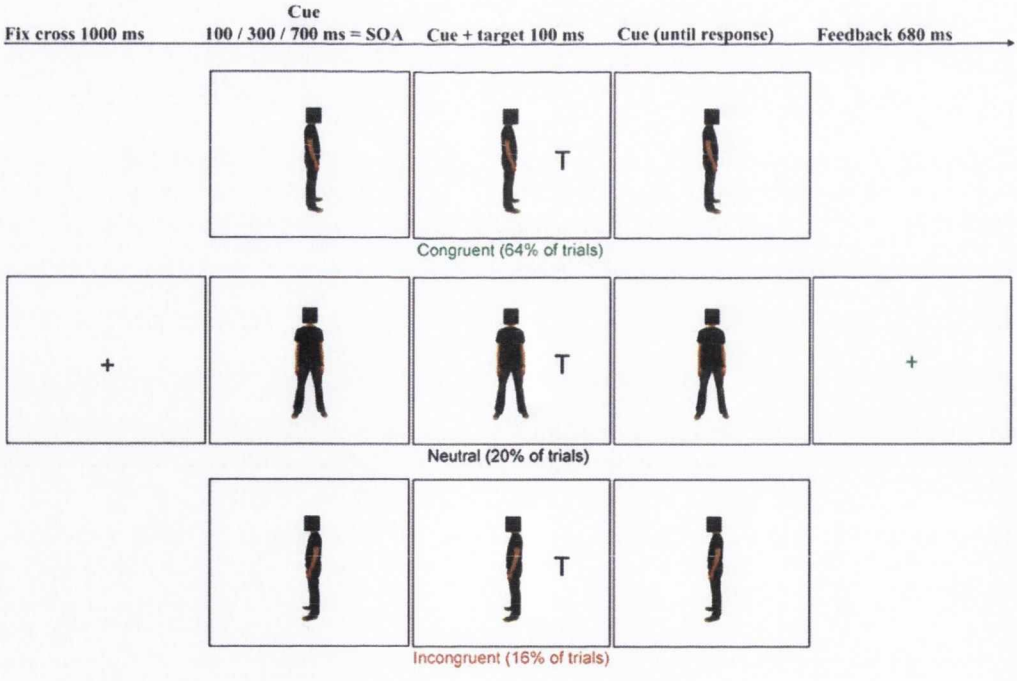


Figure 5.2. Schematic representation of a trial in Experiment 7.

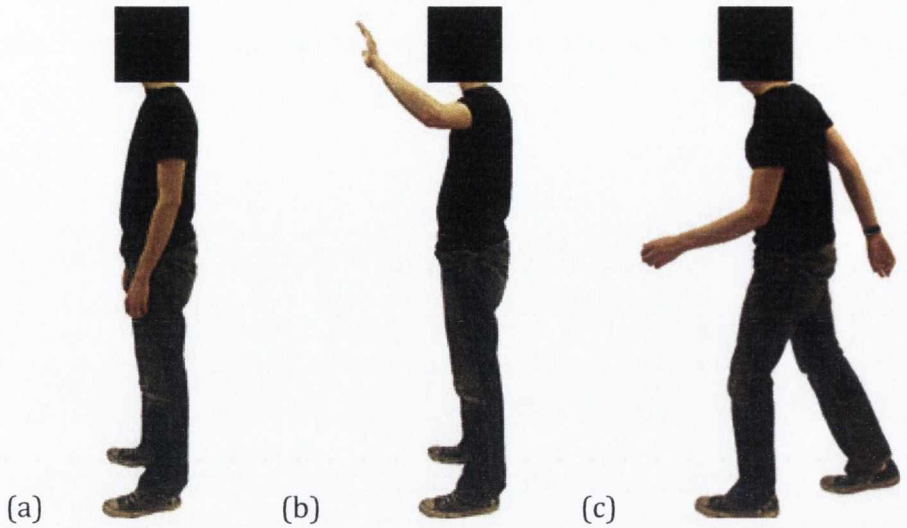


Figure 5.1. Examples of stimuli used in Experiment 7 and 8. A male model with the body orientated to the left, performing three different body poses: (a) standing, (b) waving, and (c) walking.

Design

The experiment was based on a fully factorial, three-way, within-subjects design in which the orientation direction of the model relative to the location of the target (neutral, congruent or incongruent), body pose (standing, waving, or walking), and SOA (100, 300, or 700 msec) were orthogonally manipulated, resulting in 27 conditions. However, the probability of neutral, congruent, and incongruent trials was not identical. Following Posner (1984, Experiment 1), 20% of the trials included models oriented towards the viewer (i.e., neutral trials), 64% oriented towards the target location (i.e., congruent or predictive trials), and 16% oriented towards the opposite side than that of the target location (i.e., incongruent or counter-predictive trials). Thus, when a profile view of a model was presented (i.e., congruent and incongruent trials) it had a 80% predictability with respect to the future target location.

Procedure

The protocol of the experiment was based on a Posner attentional cueing task with central cues. As shown in Figure 5.2, each trial began with the

presentation of a fixation cross for 1000 msec (participants were instructed to keep their eyes on it), followed by a centrally presented image of a human model. After 100, 300 or 700 ms (SOA), a target letter appeared on the left or right side of the model. The target letter disappeared after 100 ms, while the picture of the model remained present until a response was recorded. Participants were required to discriminate the target letter ("T" or "L") as fast and as accurately as possible, by manually pressing the upper-key on the response box with the index finger of their preferred hand to indicate the letter "T", or by pressing the lower-key with the thumb of the same hand to indicate the letter "L". Feedback was provided following each response: correct responses were followed by a green plus sign (0.5° x 0.5°) and incorrect responses were followed by a red minus sign. These feedback symbols were presented at the location of the previous fixation cross for a duration of 680 msec. No inter-trial interval was provided and the whole cycle of events was directly repeated to produce the next trial. Participants were explicitly informed that "Although the direction in which the body faces does not always predict the location of the target, your performance will generally be better if you take notice of this direction".

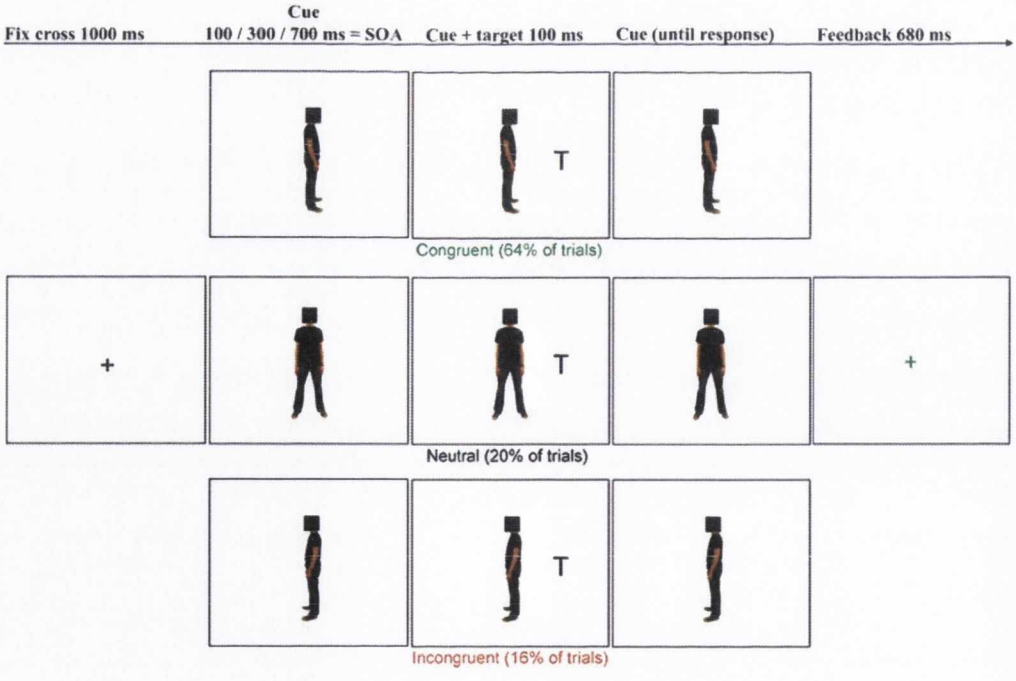


Figure 5.2. Schematic representation of a trial in Experiment 7.

Each participant first completed a set of 36 practice trials, in order to get familiarized with the stimuli, the targets and their respective responses. This was followed by 450 experimental trials. These included 288 congruent trials (64%), 90 neutral trials (20%), and 72 incongruent trials (16%), which in turn were comprised of a combination of 4 models in 3 body poses (standing, waving, walking), presented in 3 SOA's (100, 300, 700 ms) with 2 target letters (L or T) in 2 possible target positions (left or right). Trials were presented in a random order. After each 100 trials, participants were given the opportunity to take a one-minute rest. The entire experiment lasted approximately 30 minutes after which participants were debriefed.

5.2.2. Results

The median reaction times (RTs) for correct responses and associated error rates were calculated for each of the 27 conditions as a function of body pose (standing, waving or walking), SOA (100, 300, 700 msec) and congruency (congruent, neutral, or incongruent). The average median RT in the experiment across participants was 349 ms and the average error rate 4.39%.

At first, we limited the analyses to data from the congruent and incongruent conditions (i.e., data from the neutral conditions were not included), for ease of interpretation. Separate, three-way within-subjects analysis (ANOVA) with the factors congruency (congruent, incongruent), body pose (standing, waving, walking), and SOA (100, 300, 700 ms) were conducted on the RT and error data. The analysis of the correct RT-data revealed significant main effects of SOA [$F(2, 46) = 17.068$, $MS_e = 965.782$, $p < .001$], and congruency, $F(1, 23) = 13.054$, $MS_e = 2005.563$, $p < .001$. Furthermore, a significant interaction between SOA and congruency was observed, $F(2, 46) = 3.602$, $MS_e = 709.299$, $p < .05$. All other main effects and interactions did not reach significance (all p's $> .23$). As shown in Figure 5.3, congruent conditions resulted in faster responses than incongruent conditions, but this cueing effect was modulated by SOA. Planned pairwise comparisons revealed a significant cueing effect (i.e., incongruent minus congruent) of 20 ms at SOA 300 ms ($p < .005$), and 21 ms at SOA 700 ms ($p < .005$). The 6 ms cueing effect observed at SOA 100 ms did not reach significance.

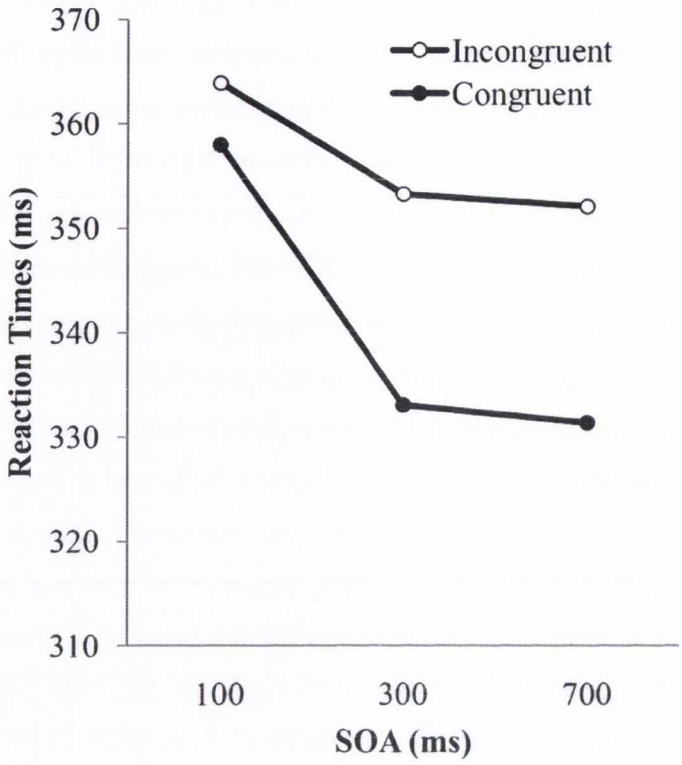


Figure 5.3. Median reaction times (msec) as a function of congruency and SOA in Experiment 7.

The analysis of the error data (see Table 5.1) showed a significant main effect of body pose [$F(2, 46) = 3.908$, $MS_e = 26.756$, $p < .05$], and a significant interaction between body pose and congruency, $F(4, 92) = 3.224$, $MS_e = 26.959$, $p < .05$. All other main effects and interactions did not reach significance (all p's $> .17$). Post hoc comparison of the error rates of congruent and incongruent conditions for each body pose (using Bonferroni correction), showed no significant difference for the standing (4.5 % vs. 4.9 %, n.s.) and walking pose (4.0 % vs. 4.0 %, n.s.), thus indicating that the congruency effects found in the RT-data are not due to a speed-accuracy trade-off. However, for the waving pose, a significant difference was observed, with more errors in the congruent compared to the incongruent condition (4.3 % vs. 1.7 %, $p < .01$). The latter results complicate the interpretation of the congruency effect found in the RT-data as faster RTs observed in congruent conditions may be due to a speed-accuracy trade-off.

Table 5.1. Mean error rates (%) for the standing, waving, and walking body pose, as a function of SOA and congruency in Experiment 7.

	Standing			Waving			Walking		
	Congruent	Neutral	Incongruent	Congruent	Neutral	Incongruent	Congruent	Neutral	Incongruent
100 ms	5.7	5.0	4.2	4.7	1.7	0.5	5.2	5.8	6.3
300 ms	3.0	6.7	5.7	3.7	7.1	2.1	3.9	7.1	3.1
700 ms	4.8	2.9	4.7	4.4	5.0	2.6	3.0	7.1	2.6

Given the possibility of a speed-accuracy trade-off for conditions showing a waving body pose, and the possibility that different body poses may be processed at different speeds, thus resulting in different temporal profiles of cueing effects, we conducted separate two-way, within-subjects analyses of variance (ANOVA) on the RT- and error-data of each body pose (again limiting the analyses to congruent and incongruent conditions). Figure 5.4 shows the RT-data as a function of SOA and congruency for each pose.

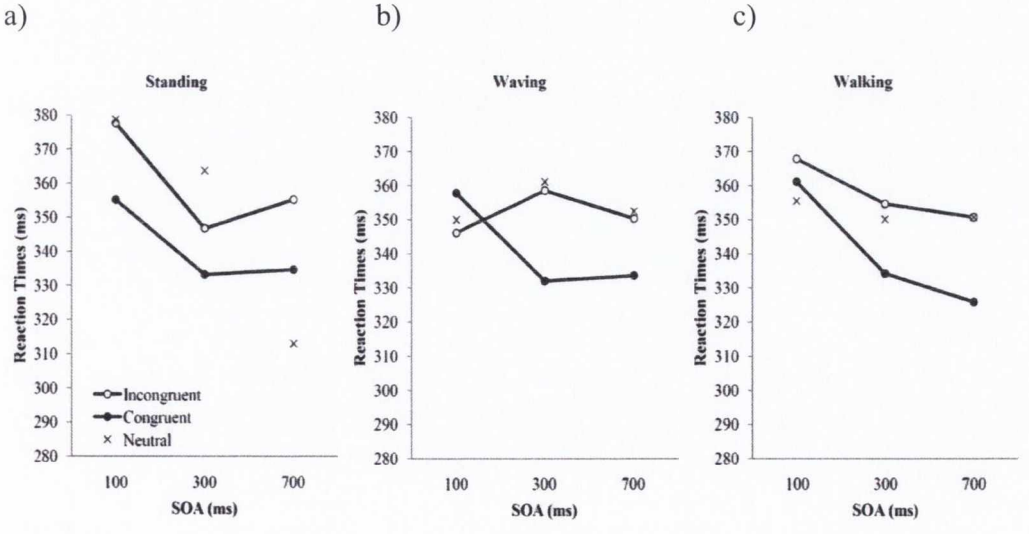


Figure 5.4. Median reaction times for the standing, waving, and walking body pose, as a function of SOA and congruency in Experiment 7.

The analysis of the RT-data of the standing pose (see Figure 5.4a) revealed significant main effects of SOA [$F(2, 46) = 11.023$, $MS_e = 860.646$, $p < .001$] and congruency, $F(1, 23) = 7.950$, $MS_e = 1612.167$, $p < .01$. The interaction between both did not reach significance ($F < 1$). Reaction times in the congruent conditions were approximately 24 ms faster compared to incongruent conditions (349.6 vs. 373.9 ms). Analyses of the error data showed no significant main effects of SOA ($F < 1$) or congruency ($F < 1$), and no interaction between both factors, $F(2, 46) = 1.731$, $MS_e = 33.167$, $p = .19$. Thus, the main effect of congruency observed in the RT-data does not seem to be a result of a speed-accuracy trade-off.

Analysis of the RT-data of the waving pose (see Figure 5.4b) revealed no significant main effects of SOA [$F(2, 46) = 1.394$, $MS_e = 896.803$, $p = .26$] and congruency, $F(1, 23) = 7.950$, $MS_e = 1088.688$, $p = .07$. However, the interaction between both factors was significant, $F(2, 46) = 5.708$, $MS_e = 826.773$, $p < .01$. Planned comparisons revealed that at SOA 100 ms reaction times for congruent conditions and incongruent conditions did not differ significantly (i.e., 12 ms slower for the incongruent condition, n.s.). At SOA's of 300 and 700 ms, congruent conditions resulted in significantly faster reaction times than incongruent conditions (respectively 26 and 16 ms; $p's < .05$). However, analyses of the error data showed a significant main effect of congruency, $F(1, 23) = 10.599$, $MS_e = 21{,}494$, $p < .005$. The main effect of SOA was not significant ($F < 1$), nor was the interaction between SOA and congruency, $F(2, 46) = 1.237$, $MS_e = 19.943$, $p = .30$. As mentioned before, inspection of the mean error rates showed that in the congruent conditions significantly more errors were made compared to the incongruent conditions (1.7% vs. 4.3%), thus indicating a possible speed-accuracy trade-off complicating the interpretation of the congruency effect in the RT-data.

Analysis of the RT-data of the walking pose (see Figure 5.4c) revealed significant main effects of SOA [$F(2, 46) = 5.941$, $MS_e = 1517.887$, $p < .01$] and congruency, $F(1, 23) = 6.363$, $MS_e = 1701.201$, $p < .02$. Reaction times to congruent conditions were on average 17 ms faster than to incongruent conditions. Though the cueing effect seemed to increase with increasing SOA's (7 ms at SOA 100 ms, 20 ms at SOA 300 ms, and 25 ms at SOA 700 ms), the interaction between both did not reach significance ($F < 1$). Analyses of the error

data showed a significant main effect of SOA, but no main effect of congruency ($F < 1$) and no interaction between SOA and congruency ($F < 1$). Thus, the main effect of congruency observed in the RT-data does not seem to be a result of a speed-accuracy trade-off.

To summarize, for both the standing and walking body pose a cueing effect was found; body poses oriented congruently relative to the target location produced faster reaction times than incongruently oriented poses. For the waving pose, the results of the RT-data were less clear as they showed signs of a speed-accuracy trade-off. With respect to the timing of the cueing effect, the results of the standing and walking pose suggest that cueing effects may already be present with an SOA of 300 ms, perhaps even at 100 ms SOA (especially for the standing pose).

The neutral condition has been initially included in the design in order to further explore this cueing effect in terms of facilitation (the difference between the mean RTs for congruent and neutral conditions) and cost (the difference between the mean RTs for incongruent and neutral conditions). However, during the course of the data examination we noticed that the analysis and the interpretation of both the facilitation and the cost effects are not evident (see Figure 5.4). We assume that the problem with estimating of these effects might have been related to the "problem with control condition" in studies based on social stimuli[15] (Fox, 2005; Senju & Hasegawa, 2005). Therefore we decided to omit the neutral condition in the analysis of the current experiment.

5.2.3. Discussion

To summarize, the results obtained with standing and walking body poses seem to indicate that centrally presented directional body poses can be used to voluntarily shift attention. For both poses reliable cueing effects were found at an

[15] Senju and Hasegawa (2005) suggested that the social information conveyed by eye gaze is composed of two major components: direct and averted gaze (see also Perrett & Emery, 1994). The fact that direct and averted gaze exert qualitatively different effects generates a methodological problem while investigating the perception of directional, attentional cues. Research showed that the perception of straight gaze and averted gaze are two distinct, cognitive experiences and have different influences on cognitive processing and the progression of social interaction (Fox, 2005). Therefore, direct gaze is sometimes incorrectly conceptualized as a *control* or *neutral condition* for a lateralized gaze condition.

SOA of 300 ms. However, both body poses showed different temporal profiles of the cueing effect. For the standing pose, the data suggested an earlier facilitation effect (i.e., already present with an SOA of 100 ms) compared to the walking pose (i.e., starting with an SOA of 300 ms). This earlier cueing effect with the standing pose may reflect the involvement of an involuntary cueing process, and/or faster processing of the direction of the stimulus, and/or faster disengagement of attention from the stimulus. Though it is not clear which of these would apply, it may (counter intuitively) be related to the implied motion in the image, which was present in the walking pose but not in the standing pose. Experiment 8 addressed some of these issues by using the same three poses with occluded heads in a similar central cueing paradigm. However, contrary to Experiment 7, the centrally presented stimuli were uninformative with regard to the target location. This way, the experiment tested whether involuntary shifts based on directional body information do occur, and whether the time-course of potential cueing effects differs for body poses with and without the presence of implied motion or action (i.e., waving and walking versus standing).

5.3 Experiment 8

In Experiment 8 participants were explicitly told that the central stimulus would be uninformative with respect to the target location. Unlike Experiment 7, only bodies presented in profile (oriented left or right) were used. In half of the trials the orientation direction of the body was congruent to the location of the upcoming target, and in the other half it was incongruent. Similar to Experiment 7, the same three SOA durations were adopted and the same three body poses (i.e. waving, walking or standing) with their heads occluded.

5.3.1. Method

Participants

Nine undergraduate students and staff members from the Institute of Neuroscience, Trinity College Dublin (3 males and 6 females, with a mean age of 28.3 years) participated in the experiment. All reported normal or corrected-to-normal vision and were naïve with respect to the purpose of the study. The study

was approved by the Ethics Committee of the School of Psychology at Trinity College Dublin, accordingly, all participants provided informed consent prior to the experiment.

Apparatus and stimuli

The apparatus and stimuli were identical to Experiment 7, with the following exception. In the present experiment only the stimuli in profile view, oriented either to the left or right, from Experiment 7 were used (i.e., no models were shown from a frontal view). Thus, the stimulus set consisted of 24 different stimuli, which were a combination of four models in three poses (standing, waving, and walking) oriented either to the left or right.

Design

The experiment was based on a fully factorial, three-way, within-subjects design in which congruency (congruent or incongruent), body pose (standing, waving or walking), and SOA (100, 300, or 700 ms) were manipulated. As in Experiment 7, congruency referred to the orientation of the body relative to the target location (i.e., body oriented to the side at which the target would appear was congruent, whereas the body oriented to the opposite side was incongruent). Importantly, unlike Experiment 7, in the present experiment 50% of the trials were congruent and 50% incongruent and no neutral trials were included. Thus, the orientation direction of the central stimulus did not predict the location of the target.

Procedure

The protocol of the experiment was similar to Experiment 7 with the following exceptions. First, in the instructions it was emphasized that the central stimulus was irrelevant to the prescribed letter task, and that the orientation of the body was uninformative about the side on which the target letter would appear on each trial. Second, unlike Experiment 7, in which target stimuli only appeared for a duration of 100 ms, in the present experiment the target stimulus remained present until a response was recorded.

Each participant first completed a set of 48 practice trials. This was followed by 3 blocks of 288 experimental trials. Within each experimental block,

trials were composed of a combination of images of the 4 models, 3 body poses (standing, waving, or walking), 3 SOA's (100, 300, or 700 ms), 2 target letters (L or T), and 2 target positions (left or right), and each trial was repeated twice. In half of the trials the body of the model was oriented towards the direction of the target location (i.e., congruent trials), in the other half the body was oriented in the direction opposite to that of the target location (i.e., incongruent trials). All trials within each block were presented in a random order. After each 96 trials, participants were given the opportunity to take a one-minute rest. The entire experiment lasted approximately 55 minutes after which participants were debriefed.

5.3.2. Results

The median reaction times (RTs) for correct responses and associated error rates were calculated for each of the eighteen conditions as a function of pose (standing, waving or walking), SOA (100, 300, or 700 ms) and congruency (congruent or incongruent). The average median RT in the experiment across participants was 339 ms and the average error rate 2.44%. For each body pose we conducted separate two-way, within-subject analyses of variance (ANOVA, including the factors SOA and congruency) on the RT and error-data.

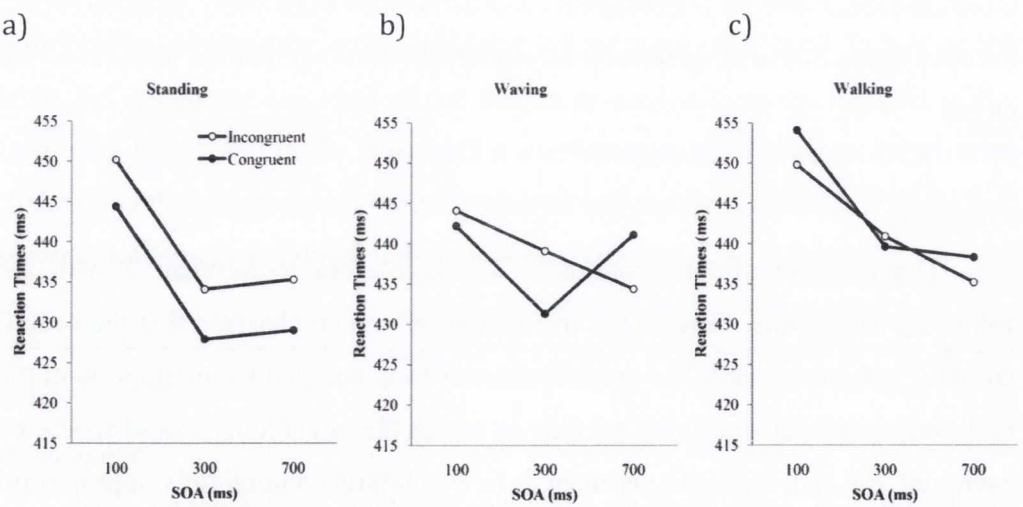


Figure 5.5. Median reaction times for the standing, waving, and walking body pose, as a function of SOA and congruency in Experiment 8.

Analysis of the correct RT data for the standing pose revealed significant main effects of SOA [$F(2, 16) = 5.403$, $MS_e = 276.625$, $p < .02$], and congruency, $F(1, 8) = 5.652$, $MS_e = 89.208$, $p < .05$. The interaction between both factors was not significant ($F < 1$). As shown in Figure 5.5a a small, but reliable 6 ms cueing effect (incongruent minus congruent) was present across all SOAs. Analysis of the error data (see Table 5.2) showed no significant main effects of SOA and congruency, nor was the interaction between both significant (all *F-values* < 1), thus the effect of congruency in the RT data does not seem to be due to a speed-accuracy trade-off.

Table 5.2. Mean error rates (%) for the standing, waving, and walking body pose, as a function of SOA and congruency in Experiment 8.

	Standing		Waving		Walking	
	Congruent	Incongruent	Congruent	Incongruent	Congruent	Incongruent
100 ms	3.0	2.4	2.3	2.6	3.5	1.6
300 ms	2.6	2.4	1.7	2.3	2.4	2.1
700 ms	2.1	3.8	1.7	4.0	1.2	2.3

Analysis of the correct RT data for the waving pose revealed no main effects of SOA ($F < 1$), or congruency ($F < 1$). The interaction between both factors also failed to reach significance, $F(2, 16) = 3.566$, $MS_e = 66.576$, $p = .06$. As shown in Figure 5.5b, with an SOA of 100 ms, a 2 ms ($p = .79$) cueing effect (incongruent minus congruent) was observed. For the SOA of 300 ms the cueing effect increased to 8 ms ($p = .30$), and finally, with an SOA of 700 ms the cueing effect reversed to -7 ms ($p = .10$). Analysis of the error data showed a significant main effect of congruency, $F(1, 8) = 6.997$, $MS_e = 1.874$, $p < .05$. But there was no effect of SOA [$F(2, 16) = 1.996$, $MS_e = 2.804$, $p = .17$], and the interaction between SOA and congruency was not significant ($F < 1$). An inspection of the mean error rates shows that more errors were made in the congruent (2.9 %) compared to the incongruent conditions (1.9 %). Thus, similar to Experiment 7, the RT data to the waving pose condition do not lend themselves to easy

interpretation because of possible speed-accuracy trade-offs. For example, with an SOA of 300 ms there seems to be a hint of a positive cueing effect (i.e., congruent condition producing faster responses than incongruent condition), however, the error data point in the opposite direction (i.e., more errors in the congruent than the incongruent condition).

Analysis of the correct RT data for the walking pose revealed no effect of SOA ($F < 1$). The main effect of congruency and the interaction between congruency and SOA were also not significant (all *F-values* < 1). Analysis of the error data showed a significant main effect of SOA, $F(2, 16) = 5.014$, $MS_e = 4.470$, $p < .02$. The main effect of congruency ($F < 1$), and the interaction between SOA and congruency were not significant, $F(2, 16) = 1.2501$, $MS_e = 3.036$, $p = .32$.

5.3.3. Discussion

We found some evidence for involuntary shifts of attention based on directional body information (in the absence of directional head information), however only when the body performed a standing pose. Counter intuitively, such cueing effects did not occur in responses to images of implied dynamic poses (i.e., including implied motion), such as waving and walking.

5.4 General Discussion

The main theme of this chapter is the exploration of spatial orienting triggered by directional body information, in particular on the effects of voluntary and automatic cueing of attention. In order to tackle specific empirical questions concerning *joint attention*, which is one of the key issues within the domain of social cognition, we adapted and implemented in two experiments a well-known spatial cueing paradigm. In particular, we investigated whether an image of the posture of a human body, which is thought to be automatically processed (Langton, 2000; Langton et al., 1996; see Chapters 2, 3 & 4) can, like other social cues (e.g., Langton & Bruce, 1999; Driver et al., 1999), orient attention either *voluntarily* and/or *automatically*. We first investigated whether such an orienting effect can arise voluntarily. Despite the fact that people are extraordinarily

sensitive to probabilities in spatial cueing studies (Spence & Driver, 1996), participants were explicitly informed about the informativeness of the central, bodily cue (particularly, that the target letter was more likely to appear on the congruent side). The findings of Experiment 7 revealed a significant cueing effect of the human body in standing and walking poses, so that when these body poses were oriented congruently relative to the target location they produced faster reaction times than when they were incongruently oriented. Because of the fact that we cannot rule out a speed-accuracy trade-off effect from the responses to the waving pose, the inferences we can draw about underlying cognitive processes in this condition are limited.

Regarding the time course of the voluntary orienting effects of attention from the standing and walking poses, our results revealed that for both poses reliable orienting effects were found at an SOA of 300 ms. However, two different temporal profiles of cueing effects were revealed: Whereas the standing pose triggered a facilitation effect relatively early (i.e., already at the SOA of 100 ms, and maintained till the SOA of 300 ms), the walking pose seemed to initiate a response facilitation only at an SOA of 300 ms, maintaining such effect till SOA of 700 ms. Furthermore, only for the standing pose signs of inhibition of return were present at SOA 700 ms. An inhibition of return effect might possibly be revealed also for the walking pose if longer SOAs would have been included in the experimental design. Moreover, the data seem to imply that early attentional cueing by body orientation is dependent on the onset of a target object at the side cued by the body: At short SOAs revealed are only facilitation effects (the difference between responses to a body oriented congruently with the target location and to the neutral condition), and when additional processing time is provided (at the SOA of 700 ms), a cost effect in the condition of the standing pose occurred (incongruent body compared to the neutral condition). In summary, the results from Experiment 7 obtained with standing and walking body poses seemed to indicate that centrally presented directional body poses may serve as an effective cue triggering voluntarily shifts of visuospatial attention. The very early beneficial effect with the standing pose obtained in Experiment 7 might reflect the involvement of an involuntary cueing process. Alternatively, it is also possible that the standing pose stimulus is processed faster than other poses, and/or allows for faster disengagement of attention from the stimulus. The first possibility was

tested in experiment 8 and two further issues are discussed in the later part of this General Discussion.

Experiment 8 tested whether the automatic orienting of attention in the direction of a seen human body can arise even when that direction is entirely uninformative and task-irrelevant to the prescribed target task. This experiment was designed to pursue the hypothesis that the cueing effect triggered by the body cues are reflexive in nature, which have been suggested by the results in Experiment 7 (i.e., a very early cueing effect in the standing pose condition). This suggestion was partly corroborated by findings in Experiment 8, particularly that a centrally presented human body in a standing pose triggered involuntary, reliable cueing effects across all SOAs. However, such an effect was not replicated by the poses of waving and walking. It is possible that such body poses do not have a propensity to cue our attention in a reflexive manner. However, more probable is that the processing time of such images implying dynamic human bodies (i.e., representing implied motion) is longer, thus extraction of directional information can take relatively longer than the processing of a standing pose. This interpretation is in line with the results of Experiment 7, which revealed that the pattern of the cueing effect, which occurred for the standing pose as early as an SOA of 100 ms and lasted only till the SOA of 300 ms but occurred for the walking pose respectively later (at an SOA of 300 ms and remained until the SOA of 700 ms). This observation seems compatible with a slower processing of a walking pose and consequently slower attentional shifts towards the direction that the body is facing compared to the standing pose. Accordingly, Shiffrar and Freyd (1993) suggested that once a human body stimulus includes implied motion, additional processing time might be needed to accurately interpret the body posture and to *reconstruct* the path of an apparent action. Lorteije et al. (2006) showed that the latency in cortical response[16] to images containing implied motion is even longer than the response to real motion. The fact that the processing of implied motion in human bodies takes additional time, can potentially explain the advantage for the fast extraction of directional information from a standing, relaxed or *actionless* body pose.

[16] This study investigated fMRI activation in the human medial temporal complex (MT+).

Moreover, it is possible that the images of bodies representing a particular action (e.g., waving, walking) can delay the disengagement of attention. Our visual system is tuned to direct our attention to sudden changes in the environment. Waving and walking poses present implied motion suggesting that a certain action is being performed nearby the observer, thus a sudden change associated with an observed person in motion can be expected in the near future. In order to enable an anticipatory response to the action outcome, it is possible that we need to perform a mental simulation of the motion trajectory (Nijhawan, 2008). Such a process is aided by our implicit knowledge of a common body representation (Freyd, 1983, Kourtzi & Kanwisher, 2000; Wilson & Knoblich, 2005). Motor programs involved in the representation of human body positions create a "forward-model simulation" that predicts the likely trajectory and timing of the action (Knoblich & Flach, 2001; Wilson, 2006). For example, Kerzel (2003) concluded from his study that to extrapolate the perceived motion from a stimulus, a maintained engagement of attention is necessary. Consequently, it has been reported within a substantial body of recent research that a motion signal effectively captures the observer's attention (Abrams & Christ, 2003; Franconeri, Hollingworth, & Simons, 2005; Franconeri & Simons, 2003; Thomas & Luck, 2000). Such a shift in attentional deployment by motion information contained in a stimulus can subsequently cause a delay in the orienting of visual attention (Khurana, Watanabe, & Nijhawan, 2000). In conclusion, the time-course of potential cueing effects differs for varied body poses with and without an implied motion or action component (i.e., waving and walking, versus standing). A reflexive cueing effect might perhaps also be found for poses other than standing poses, if the necessary time for processing these more complex postures might be provided.

Another explanation for not obtaining consistent reflexive cueing effects across all body-pose conditions might be that a holistic, configural processing of the human body image has been distorted by not providing visual information from the head. Recent findings suggest that perception of "headless" bodies may drastically modify the body representation (Yovel, Pelc, & Lubetzky, 2010). The results of Yovel and colleagues indicated that the body inversion effect (BIE) is abolished once the body image is presented without the head (see also Minnebusch, Suchan, & Daum, 2009; Reed, Stone, Grubb, & McGoldrick, 2006).

Also the efficiency by which different body postures are discriminated is reduced once head information cannot be used for such discrimination (Reed et al., 2006). However, an image of a headless body does not necessarily have to appear to us as incomplete or unnatural. In particular, in the present study the head was covered by another object, which may have helped to maintain the impression of the presence of the head (see Figure 5.1). Yet, head information might provide a significant "reference point" for the discrimination of body orientation. Therefore, removal of head information might have crucially jeopardized the body representation and consequently the categorization of bodily features, including its orientation. It is not clear however, why in that case a "headless" standing pose triggered reflexive shifts of attention and why only the processing of implied dynamic poses would have been jeopardized. It is possible that the head as a referential point for configural body processing is only indispensable in conditions where an action of the human body needs to be identified by extracting directional information from motion implied in the body posture. Therefore, future research is required to exploit and determine the precise conditions (i.e., action component, time windows) under which facilitatory or/and inhibitory effects can be reliably obtained with perceived head and body orientations jointly influencing the spatial orienting of the observer.

CHAPTER 6

DOES BODY INFORMATION MODULATE REFLEXIVE ORIENTING OF VISUOSPATIAL ATTENTION BY HEAD ORIENTATION?

Abstract

The present study investigated whether visual mechanisms involved in reflexive attentional orienting based on gaze direction and head orientation integrate directional body information. Specifically, we wished to test Hietanen's (2002) proposal that when both head/gaze and body information is present, reflexive attentional cueing in the direction signalled by gaze and head cues depends on processes which signal that the observed person has their direction of attention averted within his or her frame of reference (i.e., relative to the body). Reflexive attention orienting was assessed by means of a Posner cueing task with central full body stimuli. The head of the human character was always averted and its direction was unpredictive with respect to the target location. To assess the modulating role of directional body information (i.e., trunk, arms, and legs), the orientation of the body relative to the head was manipulated. We observed that head direction, even though completely task-irrelevant and unpredicitive with respect to the location of an upcoming peripheral target, can induce reflexive attention shifts in the direction signalled by the head. However, attentional cueing effects were restricted to those conditions in which the orientation of the observed person's body did not coincide with the orientation of the head. These results are consistent with a hierarchical referencing model of reflexive attentional orienting proposed by Hietanen (1999, 2002), and provide further support for the idea that reflexive attentional orienting is limited to those combinations of head and body orientations which signal that the observed person has an averted direction of attention in his or her frame of reference. This conclusion is also strengthened by the observation that in conditions where the head and body are oriented in opposite directions, cueing effects showed earlier onsets and were larger in magnitude than in conditions with an averted head and body oriented towards the viewer.

6.1 Introduction

The focus of the present study is on the role of directional body information (specifically, the trunk and lower-body) in reflexive attention cueing. In Chapter 5, we showed that in the absence of directional gaze and head cues (i.e., a human

figure with its head occluded), directional body information can trigger automatic shifts of the viewer's attention in the direction in which the body is oriented. However, in everyday life, social signals are almost never perceived in isolation, but rather as part of bigger social context. It is known that contextual variables can operate on the process of the integration of social information, so that the saliency of particular social cues can be increased or decreased (e.g., Birmingham, Bischof, & Kingstone, 2008a, 2008b; Ristic & Kingstone, 2005). Moreover, the spatial orienting of attention and direction determined by particular social signals seems to depend on the interrelation between multiple, directional social cues (Bayliss, di Pellegrino, & Tipper, 2004; Hietanen, 1999, 2002; Langton, 2000; Ricciardelli & Driver, 2008; Seyama & Nagayama, 2005). Accordingly, in comparison to Chapter 5 in which we studied reflexive orienting of attention based on pure directional body information, the present study takes a step further, and examines the role of directional body information (i.e., trunk, arms, and legs) in reflexive attentional cueing when directional head and gaze cues are also available.

Although it has been suggested that directional body information can influence the processing of gaze direction (Emery, 2000; Perrett et al., 1992; Shepherd, 2010), empirical behavioural data on this issue are sparse. In an explicit gaze direction discrimination task (i.e., the task for the participant was to answer "is gaze averted or towards the observer?"), Seyama and Nagayama (2005) observed that response speed was affected by the orientation of the body: A stimulus with an eye gaze and trunk orientated to the front resulted in a slower discrimination of gaze direction compared to a stimulus with frontal gaze direction but a trunk oriented sideways. Furthermore, they found that a stimulus with an averted eye-gaze and the trunk oriented in the same direction also resulted in a slower discrimination of gaze direction compared to a stimulus with averted eye-gaze and its trunk oriented towards the viewer. With respect to the central issue of the present study, namely the role of body direction in the generation of automatic shifts of attention, we have knowledge of only one study. Hietanen (2002) independently manipulated the orientation of the head and trunk in a Posner (1980) attentional cueing paradigm with central cues, and observed that reflexive orienting of the viewer's attention in the direction signalled by an averted head was induced only when the trunk of the observed person was facing

the viewer, and not when its trunk was oriented in the same direction as the averted head. Based on these results, Hietanen argued that reflexive shifts of attention in the direction signalled by the head are only triggered when information about the head and trunk of the observed person are combined and signals an averted attention direction in the observed person's own frame of reference (see also Chapter 4). Hietanen suggested that in the orienting of social attention, different cues are first used to derive whether the observed person has their attention diverted within their own frame of reference. If the relation between these cues suggests that the other person has a laterally averted attention, only then will the observer's own attention be shifted in the same direction.

These empirical observations by Hietanen, and the proposed mechanism underlying the reflexive shifts of attention, are crucial for our understanding of how different social cues combine if we wish to better understand automatic orienting of attention based on social cues in more realistic settings. The aim of the present study was to test the robustness of the mechanisms proposed by Hietanen in several ways. On a general level we wished to replicate Hietanen's findings with full-body stimuli (Hietanen used stimuli with only head and trunk visible) and a slightly different task. Whereas Hietanen used a speeded detection task (detecting an asterisk which appeared to the left or right of the central stimulus) with a limited amount of catch trials, in the present study participants had to discriminate upward or downward pointing arrows, which could appear within two placeholders, and which were present throughout the entire trial. We introduced this task to control better for possible anticipatory responses. A second aim was purely methodological in nature. Hietanen assessed head cueing effects by comparing conditions with an averted head (and the trunk was either identically oriented or facing the viewer) with a control condition with a frontal facing head and body. However, several authors have pointed out that using a social cue directed towards the observer (and in particular direct gaze) as a neutral condition in an experimental design can be misconceived (e.g., Friesen & Kingstone, 1998). This is because direct gaze is a very salient and engaging social stimulus (Von Grünau & Anston, 1995), which in turn may prolong the time to disengage attention from the stimulus. Moreover, the phenomenon of eye contact with another human can trigger additional cognitive processes (e.g., concerning communication or interaction; Kampe, Frith, & Frith, 2003; Saxe,

2006) within a task or immediately after the "facing situation" (Senju & Johnson, 2009) and these additional processes may affect task performance. To avoid such a confound, in the present experiment cueing effects were inferred by comparing conditions with identical but averted head orientations. Finally, whereas Hietanen assessed cueing effects induced by an averted head in conditions which included either an identically oriented trunk or a frontal facing trunk, we introduced a condition in which the body was oriented in the opposite direction to that of the head (i.e., the head was averted to the left and the body was oriented to the right, or vice versa). In light of our finding in Chapter 5 that body orientation in itself (i.e., in the absence of head information) can induce reflexive shifts of attention in the direction in which it is oriented, we reasoned that including a condition in which the body was oriented in the opposite direction of the head would be a more stringent test of the mechanisms proposed by Hietanen. According to the mechanism described by Hietanen, this condition should produce a reflexive cueing of attention in the direction of the head even though the body is oriented in the opposite direction. If in this condition reflexive attentional cueing is observed, it would, together with our finding in Chapter 5 that a pure directional body cue causes reflexive attentional shifts in the direction of the body, provide strong evidence in favour of the model proposed by Hietanen.

6.2 Experiment 9

The present study investigated whether visual mechanisms involved in the orienting of attention, particularly those based on gaze direction and head orientation, also integrate directional body information as suggested by Hietanen (2002). Specifically, we wished to test Hietanen's proposal that when both head/gaze and body information are present, reflexive attentional cueing in the direction signalled by gaze and head cues depends on processes signalling that the direction of the observed person's attention is averted in his or her frame of reference. The orienting of attention was assessed by measuring the speed at which targets presented to the left or right of a central full body stimulus were discriminated. The head of the human character was always averted and head

direction was unpredictive of the target location (i.e., congruent[17] in one half of the trials and incongruent in the other half). To assess the role of directional body information (i.e., trunk, arms, and legs), the orientation direction of the body relative to the head was manipulated. In one third of the trials the orientation of the body was identical to that of the head (i.e., corresponding head-body relationship), and in two thirds of the trials the body was oriented differently (non-corresponding head-body relationship). Half of the non-corresponding trials included a body oriented towards the viewer (non-corresponding frontal body) and the other half included a body oriented towards the opposite side of the orientation of the head (non-corresponding sideways body). As was the case for head direction, neither body orientation, nor the correspondence between head and body orientation was predictive with respect to the target location. Eye-gaze direction was always kept straight ahead relative to the direction in which the head was oriented (i.e., pupils were always centred within the eyes and aligned to the direction of the head). To allow for the precise manipulation of the orientation of the body, computer-generated stimuli of human characters were used (Seyama & Nagayama, 2005; Yovel, Pelc, & Lubetzky, 2010).

Because we were interested in rapid attentional orienting, two relatively short stimulus onset asynchronies (SOA) between the centrally presented social cue and the target were used, namely 120 ms and 240 ms. Attentional cueing effects were assessed by comparing response times to targets in conditions in which the direction of the head was pointing towards the opposite side than that of the target versus conditions in which the direction of the head was pointing towards the location of the target. Following the mechanisms suggested by Hietanen (2002), we expected attentional cueing effects in conditions in which the

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[17] Note that here and in the remainder of this chapter, the term head-congruency will be used to refer to the relationship between head orientation and target location (i.e., a congruent relationship refers to the head being oriented towards the target location, while an incongruent relationship refers to the head being oriented in an opposite direction). The term head-body-correspondence will be used to refer to the relationship between head and body orientation (i.e., a corresponding relationship refers to a stimulus in which head and body are identically oriented, while a non-corresponding relationship refers to a stimulus in which head and body are not identically oriented).

head and body had different orientations (i.e., non-corresponding head-body relationship), but no cueing effects when head and body were identically oriented (i.e., corresponding head-body relationship). For reasons set-out in the introduction, of particular interest was the assessment of the cueing effects in the non-corresponding conditions in which the body was oriented in the opposite direction of the head. With respect to the manipulation of the SOA, we had no specific hypotheses, yet it would be enlightening if cueing effects in the different conditions would reveal themselves at different SOAs. For example, within Hietanen's framework, information, which signalled an averted direction of attention within the observed person's frame of reference, is assumed to be a necessary condition for triggering an attentional shift in the observer towards that direction. Following this line of reasoning, one could infer that any stimulus configuration that enhances or speeds up the processing of such a signal indicating that attention was averted would also result in more rapid cueing effects.

6.2.1. Method

Participants

Nine undergraduate students of HUBrussel (Hogeschool-Universiteit Brussel), 5 males and 4 females aged between 19 to 25, volunteered to participate in the experiment. All reported normal or corrected-to-normal vision and were naïve with respect to the purpose of the study. Informed consent was obtained from each participant prior to the experiment. Instructions were provided in Dutch, the mother tongue of the participants.

Apparatus and stimuli

Stimuli were displayed on a 19-inch CRT colour monitor at a refresh rate of 75 Hz and resolution 1600 x 1200 driven by a Dell XPS 420 PC. The experiment was designed using E-prime software (version 2.0) installed on Microsoft Windows Vista. Participants sat in a darkened room, with their head stabilized on a chin-rest, which was positioned 80 cm from the monitor. Responses were collected using a serial Response Box, Model 200A (Psychology Software Tools),

which was placed in front of the participant and was aligned with the horizontal midpoint of the screen and the participant's body.

Stimuli consisted of pictures of computer-generated human characters, which subtended a visual angle of 12° in the vertical direction and were presented in the centre of the screen with the midline of their body aligned with the vertical axis of the screen. A fixation cross, subtending a visual angle of 0.5° x 0.5° and centred on the screen, was presented prior to each stimulus image.

The images of the human characters were generated by *Poser* computer graphics software (version 7.0, E-Frontier Inc.). Four models, two males and two females (the same as those used in Experiments 1 to 3 of Chapter 2), were used and each wore different clothing. The models were presented in a relaxed and symmetrical standing pose. For each model six images were created, by combining two head orientations (30° left, and 30° right), and three body orientations (30° left, a frontal view, and 30° right) (see Figure 6.1). As such, the stimulus set included 24 images (6 depictions of 4 models). These stimuli were illuminated by three infinite lights (a frontal light and two lights positioned 30° left and right of the model, each shining 45° downwards), which created smooth shading on the models. Images were rendered in colour without external shadows.

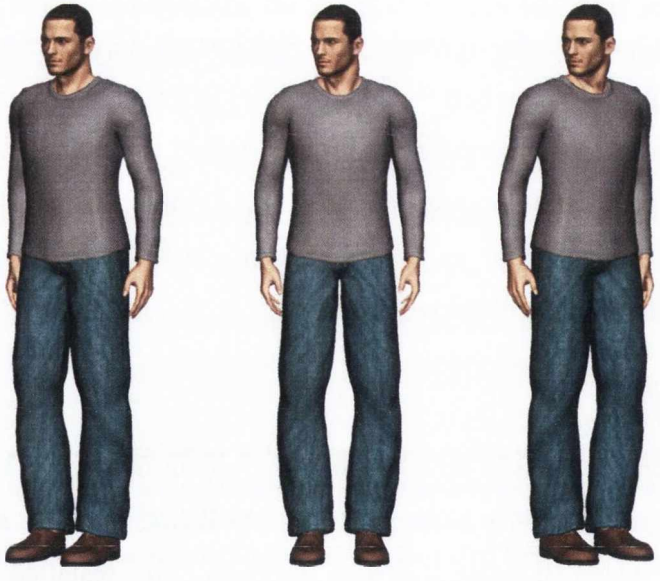


Figure 6.1. Examples of stimuli used in Experiment 9. A male character with head averted to the left and (from left to right) a corresponding body orientation, a non-corresponding frontal body orientation, and a non-corresponding sideways body.

The target stimulus, an arrow oriented upwards or downwards subtending a visual angle of 0.5° vertically, appeared on the left or the right side of the central figure, inside of one of two placeholders, which each subtended 0.9° x 0.9° (see Figure 6.2b).

Design

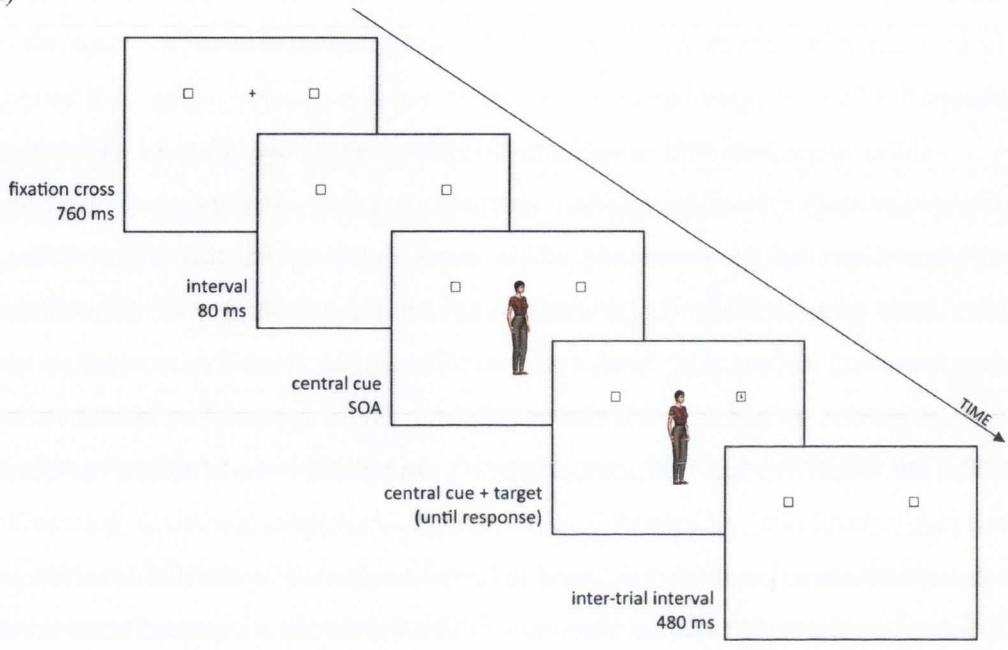
There were two within-subjects factors: congruency of head orientation relative to target position (further referred to as *head-congruency*) and the correspondence of the orientation of the head and body (further referred to as *head-body-correspondence*). The head-congruency factor comprised two values: congruent and incongruent. In the congruent trials, the head was oriented to the side of the visual field at which the target-letter would appear (i.e., head oriented to the left visual field and target appeared on the left side, or right/right), while in the incongruent trials the head was oriented to the opposite side to that of the subsequent target position (i.e., head oriented to the left visual field and target appeared on the right side, or vice versa). The head-body-correspondence factor comprised three values: corresponding, non-corresponding frontal body, and non-corresponding sideways body. In the *corresponding* trials, the body was oriented in the same direction as the head (i.e., both head and body oriented 30° to the left, or 30° to the right). In the *non-corresponding frontal body* trials, the body faced the viewer while the head was oriented sideways (body 0° and head 30° left, or right). Finally, in the *non-corresponding sideways body* trials, head and body were oriented 30° in opposite directions (i.e., head 30°left and body 30° right, or vice versa).

Procedure

Each trial began with a 760 ms presentation of a fixation cross and two empty placeholders positioned 8.2° left and right of the fixation cross. The two placeholders remained present throughout the entire trial. This was followed by an 80 ms interval, during which the fixation cross disappeared. Next, the image of the human character appeared with its head centred on the location of the previous fixation cross (see Figure 6.2). After a variable delay (stimulus onset asynchrony or SOA) the target, an arrow, which was oriented upwards or downwards, appeared within the left or the right placeholder. Participants were required to

indicate whether the target was pointing upwards or downwards by responding as fast and as accurately as possible using the associated arrow keys on the keyboard.

a)



b)

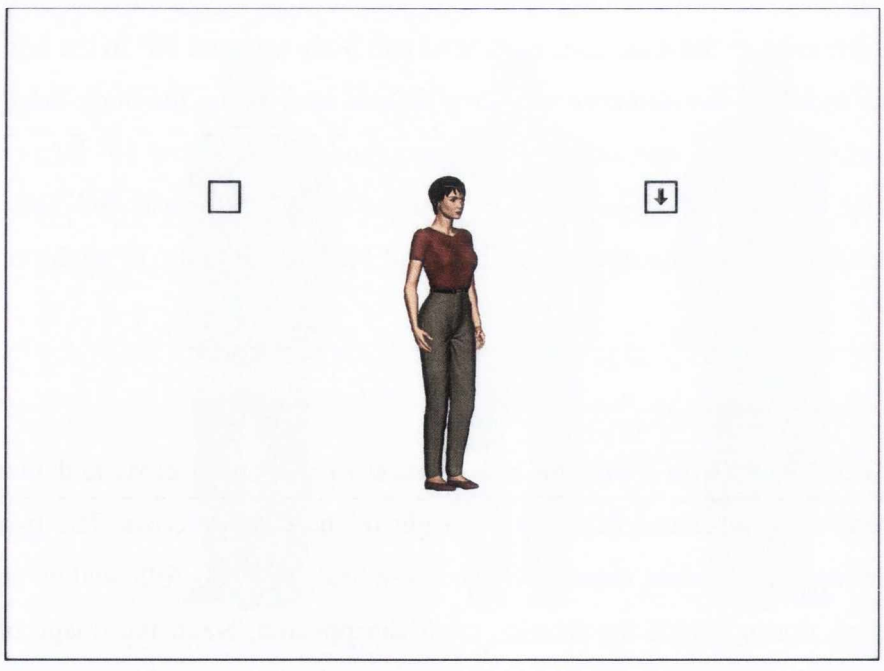


Figure 6.2. Illustration of (a) the trial sequence and (b) a detailed representation of the *cue + target* display showing a female character with head averted to the target location (i.e., congruent) and a corresponding body orientation in Experiment 9.

Participants were told to press the upper key with their index finger of their dominant hand if the arrow was pointing upwards, and to press the lower key with the thumb of their dominant hand, if the arrow was pointing downwards[18]. The central stimulus and the arrow remained present until a button press was recorded. The response was followed by a 480 ms inter-trial interval. No feedback was provided.

Participants first completed a set of 48 practice trials, followed by four blocks of 192 experimental trials. Each experimental block included a random presentation of the 24 stimuli (4 characters x 2 head orientations x 3 body orientations) x 2 SOAs x 2 targets x 2 target positions. After every block, participants were encouraged to take a one-minute pause. The entire experiment lasted approximately 35 minutes after which participants were debriefed and thanked for their participation.

6.2.2. Results

The median reaction times (RTs) for the correct responses and the associated error rates were derived for every participant for each of the twelve conditions (2 head-congruency x 3 head-body-correspondence x 2 SOA). Separate three-way, within-subject analyses of variance were carried out on the correct RT data and the error rates.

The analysis of the correct RT data revealed a main effect of head-congruency [$F(1, 8) = 8.843$, $MS_e = 438.311$, $p < .02$], a trend for an effect of SOA [$F(1, 8) = 3.756$, $MS_e = 768.464$, $p = .06$], but no significant effect of head-body-correspondence ($F < 1$). We observed significant interactions between SOA and head-congruency [$F(1, 8) = 11.146$, $MS_e = 233.343$, $p < .01$], between SOA and head-body-correspondence [$F(2, 16) = 4.221$, $MS_e = 182.373$, $p < .04$], and between head-congruency and head-body-correspondence, $F(2, 16) = 5.462$, $MS_e = 246.705$, $p < .02$. The triple interaction between head-congruency, head-body-

[18] We used upward and downward pointing arrows, together with a vertical arrangement of the response keys, because such arrangement assures an easy stimulus-response mapping, which would presumably limit the amount of response errors. Furthermore, a vertical arrangement as opposed to a horizontal arrangement of response keys would prevent any interactions between the left/right direction of body parts or left/right attention shifts and subsequent responses.

correspondence, and SOA did not reach significance, $F(2, 16) = 2.177$, $MS_e = 170.536$, $p = .15$. Because SOA interacted with both head-congruency and head-body-correspondence, separate analyses were conducted on the data for each level of SOA, thereby including the factors head-congruency and head-body-correspondence.

The analysis for the conditions with an SOA of 120 ms revealed no significant main effect of head-congruency ($F < 1$) nor head-body-correspondence, $F(2, 16) = 2.759$, $MS_e = 181.243$, $p = .093$. However, the interaction between head-congruency and head-body-correspondence was significant [$F(2, 16) = 3.918$, $MS_e = 121.792$, $p < .05$], and is illustrated in Figure 6.3. To assess possible cueing effects of head congruency, planned comparisons between conditions with congruently and incongruently oriented heads (i.e., oriented towards the target location or towards the opposite direction) at each level of head-body-correspondence were carried out. A significant cueing effect was observed when the head and body were oriented in opposite directions (i.e., in non-corresponding sideways body conditions).

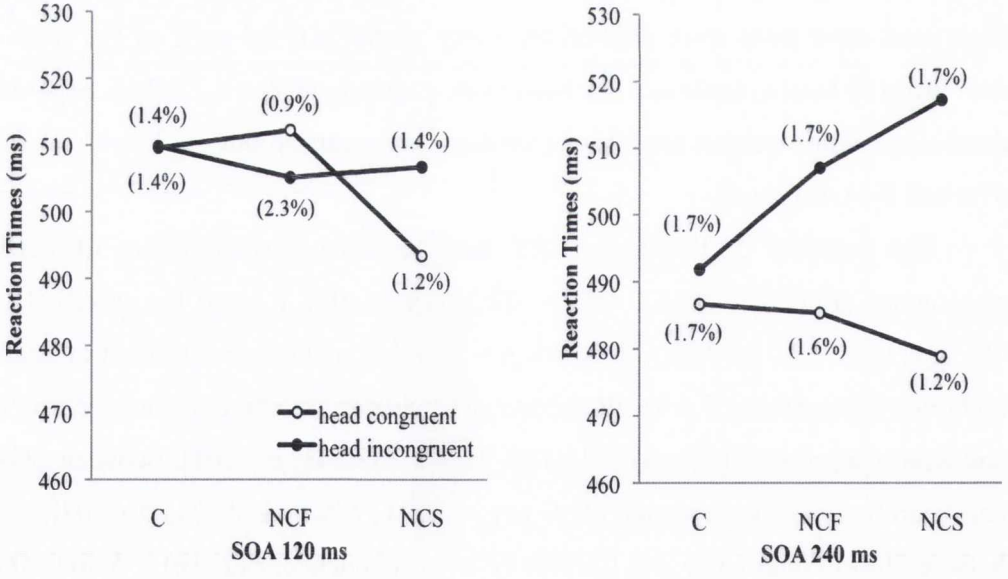


Figure 6.3. Median reaction times (ms) for the SOAs of 120 (left) and 240 ms (right), as a function of head-body-correspondence (C = corresponding; NCF = non-correspondingfrontal body; NCS = non-corresponding sideways body) and head-congruency in Experiment 9. Error rates (%) are provided between brackets.

In this case, the median reaction times in the condition with a congruent head orientation were 14 ms faster than in the condition with an incongruent head orientation (i.e., 493 ms vs. 507 ms, $p < .05$). No significant cueing effects were observed in the conditions with a non-corresponding head and body and a frontal body orientation, and in the conditions with corresponding head and body orientation (all *p-values* > 0.24).

The analysis for the conditions with an SOA of 240 ms revealed a significant main effect of head-congruency [$F(1, 8) = 10.981$, $MS_e = 584.060$, $p < .02$], but no significant effect of head-body-correspondence, $F(2, 16) = 2.148$, $MS_e = 181.706$, $p = .15$. The interaction between both factors again proved significant, [$F(2, 16) = 4.203$, $MS_e = 295.449$, $p < .04$], as illustrated in Figure 6.3. Again, to assess possible cueing effects of head-congruency, planned comparisons between conditions with congruently and incongruently oriented heads (i.e., facing in the direction of the target or the opposite direction) were conducted. Significant cueing effects were observed when the orientation of the head and body did not correspond. When the body was oriented towards the viewer (i.e., non-corresponding frontal body), on average, response times were 22 ms faster when the head was oriented towards the target location than when it was oriented away from the target location (i.e., 485 vs. 507 ms; $p < 0.03$). When the body was oriented in the opposite direction to the head (i.e., non-corresponding sideways body), the cueing effect was even more pronounced, and reached 38 ms (i.e., 479 vs. 517 ms; $p < 0.002$). On the other hand, when the orientation of the head and body were identical (i.e., corresponding), no significant cueing by head direction was observed (487 vs. 492 ms; $p = 0.65$).

To summarize, when the head and body were oriented in opposite directions (e.g., head oriented 30° left and body oriented 30° right), a cueing effect from the direction of the head was observed at an SOA of 120 ms and further increased at an SOA of 240 ms (i.e., from 14 to 38 ms). In contrast, when the orientation of the head and body was identical (e.g., both oriented 30° left) no significant cueing effects were observed at either SOAs. In conditions with a frontal view of the body, a significant cueing effect was only observed at an SOA of 240 ms and it was less pronounced in comparison to conditions in which head and body were oppositely oriented.

The overall mean percentage of error was low (1.52%). The three-way, within-subject analysis of variance on the error rates revealed no significant main effects of head-congruency, head-body-correspondence, or SOA (all *p-values* > 0.17). Furthermore, no significant interactions were observed between any of these factors (all *F-values* < 1), nor was there a significant triple interaction (p = 0.35). Separate analyses at each SOA showed a similar absence of effects of head-congruency and head-body-correspondence. For the SOA of 120 ms, no main effects were observed (all *p-values* > .29) and no significant interaction (p = .19). For the SOA of 240 ms, again no main effects were observed (all *F-values* < 1), and no interaction (F < 1). Importantly, these findings imply that the effects found in the RT-data cannot simply be explained by speed-accuracy trade-offs.

6.3 Discussion

The focus of the present study was on the influence of directional body information (i.e., trunk, arms, and legs) on the reflexive visuospatial cueing of attention triggered by directional head information. Exploration of the function of gaze following and establishing of joint attention helps to understand the role of gaze within a mentalistic framework (Baron-Cohen, Cambell, Karmiloff-Smith, Grant, & Walker, 1995; Baron-Cohen, Wheelwright, & Jolliffe, 1997; Leekam, Baron-Cohen, Perrett, Milders, & Brown, 1997), such as when considering another person's point of view (MacKay, Knott, & Dunlop, 2007). An appropriate behaviour in directing attention to the point of interest of somebody else, such as gaze following, protodeclarative (informative) pointing or any other forms of referential communication is particularly problematic for autistic individuals (Baron-Cohen, 1995a; Emery, 2000; Mundy, Sigman, Ungerer, & Sherman, 1986). An understanding of the mechanisms of gaze following, joint attention, and the sensitivity for different orientations of social cues is necessary to comprehend social perception in individuals with potential social development disorders as well as in healthy adults.

Hietanen (2002) suggested that normally head and body orientation are integrated by brain mechanisms involved in the orienting of social attention. Moreover, he proposed that only certain combinations of head and body orientation trigger reflexive shifts in the observer's attention. Specifically,

Hietanen argued that only when the observed person's head and body direction together signal an averted direction of attention in his or her own frame of reference, then a shift of attention in that direction will be triggered in the observer. To test the robustness of the mechanisms proposed by Hietanen, we conducted an attentional cueing experiment with centrally presented unpredicitve cues which differed in a number of ways from the original experiment reported by Hietanen (2002), i.e., in terms of task, stimuli, and ways of inferring cueing effects. Importantly, the present experiment also included additional conditions, which can be considered to be a more stringent test of the mechanisms proposed by Hietanen (i.e., conditions with head and body oriented in opposite directions relative to the observer).

The results of the present study generally confirm Hietanen's (2002) results and his proposed underlying mechanism (Hietanen, 1999, 2002). We observed that head direction, even though it was irrelevant to the task and unpredictive with respect to the location of an upcoming peripheral target, can induce reflexive shifts of attention in the direction signalled by the head. However, analogous to Hietanen's observations, attentional cueing effects were restricted to those conditions in which the orientation of the observed person's body did not coincide with the orientation of the head: In conditions in which the orientation of the head and body were aligned (i.e., corresponding head-body relationship) no cueing effects were observed, whereas in conditions with a sideways oriented head and a front view of the body (i.e., non-corresponding frontal body) reliable cueing effects were observed. Of specific interest was the additional condition (relative to Hietanen's study) in which the head and body were both averted but oriented in opposite directions relative to the viewer (i.e., non-corresponding sideways body). Even though the body in itself was directed opposite to the head, reliable cueing effects in the direction signalled by the head were obtained. Furthermore, the cueing effects observed with non-corresponding sideways bodies were larger in magnitude (i.e., 38 vs. 14 ms at SOA 240 ms) and started earlier (i.e., already at SOA 120 ms) relative to the cueing effects observed in the non-corresponding frontal body condition (i.e., no significant cueing effects at SOA 120 ms). Given Hietanen's proposal that reflexive shifts of attention require a signal that the attention of the observed person (within his or her frame of reference) is averted, both the earlier onset and the larger cueing effect observed in the non-

corresponding sideways body condition may be a result of faster or enhanced processing of such a signal. Specifically, the larger angle between head and body in the non-corresponding sideways body condition compared to the non-corresponding frontal body condition may result in enhanced and faster processing of the supposed averted attention signal, thus allowing an earlier triggering of attention in that direction. Further research including a fine-grained, stepwise manipulation of SOA will be needed to confirm this hypothesis.

The present results concord with Hietanen's (1999, 2002) proposal that "... in social attention orienting, the other person's gaze direction or head orientation is not related directly to an observer-based frame of reference. Instead, first different cues are used to derive the other person's direction of attention" with regards to his or her frame reference (Hietanen, 2002, p. 177). Specifically, it is argued that the processes involved in reflexive social shifts of attention, attempt first to derive whether an observed person has their attention averted by means of a hierarchical referencing mechanism in which gaze direction is referenced to head orientation and head orientation in turn is referenced to body orientation. "If the relationship between these cues suggests that the other person has a laterally averted attention, the observer's own attention is shifted in the same direction" (Hietanen, 2002, p. 177).

The specific integration process of head and body orientation as observed by Hietanen (2002) and replicated in the present study argues against a model proposed by Perrett and colleagues (1992) in which the contribution of different social cues to the computation of anther person's attention follows a strict hierarchical scheme with social cues higher up in the hierarchy inhibiting the use of lower-level cues (e.g., if gaze or head direction information is available, body information would not be used in the computation). Furthermore, the present results are also incompatible with a model of social attention orienting suggested by Langton and colleagues, based on results obtained with a Stroop paradigm (Langton, 2000). In their model, directional information from gaze, head and body information is analyzed separately and in parallel and it is argued that the outputs of each of these separate computations have independent and additive effects on the discrimination of the direction of social attention. If this were indeed the case, then, based on our finding in Chapter 5 that directional body information in itself (i.e., in the absence of directional head information) can trigger reflexive shifts in

attention in the direction in which the body is oriented, one would expect cueing effects in our condition with a non-corresponding sideways body to be smaller, or even absent relative to the condition with a frontal view of the body, because the output of the computation of body direction would counter that of head orientation. Furthermore, according this model, one would expect the strongest cueing effects in the condition with corresponding head and body orientation, yet it is precisely in this condition that we failed to observe any cueing effect. Thus the present data argue against pure parallel independent processing of social cues with additive effects in the computation of the direction of social attention. Instead our results lend support to the idea of a distinct role of an integration process of social cues by means of a hierarchical referencing scheme.

To conclude, the focus of the present study was on the modulating role of directional body information in reflexive cueing of attention based on head direction information. The results provided clear evidence that body information is automatically processed and that it exerts a modulating role in reflexive attentional orienting. The results were consistent with a hierarchical referencing model of reflexive attentional orienting proposed by Hietanen (1999, 2002), and provide further support for the idea that reflexive attentional orienting is limited to those combinations of head and body orientations which signal that the observed person has an averted attention direction with regard to his or her frame of reference. Further study should be performed to investigate the same mechanism within real-life situations (i.e., Langton, O'Donnell, Riby, & Ballantyne, 2006).

CHAPTER 7

THE PERCEPTION OF WHERE ANOTHER PERSON IS ATTENDING: INTEGRATION OF HEAD AND BODY ORIENTATION IN THE PROCESS OF JOINT ATTENTION

Autorship

Results from the following chapter were presented at the 32nd European Conference on Visual Perception (ECVP):

Pomianowska, I., Bonroy, J., Germeys, F., & Newell, F. N. (2009, August). *The role of integrated head and body orientation on the allocation of spatial attention.* Poster session presented at the 32nd European Conference on Visual Perception (ECVP), Regensburg, Germany.

Abstract

The nature of the social information that contributes to the establishment of joint attention was investigated. Specifically, we examined whether and how the orientation of an observed person's body (i.e., trunk, arms and legs) relative to their head affects the perception of where that person is attending to in their environment. Participants viewed images of a computer-generated human figure positioned centrally in a scene that contained multiple, closely spaced objects. The task was to make an overt attention shift from the head of the observed character to the object they believed the character was attending to and subsequently made a mouse click on that object. To assess the effect of body orientation relative to the head, the orientation of the body was manipulated independently from the head orientation. We found that, compared to a situation in which head and body orientation were aligned, the perceived direction towards which the character was attending was systematically shifted in the direction opposite to the direction of the body when misaligned with the head. This result suggests that in the process of social attention orienting, head orientation is initially referenced in relation to the observed person's frame of reference, and only then in relation to the observer. Furthermore, we argue that the misalignment between head and body orientation signals an intentional component in the direction opposite to the direction of the (misaligned) body, which can then influence the perceived attention direction of the observed person.

7.1 Introduction

The ability to accurately determine another person's direction of attention constitutes a considerable adaptive advantage (Emery, 2000; Langton, Watt, & Bruce, 2000). In previous chapters it has been argued that there is a strong propensity for observers to orient their attention to the same object that other people are attending, a process referred to as *joint attention*. This process is automatic (Baron-Cohen, 1995a; Galantucci & Seblanz, 2009; Seblanz & Knoblich, 2009; see also Chapters 4 & 5) and develops develops very early in life (Baron-Cohen, Baldwin, & Crowson, 1997; Butterworth, 1991).

Here we investigated the nature of the social information, which directly contributes to the establishment of joint attention. Following the definition provided by Emery (2000), joint attention "requires that two individuals… are attending the same object… based on one individual using the attention cues of the second individual" (Emery, 2000, p. 588). Accordingly, the present study concerns attentional orienting by the observer towards a specific object (or third party) in the environment at which the observed person is looking (i.e., a triadic situation; see Lee, Eskritt, Symons, & Muir, 1998), rather than general spatial attention orienting towards a certain direction (also referred to as *gaze following* by Emery, 2000), which has been the subject of extensive research (for a review, see Frischen, Bayliss, & Tipper, 2007). To reach this state of joint attention in the presence of multiple objects, the observer can use a variety of attentional cues, such as the relative position of the observed person's eyes in the head (determined from the irises within the visible part of the sclera), head and body orientation, and pointing gestures. Despite significant advances in the field of social cognitive neuroscience, much remains to be understood regarding how different combinations of these cues interact and affect the computation of social attention direction and the establishment of joint attention (Symons, Lee, Cedrone, & Nishimura, 2004). In the present study, we specifically focus on the role of the observed person's relative orientation of head and body in this process.

Intuitively, the most obvious cue to infer another person's focus of attention is the relative position of the eyes in the head (e.g., Ando, 2002; Anstis, Mayhew, & Morley, 1969; Baron-Cohen, 1994; Emery, 2000; Langton et al., 2000; Riciardelli, Betta, Pruner, & Turatto, 2009). Eye gaze information is considered to be crucial in triggering attention shifts in the observer, because the eyes naturally attract the observer's attention even if they are irrelevant to the task (Birmingham, Bischof, & Kingstone, 2009; Downing, Dodds & Bray, 2004) and triggers reflexive shifts of the viewer's visuospatial attention (Bayliss & Tipper, 2006; Driver, Davis, Ricciardelli, Kidd, Maxwell, & Baron-Cohen, 1999; Friesen & Kingstone, 1998). Yet, many studies have shown that the perception of gaze direction is also influenced by the orientation of the observed person's head (e.g., Anstis et al., 1969; Cline, 1967; Gibson & Pick, 1963; Langton, Honeyman, & Tessler, 2004; Maruyama & Endo, 1983; Maruyama, Endo, & Sakurai, 1985; Seyama & Nagayama, 2005; for an overview of these and related studies, see

Klutz, Mayes, West, & Kerby, 2009; Ricciardelli & Driver, 2008; Todorowić, 2006). For example, Gibson and Pick (1963) manipulated both head and gaze direction of the observed person and assessed the perceived direction of their gaze by asking the observer whether gaze was directed towards them. When the character's (i.e., the observed person's) head was oriented 30° to the observer's right, observers responded that they were being looked at when the character was actually looking askance approximately 3° to the right of the observer. Cline (1967) observed similar effects[19] in a study, which required participants to indicate the location towards which the observer perceived the character to be looking. When the character's head was oriented 30° to the right of the observer, perceived gaze location (for gaze directions of 4° right, 0°, 4° left, and 10° left of the observer) was systematically biased in the direction opposite to that of the head (i.e., leftwards in the present example). This *head-turn*, *overshoot* or *repulsion* effect (Langton et al., 2004), in which an error in gaze perception is induced in the opposite direction to the angle of rotation of the head (Cline, 1967; Gibson & Pick, 1963), was confirmed with both real human characters and characters displayed on a TV screen (Anstis et al., 1969). Figure 7.1a shows a schematic depiction of this overshoot effect.

However, in an apparent contradiction to the *overshoot* effect, some studies have reported *towing* of the perceived direction of gaze towards the orientation of the head (Langton et al., 2004; Maryuama & Endo, 1983; Maryuama et al., 1985). In this case, the direction of gaze is perceived to be somewhere between the angle of the head and the true line of regard of the eyes (see Figure 7.1b).

For example, Langton et al. (2004) presented combinations of frontal or 16° sideways oriented heads with eyes either directed towards or averted 16° to the left or right of the observer. The participant's task was to rapidly judge whether eye gaze was directed at the observer or averted. With a frontal head orientation and gaze directed towards the observer, on average participants correctly judged the gaze direction as being towards them in 93% of the trials, whereas this was reduced to 22% with a sideways oriented head and gaze directed towards the observer.

[19] Note that this interpretation of Cline's results (Experiment 2) is based on Cline's own claim that his results are in line with those of Gibson and Pick (1963), despite the fact that Cline's Table 2 shows opposite results. As noted by others (Anstis et al., 1963; Klutz et al., 2009), presumably Cline mixed up data for right and left.

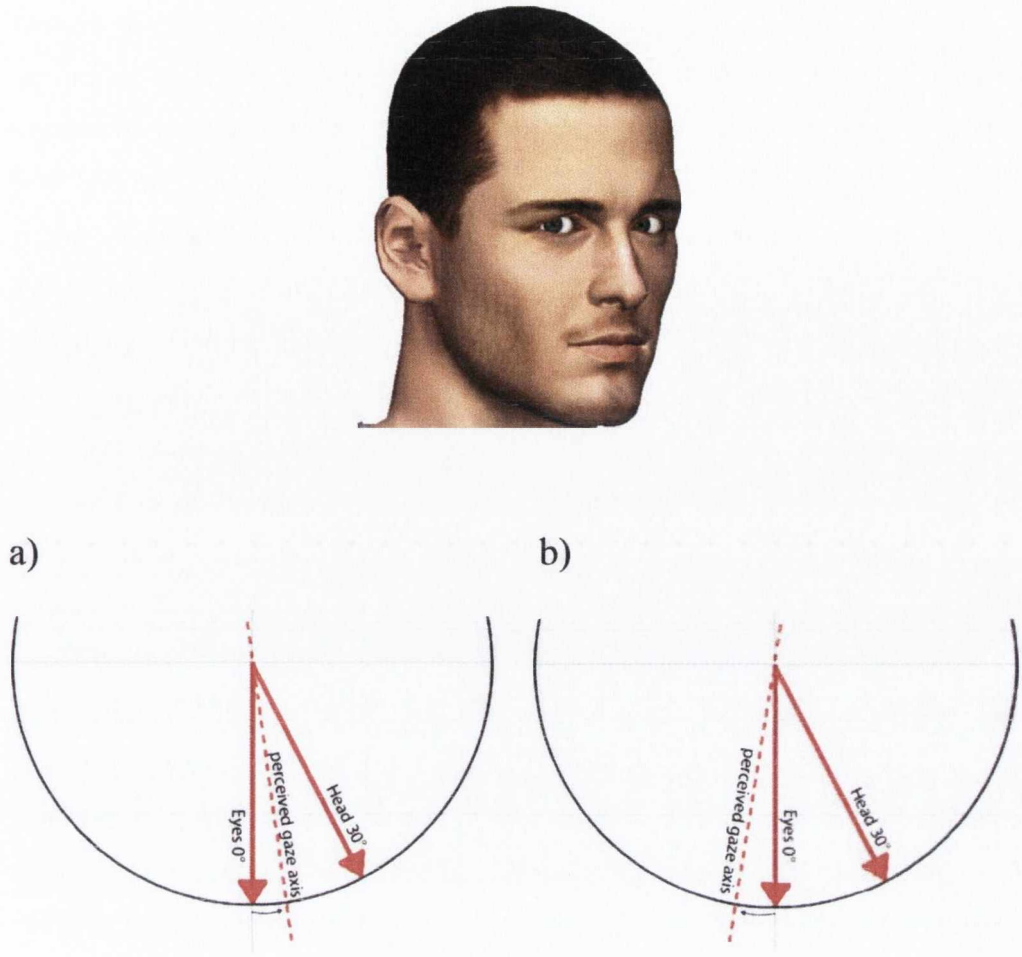


Figure 7.1. Schematic illustration of a) *towing effect* and b) *overshoot* for eye gaze-head relationship.

When head and gaze direction were both oriented to the left or right of the observer, on average participants correctly judged the gaze direction as being averted in 89% of the trials, whereas this was reduced to 45% with head and gaze oriented in opposite directions. While the errors in the perceived direction of gaze in the direct gaze condition with sideways head orientation can be explained both in terms of *overshooting* in the opposite direction of head orientation and *towing* of gaze towards the orientation of the head, the errors in the condition with head and gaze oriented in opposite directions are only compatible with the *towing* account. Accordingly, Langton et al.'s data (2004) argue in favour of the *towing* account.

Despite the contradictory findings regarding the effect of the relative orientation of gaze and head on the perceived direction of gaze (i.e., *overshooting* vs. *towing*), those studies that examined this matter in a triadic situation (i.e., a situation involving the perception of an observed person's gaze towards a third party or object), and thus meet the prerequisites for joint attention (Emery, 2000), systematically showed an overshoot effect (i.e., Experiment 2 in Cline, 1967; Experiment 1 in Anstis et al., 1969). In contrast, other studies involving a dyadic situation, generally observed a *towing effect* (e.g., Langton et al., 2004; Maryuama & Endo, 1983; Maryuama et al., 1985; though see Gibson & Pick, 1963, for evidence for an *overshoot effect* in a dyadic situation). Indeed, direct gaze in a dyadic situation may constitute a special case in social perception, with different information processing requirements, function, ontogeny, and possibly drawing upon different and functionally specific neural mechanisms (e.g., Argyle & Cook, 1976; Baron-Cohen, 1994; Campbell, Heywood, Cowey, Regard, & Landis, 1990; Hoffman & Haxby, 2000; Kawashima et al., 1999; Perrett, Mistlin, & Chitty, 1987; for a reviews, see Itier & Batty, 2009, and Shepherd, 2010). For instance, neurophysiological work on a variety of patients shows evidence for specific deficits in the perception of direct/mutual gaze rather than general gaze direction impairments (Itier & Batty, 2009).

Because eye gaze information may not always be available to the observer, as when viewing someone from a distance, an observer may instead have to rely on head or body direction, or a combination of both in order to infer where or to what object in a scene the observed person is attending. Yet, while eye gaze direction strongly constrains the perception of another person's locus of attention, head and body orientations pose weaker constraints and thus make weaker predictions about the spatial location that is attended (Shepherd, 2010). For example, in natural visual orienting behaviour, inertia typically causes the eyes to lead the head, which in turn leads the body (e.g., Suzuki, Izawa, Takashi, & Yamazaki, 2008), yet the relative contributions of eye and head movements are quite variable when orienting towards a certain location in space. Because the degree of eye-head coupling has been shown to vary both across participants and task characteristics of the orienting behaviour (see Suzuki et. al, 2008), the use of head and body cues of an observed person to infer his or her direction of attention when gaze information is poor or absent poses a challenge to the perceptual

system of the observer. Furthermore, the large oculomotor range of the eye (+/- 45°; Goosens & Van Opstal, 1997) makes the task of predicting where another person is attending underdetermined for the observer, yet the observer may need such information for appropriate social interaction. This poses the question how head orientation is used and specifically, whether the orientation of the head relative to the body plays a role in the process of joint attention. Misaligned head-body may form a special cue biasing the perceived direction of attention in specific ways due to its intentional nature or the perception of implied motion.

While reflexive spatial attention orienting into the general direction of a certain hemifield based on head and body orientation has been examined (Hietanen, 2002) to our knowledge, there are no studies available on how the relative orientation of head and body affects the perceived direction of social attention in a triadic situation and the subsequent establishment of joint attention, when eye gaze information is poor or absent (as when viewing another person at a longer distance). The aim of the present study was to address this gap. First, we wished to test whether the orientation of a character's body (i.e., trunk, legs, and arms) relative to their head affects the perception of where that person is attending. Second, if this were the case then we wished to investigate whether a similar *overshoot* effect as shown for the relationship between head and eye gaze direction in a triadic situation or, alternatively, a *towing* effect can be observed for the relationship between head and body orientation. An overshoot effect would manifest itself as a bias of the perceived attention direction in the opposite direction of the orientation of the character's body relative to the orientation of the character's head when head and body orientation are not aligned. For example, a character with a head oriented towards an object 20 degrees to their left, but their body oriented 20 degrees to the right, an *overshoot* effect would manifest itself as a perceived direction of attention further to the character's left compared to a situation with both head and body aligned and orientated 20 degrees to the left. Alternatively, a perceived direction of attention to the right relative to the head orientation would imply a *towing* effect.

7.2 Experiment 10

In order to study how the orientation of a character's body (i.e., trunk, legs, and arms) relative to their head affects the perception of where that person is attending, participants viewed images of a computer-generated human figure centrally positioned in a scene containing multiple target objects positioned in the foreground and aligned in a semi-circular array. The character's head was always oriented towards one of the targets and the participant's task was to make an overt attention shift to the object to which they perceived the character was attending and subsequently make a mouse click on it. To assess the effect of the body orientation relative to the head, the angle of the body orientation was manipulated independently for each head orientation, while eye gaze was always aligned with the orientation of the head. Because the actual target object being attended to by the character was closely flanked by other objects, we were able to assess potential biases in the perceived attention direction as a function of body orientation by identifying errors made in the target identified as being the one attended to by the character.

7.2.1. Method

Participants

Seven undergraduate students, 2 males and 5 females, from the University of Leuven (with a mean age of 24 years) participated in the experiment. All participants reported being right-hand dominant, with normal or corrected-to-normal vision and were naïve with respect to the purpose of the study. The study was approved by the Department of Psychology Ethics Committee, University of Leuven and, accordingly, all participants provided informed consent prior to the experiment.

Apparatus and stimuli

Stimuli were displayed on a 19-inch CRT colour monitor with a refresh rate of 75 Hz, driven by a Dell XPS 420 PC using E-prime software (version 2.0). Participants sat in a darkened room, with their head stabilized on a chin-rest, which was positioned 80 cm from the monitor. Responses were recorded via a computer mouse.

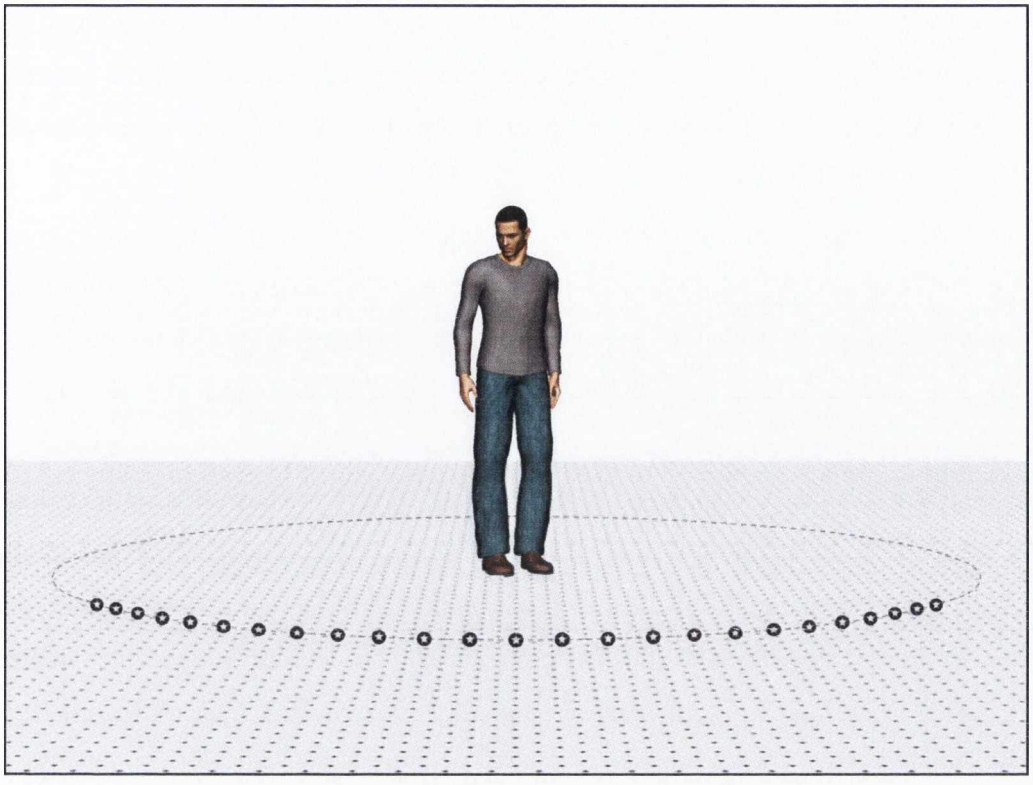


Figure 7.2. An illustration of a typical stimulus used in Experiment 10. This example includes the ground surface, markers, and a male human character with head and gaze oriented 20° to the left and body oriented 20° to the right relative to the viewer. The dashed ellipse was not present in the actual stimuli.

Stimuli consisted of four human characters positioned on a ground surface of a scene. The images of the characters subtended a visual angle of 9° in the vertical direction and the image of the head subtended a visual angle of approximately 1.1° x 0.7°. They were presented in the centre of the screen, superimposed on a ground surface, which contained a depth-perspective cue (see Figure 7.2). The ground surface contained 25 markers (black disks containing a white star) placed on a virtual circle surrounding the character (i.e., an ellipse due to the perspective slant of the ground surface). The first marker was placed in front of the character (i.e., 0°) on the circumference of the circle. Next, 24 additional markers were placed on the circumference of the virtual circle; 12 to the right and 12 to the left of the central marker, each separated by 5 degrees as measured on the virtual circle. Thus, the markers covered 60 degrees of the circumference to the right and 60 degrees of the circumference to the left of the central marker. Note that the actual on-screen separation (and thus the visual

angle) between the markers decreased as the markers were further away from the central marker due to the perspective distortion. Likewise, the size of the markers changed as a function of their position on the virtual circle (diameter of approximately 0.3° to 0.36° of visual angle).

The images of the computer-generated characters were created using Poser™ computer graphics software (version 7.0, E-Frontier Inc.). Four different characters were used, two male and two female, and each wore different clothing. Each was illuminated by three infinite lights (a frontal light and two lights positioned 30° left and right of the character from an angle 45° above the viewer), which created smooth shading on the models. Images were rendered in colour without external shadows. The models were presented in a standing pose with their heads tilted downwards 20° (i.e., tilted in an orientation facing the markers on the ground surface). Twenty different images were created from each character by combining four head orientations (40° left, 20° left, 20° right, 40° right) with five body orientations (40° left, 20° left, 0°, 20° right, 40° right). Eye gaze direction was always aligned with the orientation of the head (i.e., pupil centred within the eye).

Design

The experiment was based on a three-way, within-subjects design in which overall head orientation (left or right), angle of the head orientation (20° or 40°), and the angle of body orientation (-40°, -20°, 0°, 40°, 20°) were manipulated in a factorial way.

Procedure

Each trial began with a 1000 ms presentation of a fixation cross (subtending 0.5° x 0.5° of visual angle), which was centred horizontally and positioned at the vertical height of the subsequent character's face. In addition, the initial screen contained a ground surface, and 25 location markers. Next the fixation cross disappeared for 80 ms, followed by the appearance of the character. Participants were instructed to keep their eyes on the fixation cross until the character appeared. Upon seeing the character, they were instructed to shift their eyes towards the marker to which they perceived the character was looking. The distance between the fixation cross and the markers ranged from 10.1° (i.e., for

the central marker) to 13.8° (i.e., for the outer markers on the virtual ellipse). The character disappeared after 600 ms, leaving only the ground surface and the markers present. After another 400 ms a cursor appeared 2° of visual angle beneath the central (i.e., 0°) marker. Participants were instructed to keep their eyes fixated on the marker, which they perceived the character to be looking, drag the cursor with the mouse towards that marker, and subsequently click on it. Following this response there was a blank inter-trial interval of 100 ms. Participants were urged to click precisely on the target (i.e., the centre of the star within the black disk). A mouse click within an area of 0.7° x 0.7° surrounding the marker was accepted as a valid response to that particular marker but a click outside this region was registered as an invalid response. Both response types triggered the offset of the trial.

Participants first completed a set of 25 practice trials, followed by five blocks of 160 experimental trials. Each experimental block included two repetitions of the 80 stimuli (4 characters, 4 angles of head orientation, and 5 angles of the body orientation), which were presented in a random order. After each block, participants were encouraged to take a one-minute rest. The entire experiment lasted approximately one hour after which participants were debriefed and thanked for their participation.

7.2.2. Results

Based on the percentage of invalid responses (i.e., clicks outside the marker region), one participant was excluded from analyses (14.4 % invalid clicks). The mean percentage of invalid responses for the remaining six participants was 0.4 %. For each participant we calculated the mean response location as a function of angle of head orientation (20° or 40°), spatial hemifield towards which the head was directed (left or right), and angle of body orientation relative to head direction (40° and 20° in the same direction as the head, or 0°, or either 20° or 40° in the opposite direction of the head; in the remainder of the text we will refer to this variable as *body orientation*). For each angle of head orientation a two-way (spatial hemifield of head direction by angle of body orientation), within-subject analyses of variance (ANOVA) was carried out.

Analyses of the data with a head orientation of 40 degrees revealed a main effect of body orientation [$F(4, 20) = 12.525$, $MS_e = 7.389$, $p < .0001$], and spatial hemifield towards which the head was directed (i.e., head direction), $F(1, 5) = 15.770$, $MS_e = 12.511$, $p < .02$. The interaction between body orientation and head direction did not reach significance, $F(1, 5) = 1.091$, $MS_e = 2.032$, $p = .39$.

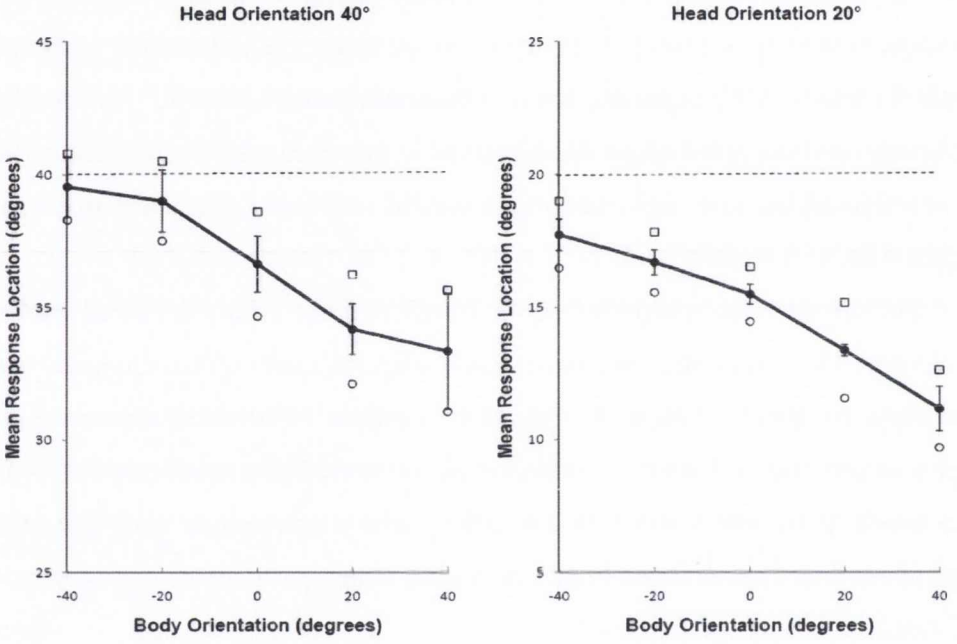


Figure 7.3. The mean response location (in degrees) as a function of body orientation for heads oriented 40° (left panel) and 20° (right panel) collapsed across left/right head orientation in Experiment 10. Error bars indicate *95% confidence intervals* based on the within-subjects standard error of the means (Cousineau, 2005). Mean response locations for left and right head orientations are shown by squares and circles respectively. Dashed line represents the true head angle.

As shown in Figure 7.3, participants gradually perceived the human character as looking further towards the direction of the head when the misalignment between body and head orientation increased. When head and body orientation were aligned (i.e., both 40°), the mean response location was at 33.3°, while a character with a head orientation of 40° and body oriented 40° towards the opposite spatial hemifield resulted in a mean response location of 39.5°. Thus, while there was an overall tendency to underestimate the character's perceived direction of attention (i.e., estimations smaller than the true 40° head orientation),

a systematic bias in the direction opposite to the direction of the body relative to the head was observed. Furthermore, the underestimation of the perceived attention direction was stronger when the head was directed to the right than to the left spatial hemifield (M_{right} = 34.7°, M_{left} = 38.4°).

Analyses of the data with a head orientation of 20 degrees revealed a similar pattern of results. A main effect of body orientation [$F(4, 20) = 7346.02965$, $MS_e = 1.145$, $p < .0001$], and head direction [$F(1, 5) = 6.386$, $MS_e = 16.888$, $p < .06$] was observed. The interaction between body orientation and head direction did not reach significance, $F(4, 20) = 2.121$, $MS_e = .536$, $p = .12$. First, as shown in Figure 7.3, there was an overall tendency to underestimate the perceived angle towards which the character was looking and this was more exaggerated when the head was directed to the right hemifield than towards the left (M_{right} = 13.6°, M_{left} = 16.2°). Second, the gradual shift in the perceived location of attention observed for the conditions with the head oriented 40 degrees was replicated: Progressive misalignment of the body away from the head orientation (e.g., head and body 20° left) towards the direction opposite to that of the head (e.g., head 20° left and body 40° right), resulted in a gradual shift of the perceived looking position further in the direction of the head (i.e., from 11.2° to 17.7°). Interestingly, when the body angle was oriented further away from the direction of the head (i.e., head 20° left and body 40° left), the character was perceived as looking less far towards the direction of the head compared to the aligned head/body stimulus (11.20° vs. 13.4°, $p < .01$). To summarize, despite a general underestimation of the perceived direction of attention, a consistent *overshoot effect* was observed with both 20° and 40° head orientations. The perceived direction of attention of the observed person was systematically biased in the direction opposite to the direction of the body (relative to the head).

7.3 Discussion

The present study examined whether and how the orientation of an observed person's body (i.e., trunks, arms, and legs) relative to their head affects the perception of where that person is attending in the environment. To examine this issue, we adopted a task in which viewers made an eye movement from the head of a full-body computer-generated human character towards a target object from

an array of objects to which they perceived the character was attending, followed by a mouse click on that object. To assess the effect of body orientation relative to the head, the orientation of the body was manipulated independently from the head orientation, which could take two values, namely 20° and 40° left or right of a straight view. We found a systematic effect of body orientation on the perceived direction of attention for both head orientations: compared to a situation in which head and body orientation were aligned, the perceived direction of attention was shifted in the direction opposite to the direction of the body relative to the head. For example, when the head was oriented 20° to the right, a body oriented further to the right (e.g., 40° right) resulted in a shift of the perceived direction of attention further to the left (compared to a situation in which both head and body were aligned at 20° to the right), while a body oriented in the opposite direction relative to head orientation (e.g., head 20° right, with a 0° frontal view of the body or a body oriented 20° left) resulted in a shift of the perceived direction of attention further to the right. In addition, we observed a general tendency to underestimate the *true* direction of attention (i.e., the direction provided by the orientation of the head or eyes, which were always aligned), and this tendency was somewhat stronger when the head was oriented to the right (relative to the observer) than to the left.

Thus, in line with previous studies which examined the relationship between eye gaze and head orientation on the perceived direction of attention in a triadic situation (Anstis, et al., 1969; Cline, 1967), a systematic *overshoot* effect was observed for the relationship between head and body orientation. However, it should be noted that the *overshoot* effect observed in the present study is a *relative overshoot* in the sense that it is defined relative to the perceived direction of attention when head and body are identically oriented, and not relative to the true head or gaze direction. Actually, the perceived attention direction never overshot the true head or gaze direction, even in conditions in which the body was in the furthest orientation, which was opposite to that of the head. In this respect, the present results could also be summarized as showing a general underestimation of the true direction of orientation of the head or gaze but that this underestimation was systematically affected by the relationship between the relative orientations of the head and body (i.e., a reduced underestimation when the body was oriented in the opposite direction relative to the head, an increased

underestimation when the body was oriented further in the direction of the head). At present we can only speculate on the reasons for this general bias in underestimating the true orientation direction of head/gaze. One hypothesis currently under investigation is that the observed underestimation is not a general phenomenon but rather related to the 20° downwards tilt of the head of the models that were used in the present experiment. Specifically, when a head is tilted away from its natural 0° tilt (i.e., perpendicular to an infinite point at the horizon) observers may, in the absence of detailed eye gaze information, estimate the actual gaze direction as being further oriented in the direction of the tilt than the actual tilt itself. In other words, the perceived direction of attention from a head tilted 20° downwards may be overestimated (e.g., 30° downwards) because a tilted head may imply that the observed person's eye gaze is presumably also oriented downwards. As shown in Figure 7.4, this would result in an overall tendency to underestimate the perceived direction of attention for the stimulus configurations used in the present experiment.

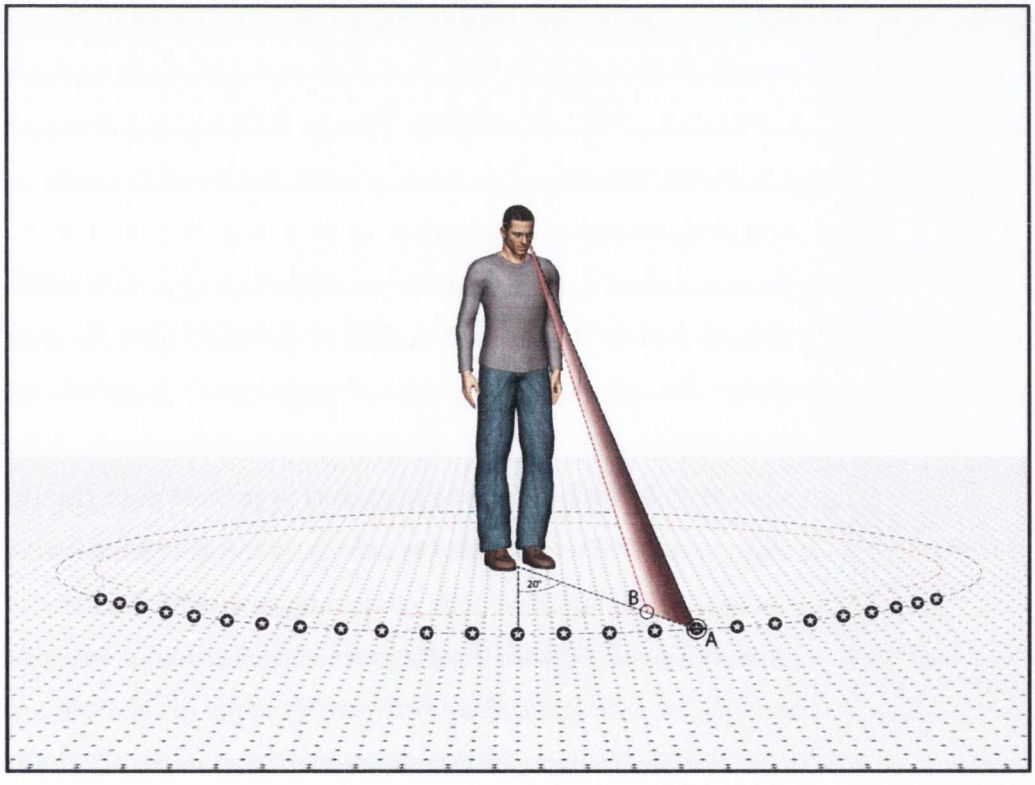


Figure 7.4. A schematic illustration of the head-tilt hypothesis. An a computer-generated human character with head and body oriented 20° to the right. A = actual gazed-at location by the displayed character. B = perceived direction of looking.

Besides showing how head and body cues are combined in the process of joint attention, the present results also confirms earlier reports that body orientation seems to be processed automatically in the computation of social attention (Hietanen, 2002; Pomianowska, Germeys, Verfaillie & Newell, 2010).

Different theoretical frameworks on how social cues (such as eye gaze, head, and body orientation) are combined for the purpose of social attention orienting have been proposed (e.g., Hietanen, 1999, 2002; Langton, 2000; Langton et al., 2000; Perrett, Hietanen, Oram, & Benson, 1992). Based on the finding that single cells in the macaque superior temporal sulcus (STS) respond to conjunctions of eye, head and body posture in particular ways, Perrett et al. (1992; also see Perrett & Emery, 1994) suggested that these cues provide signals about the direction of another individual's attention in a hierarchical manner, with eye gaze information overriding head orientation, and head orientation in turn overriding body orientation. In other words, in the presence of multiple social cues (such as eye gaze, head, body orientation), the perceived direction of an observed person's attention would be determined solely by the highest cue available in this hierarchy. Clearly, the results obtained in the present study and findings from other studies showing that gaze direction is influenced by head orientation (e.g., Anstis et al., 1969; Cline, 1967; Gibson & Pick, 1963; Langton et al., 2004) are inconsistent with the presumption of a unidirectional hierarchy of social cues in the process social attention orienting.

Based on behavioural data from a series of studies adopting a Stroop-like paradigm which required explicit discrimination (left or right) of gaze direction when head orientation was identically or oppositely oriented, Langton and colleagues (Langton, 2000; Langton et al., 2000) proposed a model in which the directional information provided by different social cues is processed in parallel and that these cues have independent and additive effects on the discrimination of the perceived direction of social attention. The model concords with studies that observed a *towing* effect of head direction on the perceived direction of eye gaze (i.e., a perceived direction of gaze somewhere between the angle of the head and the true direction of eye gaze) in a dyadic situation (Langton et al., 2004; Maryuama & Endo, 1983; Maryuama et al., 1985; though see Gibson and Pick, 1963). However, this model is not in agreement with studies showing an *overshoot* effect for the relationship between eye gaze and head direction when

examining the perceived direction of attention in triadic studies (Anstis et al., 1969; Cline, 1967), nor does it fit with the results of the present triadic study. As such the present study may contribute to the growing body of evidence that the processing of social cues in dyadic situations may represent a special case in social perception (e.g., see Itier & Batty, 2009).

The present observation that the perceived direction of attention was systematically biased in the direction opposite to the direction of the body relative to the head may suggest that in the process of social attention orienting in a triadic situation, head orientation is initially referenced in relation to the observed person's frame of reference (i.e., their body), and only then in relation to the observer (e.g., Bayliss, di Pellegrino, & Tipper, 2004; Bayliss & Tipper, 2006b). Within this framework, when the head is misaligned relative to the body, this initial referencing would signal that the observed person has an averted attention direction to his left or right, whereas an observed person with aligned head and body orientation would initially be coded as a person with their attention directed straight ahead relative to the observer. When head and body are not aligned, such a coding mechanism could bias subsequent processing stages in the direction of the head relative to the body (or similarly, against the direction of body relative to the head). Support for such a mechanism can be found in studies examining reflexive shifts of attention by central, non-predictive social cues. For example, Hietanen (1999) manipulated eye gaze and head orientation independently and found that reflexive orienting of attention in the direction of the eye gaze was induced only when eye and head direction did not coincide (i.e., there was a facilitation when eye gaze was oriented 30° to the left of a frontal view and the head was oriented towards the viewer, but no attentional cueing effects when both eye gaze and head were oriented 30° to the left). Furthermore, when a lateral head with a frontal gaze was presented, observers were faster to respond to a target when the head was oriented in a direction opposite to the location of the target stimulus. To explain these results, Hietanen suggested that in the orienting of social attention, the direction of the observed person's gaze or head is not directly encoded relative to an observer-based (or egocentric) frame of reference. Instead, gaze and head direction cues are combined into an allocentric frame of reference centred on the observed person, and only then is the direction of attention related to the observer's own egocentric frame of reference. In a similar study (Hietanen,

2002) in which spatially unpredictive social cues of a person's head and upper-body were displayed centrally, a cue containing head and upper-body oriented in different directions (i.e., head rotated towards the target but a front-facing upper-body) facilitated reaction times while a cue with identical head and upper-body direction (i.e., both head and upper-body rotated towards the target) did not.

Together, these results provide support for the suggestion that in social attention orienting, different cues are initially used to derive the other person's direction of attention in an allocentric reference frame and only after this, the other person's direction of attention is related to the observer's egocentric frame of reference (Hietanen, 2002). Furthermore, a model in which social attention orienting uses a hierarchy of social attention cues was proposed (Hietanen, 1999, 2002). According to the model, gaze direction is inferred relative to head orientation, and head orientation in turn is inferred relative to body orientation. If the derived relationships between these cues suggest that the other person's attention is laterally averted, a spatially defined directional code is then activated which may trigger an automatic shift of the observer's own attention in that direction.

Although Hietanen's model of social attention orienting was intended to explain general reflexive orienting (i.e., to the left / right hemispace in a cueing paradigm) by combinations of social cues, it can be extended to explain the overshoot effect observed by the relationship between head and body orientation in the present study which examined attentional orienting towards specific locations/objects in space (i.e., the establishment of joint attention in a triadic situation). In particular, the model proposes that attention shifts are activated based on the hierarchical referential coding of body parts (i.e., in an allocentric-based frame of reference) in which head orientation is referenced to body orientation. Accordingly, the overshoot effect observed in the present experiment can be understood in terms of stronger activation of directional codes driving attentional orienting when head and body orientation are not aligned. Specifically, when the head is oriented to the left relative to the body in the observer's own reference frame, hierarchical coding of the observed person's head relative to their body signals that the person is attending to their right in an allocentric reference frame centred on the observed person which, in turn, may activate a stronger directional code in the direction of the head relative to the body. The observation

that the overshoot effect in the present study increased progressively as the angle between body and head increased could be consistent with a stronger directional code being activated.

One reason why allocentric coding may be important is that, when body and head or gaze are not aligned, the perception of implied motion may be induced (Freyd, 1983; Jellema & Perrett, 2003a, 2006). For example, a human figure with its trunk and legs oriented to the left (of the viewer) and a head facing front, may imply a rotating action of the head from a resting posture where the direction of the head and body are aligned (to the left of the viewer) to the character's allocentric left (i.e., to the right of the observer). Thus, the misaligned head and body may have induced some form of implied motion perception, which activated a dynamically based directional spatial code as a result of allocentric coding of body parts. Furthermore, implied motion may signal an intentional component of the observed person, which in turn may influence the perceived attention direction of the observed person. Further research is required however to elucidate these mechanisms and their role in social attention orienting.

CHAPTER 8

GENERAL CONCLUSIONS

8.1 Summary

This dissertation has been undertaken with the intention of advancing our knowledge in the field of social attention perception. The point of departure for this dissertation was the assumption that the orientation of the trunk, limbs and the whole range of complex body postures play an important role in the perception of social attention (Emery, 2000). The empirical work presented within this dissertation was intended to examine whether the human body stimulus can indeed be recognized as an important source of social information, which contributes to the computation of social attention and influences the social directional signalling from other social cues (e.g., eye-gaze, head). We specifically addressed the question, whether directional body information (i.e., trunk, arms and legs) is routinely processed and integrated with directional information from other social cues in our daily social experience. The work presented allows us to clarify certain mechanisms underlying the processing of directional information on social attention extracted from the whole human body, its parts (e.g., eyes, head, trunk, limbs), and the different arrangements between these cues. The role of directional body information was investigated via four different paradigms (i.e., the Stroop paradigm, the Simon paradigm, the Posner attentional cueing paradigm, and a newly introduced localization paradigm). Consequently, the objective of the present dissertation was to provide empirical data to answer four major questions: (1) Does directional body information influence overt discrimination of the direction in which another person is looking? (2) Does the orientation of a perceived human body in itself, and/or the relationship between body and head orientation, activate a particular, spatially defined code? (3) If this is the case, can such a code be related to attentional cueing effects? In other words, does body orientation trigger (voluntary and/or automatic) shifts of attention and furthermore does it influence cueing effects triggered by other social cues? (4) Does directional body information influence processes involved in the precise localization of where (or to what object in the environment) another person is looking? In other words, we wished to assess the contribution of the body cue in the process of establishing a state of *joint attention* (i.e., a state in which the attention of the observer is oriented towards the object/event being observed by another person). The results from each paradigm

provided insights into the cognitive processes involved at different processing stages of social information processing. In this final chapter, we discuss them in the context of previously proposed models on the integration of social, directional cues. As mentioned in the introductory chapter, these models are somewhat inconsistent with each other. Therefore, the main objective of the present thesis was to provide a possible explanation for the inconsistencies between existing models on the integration of social directional information found in the literature. In attempting to answer the question of how the information from the human body is integrated with the information from other social cues (e.g., head, eyes) as well as to clarify the mechanisms underlying the integration of social information from different social cues, we will attempt to frame the final conclusions within one unifying model. We will also highlight some potential avenues for future research on this topic.

8.2 Assessment of existing theoretical models in light of the present findings

The Direction of Attention Detector system

The hierarchical model proposed by Perrett and colleagues (1992; also see Perrett & Emery, 1994) was not confirmed by any of the studies reported in the present dissertation. The results obtained with each of the four adopted paradigms showed that directional body information (which according to Perrett and colleagues should be considered the lowest cue within the assumed cue hierarchy) is automatically processed and is not suppressed by directional information from other available cues (in particular directional head information) which are situated at higher levels within the assumed social cue hierarchy. Thus, consistent with a large set of studies showing that the processing of gaze direction can be influenced by head direction (e.g., Anstis et al., 1969; Cline, 1967; Gibson & Pick, 1963; Hietanen, 1999; Langton, 2000; Langton, Honeyman, & Tessler, 2004), our results add to the few studies showing that directional body information can influence the processing of directional head or gaze information (i.e., Hietanen, 2002; Seyama & Nagayama, 2005). Together these studies make a

strong case against the unidirectional hierarchical vetoing model proposed by Perrett and colleagues.

The Positive Congruency Model

The *positive congruency model* which was largely put forward based on studies which adopted a Stroop methodology, proposed that directional information from gaze, head and body are analyzed separately and in parallel. Thus, the model predicts that the direction of attention of an observed person is signalled most efficiently when all directional cues are oriented congruently. In Chapter 2, adopting a similar Stroop task, we initially found evidence in support of the model: Discrimination of head direction was faster when head and body were congruently versus incongruently oriented. However, when task difficulty was increased (by decreasing the lateral deviation of the head from 30 to 5 degrees) the positive congruency effect between directional head and body cues reversed. Thus, although the positive congruency model was not entirely rejected, the results reported in Chapter 2 show that the issue of computing the direction of attention from multiple social cues is more complex than suggested by the positive congruency model.

The outcomes of the study reported in Chapter 4, which adopted a Simon paradigm, were also inconsistent with the predictions of the positive congruency model. The speed at which a facial expression of a forward facing person was categorised when an averted body orientation that was either compatibly or incompatibly oriented with the required response location showed a reverse compatibility effect (i.e., when the orientation of body was compatible with the required response location, responses were slower relative to when body orientation was incompatible with the response location). This result is clearly at odds with a model which assumes separate and parallel processing of different social cues, resulting independent and additive effects of cues (i.e., the positive congruency model would predict a normal compatibility effect).

The results obtained from the Posner attentional cueing task in Chapter 6, also speak against the positive congruency model. According to the model, one would expect the strongest cueing effects in conditions with a corresponding head and body orientation, yet it is precisely in this condition that we failed to observe any cueing effect. Attentional cueing effects emerged only when the body was not

aligned with the head. Furthermore, these cueing effects gained in strength when the head and body were oriented in opposite directions (compared to a condition with a frontal body). Thus, again these data argue against pure parallel processing of social cues with independent and additive effects in the computation of the direction of social attention.

Finally, the results obtained with the localization task (Chapter 7) showed that, compared to a situation in which head and body orientation were aligned, the perceived direction towards which an observed person was attending was systematically shifted in the direction opposite to the direction of the body when it was misaligned with the head. Again, the positive congruency model would have predicted the reverse of what we observed (i.e., a systematic shift in the direction of the body when misaligned with the head).

The Reverse Congruency Model

The reverse congruency model was first proposed by Hietanen (1999, 2002) to explain general reflexive orienting by specific combinations of social cues. In particular, it provided an explanation for why stimuli with congruently oriented head and trunk cues do not result in reflexive attentional orienting, while incongruently oriented head and trunk cues do. Our results obtained with the Posner attentional cueing paradigm (Chapter 6), essentially concord with those of Hietanen (2002), in showing that reflexive attentional cueing effects were restricted to those conditions in which the orientation of the observed person's body did not coincide with the orientation of the head. Furthermore, our results go beyond the empirical evidence initially provided by Hietanen in support of his model, by showing that in conditions with an averted head and body oriented in opposite directions (from the observer's point of view), cueing effects showed earlier onsets and were larger in magnitude than in conditions with an averted head and the body oriented towards the viewer. Given Hietanen's proposal that reflexive attention shifts require a signal that the observed person in his frame of reference has an averted attention direction, both this earlier onset and the larger cueing effect observed in the condition with head and body oriented in opposite directions, may be a result of faster or enhanced processing of such a signal (i.e., larger angles between head and body may result in faster processing of the supposed *averted attention* signal, thus triggering faster attention shifts).

The results obtained with the Simon paradigm (Chapter 4), namely that categorization speed of a facial expression of a forward facing person with an averted body orientation that was either compatibly or incompatibly oriented with the required response location showed a reverse compatibility effect, is fully consisted with Hietanen's model. Given the model's assumption that head orientation is referenced relative to body orientation, a left oriented body with a frontal facing head would activate an *averted attention signal* in a left-right direction (i.e., in a direction opposite to that of the body orientation), thus facilitating a right response (i.e., a reverse compatibility effect).

The results obtained with the *localization task* (Chapter 7) also fit with the model and can be understood in a similar way. We observed that the perceived direction towards which an observed person was attending was systematically shifted in the direction opposite to the direction of the body when misaligned with the head. Furthermore, this shift increased with larger deviations between the orientation of the head and body. According to the model, the referencing of head orientation relative to body orientation results in an *averted attention signal* when head and body orientation do not coincide. Thus, an observed person with its head oriented 20° to the left and its body 20° to the right (from the observer's point of view) will activate an *averted attention signal* with a left to right direction, thus causing a shift in the perceived location of attention of the observed person in a direction opposite to the direction of the body relative to the head. If one assumes that the *averted attention signal* proposed by Hietanen may differ in strength depending on the discrepancy between head and body orientation, the systematic shift in perceived attention location of the observer with larger deviations between head and body orientation can be perfectly explained by the model.

Finally, the Stroop experiments reported in Chapter 2 showed that when an overt head direction judgement had to be made, the effect of body orientation relative to head orientation varied qualitatively with task demands. At first sight, the positive congruency effect observed with easy head orientations (i.e., when the head was averted 30° relative to the viewer) is at odds with Hietanen's model, however, the reversal of the congruency effect observed with a more difficult head orientation (5°) seems to fit well with the model. In fact, within the present dissertation, which adopted a variety of paradigms, the only result that does not seem to fit with the model proposed by Hietanen is the result obtained in

Experiment 1 with the relatively easy Stroop task. Hietanen (2002), when discussing his findings on reflexive attentional cueing and his model in relation to the positive congruency effects found within a Stroop task and the proposed positive congruency model of Langton and colleagues based on these Stroop data, came across the same discrepancy. Hietanen (2002, p. 178) suggested that "the most likely reason for these discrepant results is related to the differences in the intention the visual information from social cues was used for in these studies: i.e., attention orienting vs. direction discrimination" and consequently, that "visual information from different social cues may be processed and integrated differently for the purpose of covert visual attention orienting than for overt direction discrimination of social directional cues". However, our results obtained with more difficult head orientations in the Stroop task (i.e., a reversal of the congruency effect) seem to counter this interpretation. As explained in Chapter 2, the reversal from a positive congruency to a reverse congruency effect with increased task difficulty in the Stroop task, suggests a two-stage information processing system, including a stage of parallel and independent cue processing, followed by a stage in which the cues are integrated. As argued in Chapter 2, this second stage of processing seems to be characterized by a referential coding of the head relative to the body, which is fully compatible with the model proposed by Hietanen. Thus, if we wish to integrate the current findings regarding the integration of head and body cues obtained with different paradigms within one coherent account, the analysis presented above may suggest extending the model proposed by Hietanen with an initial parallel and independent cue processing stage.

8.3 Towards an integrated model on the role of directional body information in the perception of social attention direction

The previous discussion of existing models in light of the empirical findings obtained within the experimental work of this dissertation points towards the need to reconcile a two-stage processing account (including an initial parallel, independent cue processing stage, and a referential coding stage) based on the results obtained with a Stroop paradigm with a referential coding account based on the results obtained with a Posner attentional cueing paradigm, a Simon

paradigm, and a localization paradigm. As suggested above, although Hietanen's model was intended to explain general reflexive orienting by combinations of social cues, intuitively the most straightforward option seems to extend Hietanen's model to include an initial parallel and independent cue processing stage as this has the potential to explain the entire set of results obtained within the present dissertation. Note, however, that by introducing this extended version of Hietanen's model on the basis of our empirical findings, our focus is on directional head and body cues and the way both cues are oriented relative to each other. In other words, at this stage we do not wish to claim that the extended model applies to the processing and integration of directional gaze and head cues (or any other social cues). Furthermore, there are a number of reasons why the integration of directional gaze and head information may be different from the integration of directional head and body information, one of which is the fact that visual information concerning gaze direction spatially overlaps with head information, while this is not the case for directional head and body information. Such differences could have profound consequences on how information from different cues is treated by the visual system (both temporal and in terms of the processes involved), especially if one assumes that head and gaze information have a natural tendency to be projected onto the foveal area (to discern detailed gaze information), while body information may be encoded from peripheral vision. Likewise, it can be assumed that the focus of attention when viewing a human figure is presumably biased towards the head and eyes, which could affect the interplay between gaze and head cues versus head and body cues. Thus, one should be cautious in simply transferring a proposed cue processing mechanism specifying the interplay between two specific cues to any other type or combination of cues.

Following Langton and colleagues (Langton, 2000; Langton et al., 2000) the model that we propose (see Figure 8.1) is based on the idea that a number of separate detectors exist, which process signals such as head orientation and body orientation separately and in parallel. We assume that the initial processing leading up to their activation is fast with all the characteristics of a parallel, fast feedforward or bottom-up sweep of activation (Ahissar & Hochstein, 2004). These detectors rapidly feed their outputs into a stage where the directional information encoded from the individual cues is pooled. At this pooling stage, any

interference between conflicting information from different sources is treated in an additive way. We further assume that this activation is short-lived.

On the other hand, we assume a slower, recurrent process in which the outputs of the separate mechanisms that were activated in parallel become integrated. In other words, body and head are treated as a whole and the relationship between its parts can be analyzed. In particular, following Hietanen (1999, 2002), we propose that this integration process involves a number of sequential steps. First, head orientation is referenced to body orientation (i.e., in an object-centred or allocentric way), resulting in an *averted attention signal* when head and body orientation do not coincide (if both cues do coincide in terms of orientation, no such signal is activated). This signal includes a directional code in the direction of the averted attention and is still coded in an object-centred way (i.e., an attention signal in the observed person's frame of reference). Next, the observed person's direction of attention is related to the observer's own frame of reference, transforming the activated allocentric directional code, into a view-centred code. This signal in turn feeds into the previously mentioned pooling system (i.e., a signal is only sent when head and body orientation did not coincide). We assume that this signal, given the number of processing stages involved, arrives somewhat later than the activation resulting from the initial feedforward sweep. Furthermore, we assume that there can be a continued activation of the signal as long as the stimulus is attended.

Finally, we assume that the pooling system affects both attentional orienting mechanisms (i.e., in the Posner attentional cueing task and the localization task) as well as response selection stages involved in overt discrimination tasks (i.e., in the Stroop task and the Simon task).

The proposed two-stage process is able to account for each of the results obtained within the present dissertation. First, the model can account for the effect of task difficulty in the experiments, which adopted a Stroop paradigm (Chapter 2). Here we observed a positive congruency effect when task difficulty was low and a reverse congruency effect when task difficulty was increased. The model can account for this discrepancy in two ways.

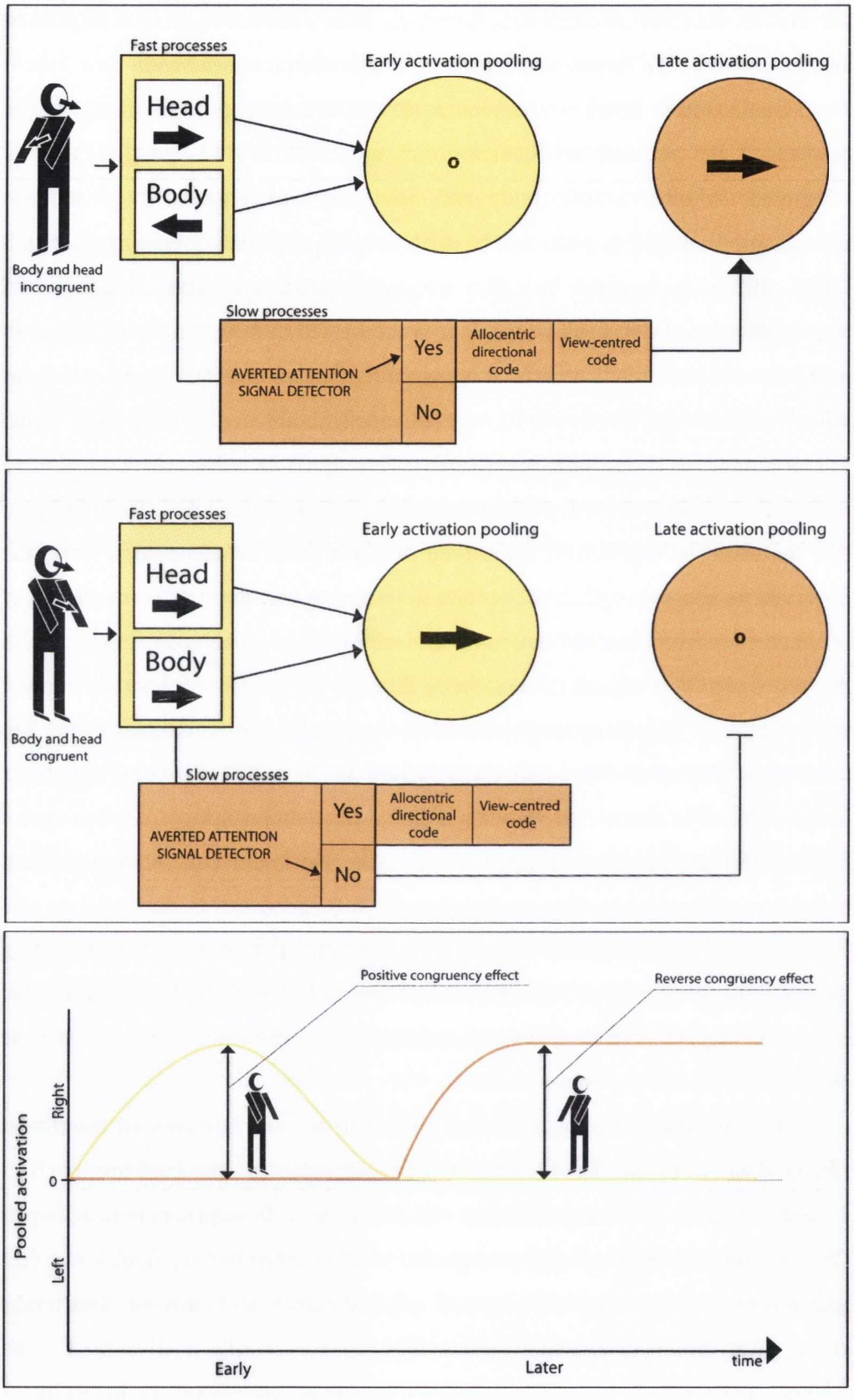


Figure 8.1. A schematic presentation of an integrated model on the role of directional body information in the perception of social attention direction.

First, if response selection is fast, the directional activation in the pooling mechanism (which is assumed to affect response selection) is the result of the fast feedforward sweep, activating the separate head- and body-detectors which in turn each send directional information to the pooling system. Because of the additive nature of the pooling system a positive congruency effect will result (congruent head and body orientations strengthen each other, incongruent orientations cancel each other out). However, when response selection is slowed because of increased task difficulty, the activation in the pooling system that resulted from the feedforward sweep will decay and will be overwritten by the slower, recurrent and integrative process described above. Because this process includes referencing of head orientation relative to body orientation, and because it only produces output for the pooling system if head and body do not coincide, the congruency effect will reverse.

A second way in which the model can account for the results is by assuming that increased task difficulty always involves the slower, recurrent and integrative process, whereas this is not the case when the task is effortless and can be resolved fast and accurately.

The model also accounts for the results obtained with the Posner attentional cueing paradigm (Chapter 6). Similar to Hietanen (2002), we observed reflexive attentional cueing effects only when head and body orientation did not coincide. Given that the earliest signs of reflexive attentional cueing were found with reaction times approximately 600 ms following cue onset (i.e., SOA of 120 ms plus a median RT of approximately 500 ms) in the present experiment (approximately 500 ms after cue onset in Hietanen, 2002), it is reasonable to conclude that attentional orienting would not be based on activation in the pooling system resulting from the initial feedforward sweep of activation, but instead from the slower recurrent and integrative process. Because the slower process does not deliver any output when faced with coinciding head and body orientations, no reflexive shift in attention would result.

Finally, both the results obtained with the Simon and localization paradigms can be understood within the proposed framework. Without spelling out each of the steps of the model for both paradigms, in both cases, reaction times were either relatively slow and/or stimulus processing was effortful, thus favouring

activation in the pooling system based on the slower, recurrent and integrative process.

To conclude, although Hietanen's model of social attention orienting was intended to explain general reflexive orienting by combinations of social cues, the current extension with an early parallel processing stage does seem to explain most of the results obtained within the present dissertation. However, predictions from this extended model await further validation. For example, on the basis of the present framework one could predict that in tasks involving both congruent and incongruent body postures which initially show positive congruency effects would show a reversal (i.e., a reverse congruency effect) when either task difficulty is increased or response times are artificially delayed, thus fostering either more effortful processing or just extended processing of the stimulus. In fact, as mentioned in Chapter 2, the latter manipulation was adopted by Ricciardelli and Driver (2008) in a Stroop task involving the judgment of gaze direction with congruent and incongruent eye/head stimuli. Consistent with our framework, Ricciardelli and Driver observed positive congruency effects when participants were put under time pressure, while reverse congruency effects were found without time pressure. Though the results obtained by Ricciardelli and Driver (2008) lend support for one of the two proposed routes to reverse congruency effects (i.e., prolonged processing), it still remains unclear to what extent prolonged processing or effortful processing may actually be the key to the reversal of observed congruency effects. While both are intimately linked with each other, further research could clarify their respective relationships with the reversal of congruency effects.

An obvious question that needs to be dealt with in future research is whether the present model can be generalized beyond the head-body relationship investigated in the present dissertation (e.g., the relationship between directional eye-gaze and head information. At this stage however, we do not wish to generalize the framework to all possible cue combinations for reasons mentioned before. A non-exhaustive search through the literature on the eye-head relationship does nonetheless point towards a first discrepancy with the present framework. Specifically, a few studies showed a *towing effect* in the gaze perception literature (i.e., the perceived gaze being towed towards the direction of the head when head and gaze are not aligned; e.g., Langton, Honeyman, &

Tessler, 2004; Maruyama & Endo, 1983; Maruyama, Endo, & Sakurai, 1985), which seems inconsistent with the present proposal. However some of these studies are under dispute either because of the artificial stimulus materials used, or their discrepancy with a range of earlier studies showing the opposite effect, i.e., the *overshoot effect* (e.g., Anstis, Mayhew, & Morley, 1969; Cline, 1967; Gibson & Pick, 1963).

8.4 Some further suggestions for future research

We already mentioned a few avenues for future research in the preceding section. Here we will briefly touch upon a selection of some additional issues that we believe deserve further clarification.

In Chapter 5, we investigated the propensity of headless bodies to reflexively trigger attention shifts. Contrary to our expectations, we observed a reflexive cueing effect only with body postures displaying a static pose (e.g., a standing pose) and not for those body postures displaying an action or implied motion (e.g., a walking pose). While it is possible that dynamic body poses do not have the propensity to cue our attention in a reflexive manner, we suggested that human figures representing implied motion may require more processing time than a static pose (also see Freyd, 1983), thus obscuring possible reflexive attention shifts. An alternative explanation is that the absence of reflexive cueing may perhaps be due to a problem of disengagement of attention from the stimulus, which in turn maybe due to a variety of causes (e.g., mental stimulation of the motion trajectory, expectations of sudden motion, etc.). Clearly, future research should first extend the observed differences in cueing effects using a wider set of dynamic and static poses. If the dichotomy is indeed confirmed further research could be carried out to test some of the hypotheses suggested in the present work.

The localization paradigm that was introduced in Chapter 7 opens a further set of questions for future investigation. One question that deserves further clarification is the fact that, in general, there was a tendency to underestimate the true location to which the observed person was attending (irrespective of the orientation of the body relative to the head). At this moment we are not sure whether this general bias reflects a true bias or whether it is a consequence of the specific methodology that was adopted. In particular, further research should be

carried out to examine whether having to drag the mouse cursor from a horizontally centred position towards the perceived target position may have caused a general underestimation of the target's location. To this end we propose carrying out the same experiment with an eye movement methodology. Instead of indicating the target by means of a mouse click, we could simply ask participants to make an eye movement to the perceived target location and with an eye contingent display change, highlight the location of the target that is being fixated until the viewer accepts the target by means of a key press. Introducing this eye movement version would also allow us to measure saccadic latencies from the head of the viewer, actual saccade landing positions etc., which could all lead to a better understanding of the processes involved in establishing joint attention. One step further would be to use the eye movement methodology in real life or in a more controlled virtual reality setting, that is while viewing another person who is dynamically shifting his or her attention in space by taking on different head-body orientations and fixating different objects within a scene.

Finally, it should be pointed out that in the present dissertation, the examination of the role of directional body information was restricted to situations in which eye-gaze direction was always identical to head direction. Further research should be carried out to examine whether the observed effects of directional body information still hold under conditions in which head and gaze direction do not coincide.

8.5 A final word on the reverse congruency effect

Throughout the present dissertation the reverse congruency effect has taken a central place. In all but one of the experiments reported, we consistently found that when head and body orientation did not coincide, some activation of a spatial code in the direction opposite to the direction of the body relative to the head was observed. Reframed, there was always evidence in favour of the activation of a spatial code in the direction, which coincides with the direction of a turn of the head from an aligned head and body towards its averted orientation. The underlying tone of the proposed model was also that this type of activation (consistent with a reverse congruency effect) is the normal modus operandi of the visual attention system (i.e., the one for which it seems to be designed). The

question one could ask then is: Why would visual processing of the head-body relationship proceed this way?

We believe there are a number of potential reasons for this. First, as pointed out by Hietanen (2002), the observed reversed congruency effect may turn out to have an adaptive function. That is, a combination of incongruent cues may signal that the observed person is in a state of *active attentional behaviour*, i.e., an averted gaze direction relative to the head, or (as in the present dissertation) a rotated head relative to the body, may signal that something or some sudden event has attracted the observed person's attention (perhaps a dangerous animal or some food) and function as an ostensive sign (Gergely, 2010). In a broader perspective, this adaptive function could be framed in terms of the benefits of being able to reach a state of joint attention. Second, the specific activation pattern could be related to the perception of implied motion. Perhaps when confronted with an image of a rotated head, our visual system assumes that the head is in the course of a rotating action and anticipates its upcoming position, thus overestimating its true angle. Finally, in the absence of precise eye-gaze information, the visual system may use a strategy of overlearnt contingencies between the rotated angle of the head (relative to the body) and the actual direction of gaze. Specifically, when we want to attend to an object in our environment, which is not located directly in front of us, we usually shift our eyes towards the object, unless the angle exceeds a certain magnitude. When this angle is exceeded we turn our heads, but we do not turn our head completely towards the object. Instead we turn our head somewhat in the direction of the object and the remaining angle is taken care of by an averted gaze. Given that small rotations of the head usually go together with small angles of averted gaze, and larger head rotations with large angles of averted gaze, our perceptual system may implicitly use this correlation when the gaze direction of an observed person is poor or unavailable. This would imply that the larger the deviation between the orientation of the head and body, the stronger the perceived direction of attention will be biased in the direction specified by a turn of the head from an aligned pose to an averted head pose. Such a perceptual bias may turn out to deliver more accurate information on the direction in which an observed person is attending in the real world. Further research may shed light on which of these explanations or combination of explanations is valid.

8.6 Conclusions

We situated the current research as being on the cross-point of two separate lines of research: the field of visuospatial attention and social cognition. Using a number of paradigms, we demonstrated that directional body information as a social cue is processed automatically and that it affects overt discrimination of attention direction, voluntary and reflexive attentional orienting, and processes involved in the establishment of joint attention.

By emphasizing the role of the body as a social cue in the process of the computation of social attention, we hope to indicate that the computation of the direction of social attention is more sophisticated than it has been suggested so far in the literature and that this domain awaits essential follow-up research in order to elucidate its details. For that purpose we proposed a framework, which is an attempt to reconcile the different empirical findings obtained in the present dissertation. The framework can serve as a theoretical point of departure for future empirical work and allows us to make more specific predictions while investigating the intriguing topic of the phenomenon of social attention.

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APPENDICES

Appendix A

Ethics Approval Letter

School of Psychology
University of Dublin, Trinity College
Dublin 2, Ireland

Tel: +353 1 896 1886
Fax: +353 1 671 2006

F.A.O. Iwona Pomianowska

School of Psychology Research Ethics Committee

27 June 2007

Dear Iwona,

Following receipt of a signed 'working with adults' form, the participant recruitment poster and confirmation of a break for participants during the study, I am pleased to inform you that your application entitled "Motion and sound in action perception" has been approved by the School of Psychology Research Ethics Committee.

Yours sincerely,

Kevin Thomas, PhD
Chair,
School of Psychology Research Ethics Committee

Appendix B

Exemplary Information Sheet and Consent Form for participants:

Together with my supervisor (Dr Fiona Newell), I (Iwona Pomianowska) am investigating what cues contribute to the perception of human action. The following experiment is a part of a research project in the School of Psychology, Trinity College Dublin.

You will be required to complete some simple, perceptual tasks on the computer. For example you may be presented with a display of various human movements and actions and you will be asked to categorize the action displayed in the visual image.

You will gain 1 research credit per 30 mins of your participation. The experiment should take around 1 hour.

Please be assured, that if you agree to partake in this study, your responses will be completely confidential and known only to the researchers involved in the study. Furthermore, under the Freedom of Information Act, you have the right of access to your own personal data upon request. If at any time you have a question, please feel free to ask it, and you can contact any of the researchers who are involved in this study: Iwona Pomianowska (pomianoi@tcd.ie or Ext 8418) or Dr. Fiona Newell (Fiona.newell@tcd.ie; Ext 8402).

If you are interested in taking part, we would like to ask you to sign below to give your consent to take part. Please be aware that even when you do consent to take part, you have the right to withdraw from the study at any time without prejudice. We would like to thank you for your attention and be very grateful if you decide to participate in our study.

Yours sincerely,

Iwona Pomianowska,
Multisensory Cognition Group
School of Psychology and Institute of Psychology
Trinity College Dublin
Email: pomianoi@tcd.ie
Tel.: 01 8968418 (or Ext 8418 inside TCD)

I agree to take part in this study.

Name _____

Address _____

Phone: _____

_____

I am aware that I may be contacted by the researchers and invited to take part in follow-up studies.

Signed _____

Appendix C

Information Sheet and Consent Form for actors taking part in stimuli creation

INFORMATION SHEET

STUDIES ON PERCEPTION OF HUMAN ACTION

Title of project: Social cues perception.

Researchers: Iwona Pomianowska & Dr. Fiona Newell,
Multisensory Research Group, Trinity College Dublin

Information about the project:

My name is Iwona Pomianowska and as part of my postgraduate research I want to investigate how motion and auditory information determine the perception of human action. I want to investigate how we recognize simple, every day actions and social interactions between people. I want to see also, whether the performance of real versus virtual humans is perceived differently.

To create the video material needed for this experiment we need to record the performance of real actors on the video tape and also capture their motion digitally as well. Thus, you might be recorded in two ways: using video capture or/and using a motion capture system, which tracks your movements and records them on the computer. As an actor for motion capturing, you will be given a motion capture suit to wear, which is a black suit with motion sensors attached.

Your task will be to demonstrate simple every-day actions or to interact with somebody else in a simple conversation, encounter or throwing and giving some objects.

The completion of these tasks will take approximately 1 hour.

If at any time during the recording you wish to withdraw from the study then you may, without prejudice.

Your participation and help with creating our stimuli will be deeply appreciated.

If, at any time, you have any questions regarding this research, please feel free to contact Iwona Pomianowska (pomianoi@tcd.ie) or Dr. Fiona Newell.

Letter of Consent - Actors

Title of Project: Social cues perception

Participation in the study is entirely voluntary and if you agree to participate you have the following rights:

1. The information from this study will be kept strictly confidential and will not be made available to any other people outside the research team. Your identity will also remain confidential.

2. As participation is completely voluntary, you are free to withdraw from the study at any time, without prejudice.

I, the undersigned, give my informed consent for my appearance to be recorded in order to allow the creation of video stimuli by the Multisensory Research Group, TCD at the Trinity College Institute of Neuroscience.

Full Name: _____

Signed _____

Date _____

Contacts for any further queries:

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