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“A Gaze into politics. The role of ideology, personality and political group processing in shaping automatic social behaviors”

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European Ph.D. program in ‘Cognitive Plasticity and Rehabilitation’

XXIV cycle

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Acknowledgments

First of all, I am deeply grateful to Professor Salvatore Maria Aglioti, without him, his ideas, his enthusiasm, his will to explore new fields and to bet on new lines of research and, last but not least, on me as researcher. His eclecticism is a rare and precious quality, which enrich also who is around him. Without him most of the studies I am presenting here would have simply not be possible.

I owe Professor Anna Maria Borghi a huge debt of gratitude because she made me discover the amazing world of the empirical research on the embodiment. During the time, she also became a good friend, who provided me human support, beyond giving precious professional advises. Without her and her teaching I would simply have never became a researcher.

I want to thank all of the members of the Social and Cognitive Neuroscience Lab - Sapienza. In particular, I want to thank Matteo Candidi and Filippo Crostella, because they taught me most of the skills needed to run my experiments with TMS and eye tracking. Without them, most of the experiments I present here would simply have been never ran (or, at least, not by me).

In this activity, beyond the professional quality, it is important to share meaningful human relations, if not with everybody, at least to some of the co-workers. Under this light, I want to thank again the afore mentioned Matteo and Filippo, and most importantly, Maria Serena Panasiti with whom I shared this tough and fascinating path during these three years of Ph.D. program, in which as colleagues, we continuously shared ideas and, also, support. Which is not something that always happens among colleague in a so competitive environment as the research is, whereas the "*mors tua vita mea*" motto, may easily over-rule all the professional and human relations.

To this regard, I am also grateful to Cristina Cimmino, who happened to be at the same time a long term friend and a colleague, with whom I also shared all the anxieties of being a Ph. D. students in these years, by having some of the most important coffee breaks talking about our human and professional lives.

I want to thank also my co-workers in the Social, Affective and Cultural Neuroscience Lab – Northwestern University, because the continuous exchange of ideas with them has largely influenced many of the interpretations of data you can find here. In particular, Bobby Cheon has been a really tireless and precious source of ideas to me, especially for future directions of research.

I also want to thank Emmanuel Guzman and Laura Ortega, from the Visual Perception, Neuroscience and Cognition Lab – Northwestern University, who gave me a huge human and scientific support as I started to write this dissertation in Evanston, IL.

I want to thank Paola, because she has always believed in me, even when everything seemed to be dark. Without her support in many of the hard times we shared together, I would probably have sank, even before landing anywhere.

I thank my parents, Emanuela and Roberto. I inherited by them (culturally, rather than genetically) that will of knowledge that pushed me to keep in studying and giving me new questions. They also taught me that culture, knowledge and curiosity are values, in a world in which only getting easy money seems to determine the prestige of an individual. I think their teaching has been determinant in developing Openness to experience, an attitude that is fundamental both in Politics and Science, two of my biggest passion, which I tried to blend together in my research. I hope to have done it at least decently.

Any political reflection that is of possible political significance is ideological: in its terms policies, institutions, men of power are criticized or approved. J.S. Mill

1. Introduction: a gaze into the gaze

This introduction's title aims to catch the intimate chiasmic nature (Merleau-Ponty, 1968) of the gaze as subject and object of an action at the same time. As pointed out by Gibson and Pick (1963) "the act of looking can be treated as a source of stimulation as well as a type of response". Our gaze, and its use as an important communication tool, is at the very basis, along with another important social cognitive tool as language, of building complex societies, ruled by that complex blend of cooperation and competition, tendency to equality and faith in hierarchies, we call politics.

A growing interest in the study of 'the political brain' over the past few years can be noted (Amodio, Jost, Master, & Yee, 2007; Kaplan, Freedman, & Iacoboni, 2007; Knutson, Wood, Spampinato, & Grafman, 2006; Zamboni et al., 2009). Even if these studies have been accused to be redundant, not adding anything else than some colored brain map to what psychologist have already discovered by means of questionnaires and experiments (Legrenzi & Umiltà, 2009), it has to be acknowledged, on the other hand, that some of these studies provided us some more important insights not achievable by the mean of classical behavioral research. For example, even if the reduction of individual ideological differences into a uni-dimensional left-right spectrum is still considered the standard in political psychology (Catellani & Corbetta, 2008), a study on the neural correlates of political attitudes are showing political beliefs distribute themselves within a multi-dimensional (rather than uni-dimensional) space (Zamboni et al., 2009). Indeed, Zamboni and

co-workers (2009) identified the dimensions of individualism, conservatism and radicalism as important bases underlying political beliefs, revealing that these dimensions are related to the activation of specific brain areas. Having to judge political statements related to Individualism was found to be linearly associated with activation in ventromedial prefrontal cortex (VMPFC), dorsomedial prefrontal cortex (DMPFC), and temporo-parietal junction (TPJ, all these structures involved in mentalizing and in self-other distinction), the ones related to conservatism with activity in the right dorsolateral prefrontal cortex (DLPFC, involved in cognitive control), and, finally, radicalism related statements processing was linearly associated with activity in the posterior cingulate (PCC). This region is, involved in emotional salience processing and this is coherent with a following finding by Dhont and colleagues (2011) who also showed that people endorsing more radical views (anarchist) exhibit higher late positive potentials in an oddball task for political related targets evalutively inconsistent with the context stimuli.

Here I will provide some background about how eyes are the foundation of the very first forms of communication in humans and in non-human primates. These species have evolved as social species that organize themselves in social groups wherein more complex social processes emerge (e.g. dominance, hierarchies, coalitions). The relevance of eyes as a powerful mean of communication seems to be related to the complex social interactions. Primates have evolved powerful social skills in which eyes seem to play a first-order role, especially in humans, where cooperation seems to be very central. The relevance of the information that may be conveyed by our eyes may have shaped an automatic-like, gaze-following behavior. This behavior consists in automatically imitating the oculo-motor behavior of a conspecific, shifting our attention accordingly. Social cognitive skills as gaze-following, reflexive social attention, joint attention and theory of mind are some of the tools that allowed us to build more complex forms of societies where, instead of mere dominance based on physical strength, coalitions dynamics have evolved in political organizations. In Western democracies at least two abstract, widespread, coalitions usually compete to rule a national society. These divisions within many Western societies are often underlined by more basic personality, social cognitive, affective and basic cognitive processes and provide a powerful matrix of identity identifications that also

drive people to very quickly assign others in valence-labeled categories. Here we investigate how gaze-following behavior, similarly to other social attention reflexive behaviors and similarly to other very basic motor resonance processes that occur in action perception (study 1), can be modulated both by individual differences within the observers and differences of the observed faced either in low level socially relevant features (e.g. cues of dominance or trustworthiness in the know-to-be rapid impression formation process in social perception) and, more importantly, in high level categories as the belonging to an in or out political group.

I will show these results reporting the single behavioral and neural evidences collected in these years of doctoral program. Some studies have been published, others are under preparation (both kind of studies can be found in the Appendix). Some other studies are still at a very preliminary stage in their collection/analysis and I will quickly refer to them in the dissertation. However, I will show and discuss all these evidences under the light of research on gaze-following behavior and political psychology investigation. Finally, I will discuss limitations, opened questions and future directions of this research.

2. Eyes are the window of our (social) mind (and brain)

2.1 Cogitamus, ego sumus: the social nature of human brain

"Eyes are the window to the soul" reminds us an old proverb. The Cartesian concept of souls as separated from bodies (but this distinction largely precedes Descartes himself, and has been surely the backbone of Christian thought in general) had large influence on research in Psychology, hidden behind terms as psyche, or mind. The development of a Cognitive Neuroscience (Gazzaniga, Ivry, & Mangun, 2002) has helped to go beyond this dualism, trying to find the neural underpinnings of our cognitive processes (e.g. reasoning, attention, memory). But the limit of this approach s that a sort of dualism has been still maintained, keeping apart, and almost hierarchically organized, cognition and forms of experience more connected to our body and its motor experience or interoceptive states. A challenge to this approach has been represented by the study of the importance of emotion (Damasio, 1995) and motor experience (Rizzolatti, Fogassi, & Gallese, 2006; Rizzolatti & Sinigaglia, 2006) in cognition (but I will come back to this issues more extensively later on). It's not a case that Damasio, in the attempt of providing a theoretical framework to a variety of studies, which have a common feature in their monistic approach, recalls the thought of the Dutch philosopher Baruch Spinoza (Damasio, 2003). The peculiarity of the philosophy of Spinoza consists not only in his materialistic approach to the body *vs* mind debate, which challenged the Cartesian separation between *res cogitans* and *res extensa*. Another important contribution of the Dutch 17th century philosopher consist in the importance given to the social nature of the human beings. Indeed, the Spinoza concept of *conatus* (Spinoza, 1677/1988) provides the explanation of why we seek to build social relationships, by the mean of positive emotions such love, in order to build a bigger and more powerful mechanism than the one provide by our single, isolated bodies (and brains, we would add).

More recent theories on the development of brains seem to perfectly fit with an idea of human brain as a tool build-to (and build-by) sociality. The evolution of brain seems to be closely interweaved with group size and the number of individual's in the innermost circle of friends (Dunbar, 1998).

But, within different taxa, only anthropoid primates and humans (not, for instance, prosimians) show a robust correlation between group size and relative cortex size, as reported by Dunbar and Shultz (2007). Indeed, the differences between taxa are explained mostly by pair bonding, which is a kind of relationship, which necessitates the active representation of a significant other's perspective (Dunbar & Shultz, 2009).

But at a certain point of the evolution, it seems that the skill developed for pair bonding where applied to develop relationships with not reproductive partners and that explains why in anthropoid primates and humans, but non within other *taxa*, relative brain size and social groups correlates.

Dunbar suggests that the outcome of this evolution is the development of high social cognitive skills required in an environment of complex social interactions and complex mating strategies. More importantly, Dunbar notices how at a certain point of the neocortex evolution, visual areas and other cortical areas didn't gain size isometrically. This observation holds, at different degrees, with apes and humans. Henceforth it seems that mind reading skills have developed. Mind reading skills are present even in monkeys, but they seem to rely more on regularities in behavior than in inferring others mental states (Cheney & Seyfarth, 1990). This more fine-grained ability seems to be related to the relative more availability of resources for processing not online visual information and allows individuals to develop complex behaviors as deception. Also, in humans these social cognitive skills are the prerequisite of the development of language (see Tomasello, 1999). Anyway, making a step backward, visual signaling represents an important prerequisite of further cognitive skills developments (Emery, 2000).

2.2 Eyes as a communication tool

Primate brain indeed is particular sensitive to visual signals with more than 25 neocortical areas that are predominantly or exclusively visual in function, plus an additional 7 areas that we regard as visual-association areas on the basis of their extensive visual inputs (Felleman & Van Essen, 1991). Even though social relevant visual signals have been found also in other species (Bradbury & Vehrencamp, 1998), primates have a unique ability to use

intricate visual social signals that appear to have multiple meanings. Among them, gaze functions to provide information, regulate interaction, express intimacy, exercise social control, and facilitate service and task goal (Kleinke, 1986). In many species, the perception of direct gaze elicits and may be associated to threat and dominance (Emery, 2000; Senju & Johnson, 2009), included humans (Linkey & Firestone, 1990). Neuroimaging studies have shown as, even in humans, direct gaze may cause amygdala activation and rising in arousal (Adams, Gordon, Baird, Ambady, & Kleck, 2003; Whalen et al., 2004). Typically developing adults explore faces paying a lot of attention on eyes area compared to other facial features (Pelphrey et al., 2002). Eye region exploration has, in general, a fundamental role in recognition emotions in others. Preference for eyes, within a marked preference for face processing from the birth, comes out as early as at 7 weeks of life in infants (Haith, Bergman, & Moore, 1977). Fixation patterns of emotional faces infants an adults suggest an avoidant gaze behavior at play since the infancy, even though a more prominent avoidance of eye contact might be a learned response toward others' anger and fear that emerges later during development (Hunnius, de Wit, Vrins, & von Hofsten, 2011). Also, pattern of eye fixation are susceptible to individual differences in humans: more neurotic people spend much less time in exploring eyes of fearful faces than others (Perlman et al., 2009).

Perceived eye contact in humans modulates perception and cognition in various ways. Both neurotypical and autistic children performed better in a visual search task when the target were faces with target faces than faces with averted gaze (Senju, Hasegawa, & Tojo, 2005a; Senju, Kikuchi, Hasegawa, Tojo, & Osanai, 2008). Also, in a gender discrimination task, participants where faster when the faces the had to categorize had straight gaze, rather than averted (Macrae, Hood, Milne, Rowe, & Mason, 2002). Authors underline how this finding show that "people's sensitivity to eye gaze would also prompt the emergence of some important social-cognitive effects pertaining to the efficiency of the person-construal process". The effect of direct gaze on categorization is so strong that applies to implicit categorization as well: Trawalter and colleagues (2008) found that White perceivers selectively attended to the faces of young Black men, but only when the faces displayed a direct gaze, "suggesting that social category

memberships and eye-gaze cues worked jointly to signal target threat potential to perceivers, who responded by directing their attention (albeit non consciously) to the presumed source of the threat".

This result on categorization extends even to the domain of evaluation (Mason, Tatkow, & Macrae, 2005) being people more likely to judge a face as more likeable and attractive when displayed a social engagement signal as direct gaze, a result that may be explained by neuroimaging evidences of activation of reward system by a an attractive face with gaze directed on us rather than averted (Kampe, Frith, Dolan, & Frith, 2001). Coherent with his link with arousal, direct gaze can risen it to a point that ma be detrimental for the task, as shown by a study in which participants had more interference in a Stroop task under the eye contact condition (Conty, Gimmig, Belletier, & George, 2010).

Rhesus monkey brain contains neurons that respond preferentially to the sight of human or monkey faces (Perrett & Emery, 1994; Perrett, Rolls, & Caan, 1982). Perrett and colleagues (1982) found that a cell population within the fundus of the rhesus monkeys superior temporal cortex (STS) responded to both monkeys and humans faces two to ten times more strongly than to other objects and that the magnitude of the response was relatively resistant to changes in rotation, color or size, unless the rotation was to profile. In humans, face identity and gaze processing have been found in two different regions; fusiform face area and STS respectively. Hoffmann and Haxby (2000) have shown that matching faces for gaze and for their identity involved two different brain areas, STS and fusiform face area (FFA), respectively. Direct gaze, compared to averted, activated approach brain system, measured by the mean of hemispheric asymmetry in the frontal electroencephalographic activity, but only when participants were facing a real person, not when looking at a picture of a face (Hietanen, Leppänen, Peltola, Linna-Aho, & Ruuhiala, 2008). In general, neural and behavioral evidences have suggested different hypotheses about the involved of the so-called social brain (Adolphs, 2009), some of them rely on an arousal process, while some others suggest the automatic involvement of metalizing mechanisms and their underlying neural processes like midline media prefrontal cortex and posterior STS/Tempo-parietal junction (TPJ, see (Senju & Johnson, 2009) for a review). Senju and colleagues have proposed, instead,

a Fast-track modulation track, which relies on subcortical face processing (de Gelder, Frissen, Barton, & Hadjikhani, 2003), a "quick and dirty" (LeDoux, 1996) pathway that can modulate gaze processing (Johnson, 2005).

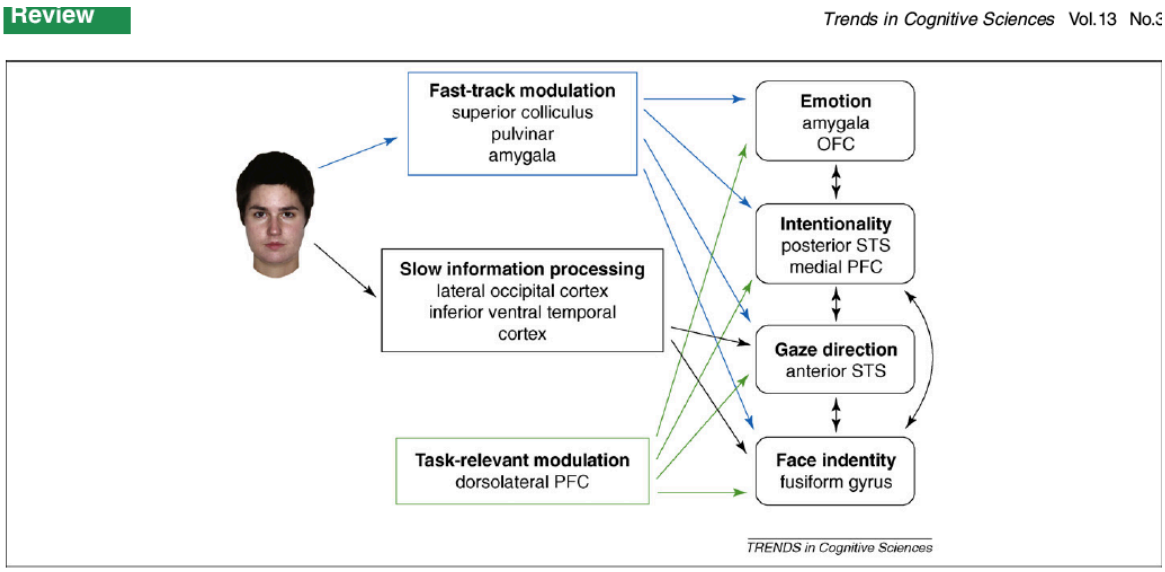

Figure 1. Fast-track modulator model proposed by Senju and colleagues(2009).

"The fast-track modulator model in that the subcortical pathway initially detects eye contact, and then subsequently modulates cortical processing. The stimuli that best activate the putative subcortical face processing route are consistent with the idea that this route can support the detection of eye contact also" (Senju & Johnson, 2009). This model is consistent with the very praecox sensitivity of newborns to eye contact as early as they are 4 month of age (Farroni, Csibra, Simion, & Johnson, 2002), which suggests that human infants are equipped with a bias to detect and orient towards faces that make eye contact with them. Compared to theory that states an innate mentalizing module, which relies on an eye detection module, this model leaves more open the effect of environmental factors on this eye contact to social brain pathway.

Phylogenetically, visual stimuli which just resemble eyes can be found in a lot of other animals, like in peacocks plumage, in some kind of moths, butterflies, fishes, snakes, wasps, cockroaches and pheasants (Blest, 1957).

These signs, known as "eye spot", have an adaptive function because they scare possible predators. Indeed some birds avoid to eat eye-spotted moths and avert their attention to insects which are not endowed of those (Blest, 1957).

Even though many non human primates are aware of others gaze and can use gaze for primitive forms of communication as sharing the attention (see Emery, 2000 for an extensive review), it seems that eyes have developed in humans in a manner that seems to maximize their communication power. Indeed, Kobayashi and Kohshima (1997), have demonstrated that, across species, humans have the biggest index of exposed sclera size (SSI) in the eye outline and the width–height ratio (WHR).

SSI means that iris has more moving space and it's correlated with walking height and with body size in general. That's due to a trade-off between head movement and eye movement in order to move the visual field itself as demonstrated by a correlation between the eye movement/ total movement ratio and SSI (Kobayashi & Kohshima, 2001).

Moreover, the human eye sclera in the eye outline is the only one that's white. Other non-human primates show a color (most of them have a brown one) of sclera, which seems to allow them to camouflage, rather than highlight, their gaze (Kobayashi & Koshima, 2001).

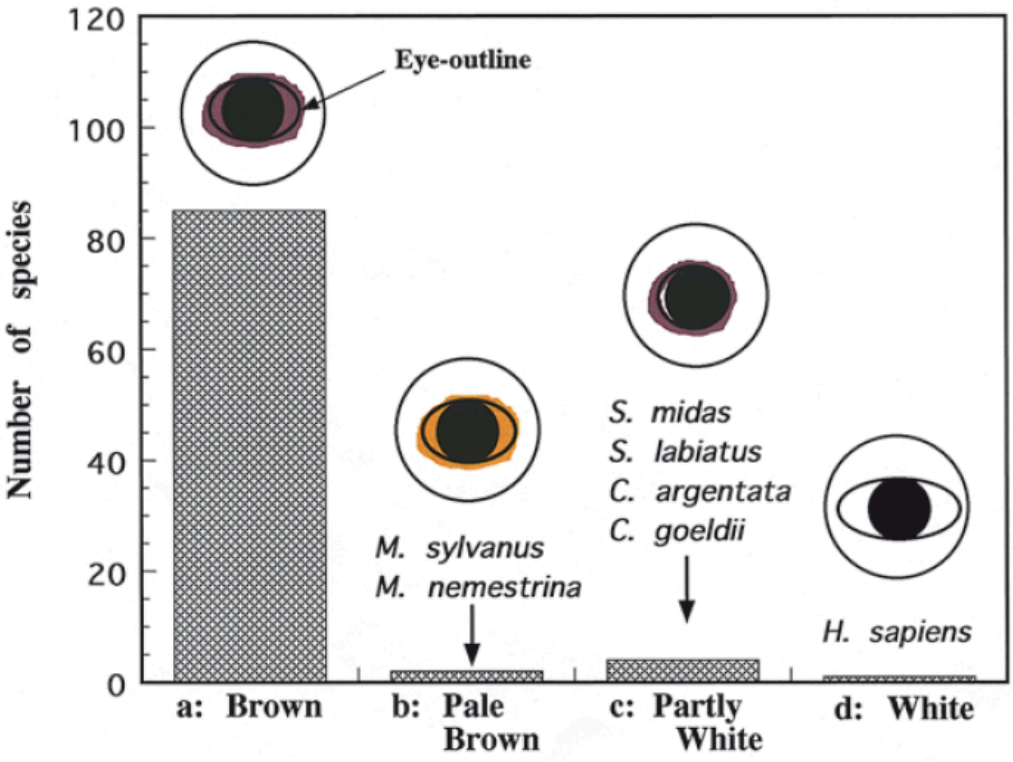

Figure 2. Frequency of species with different color of sclera in the eye outline(2001).

But it's interesting to note that, in 9 out of 10 non-human primate species analyzed, the color of sclera is higher during the infancy, suggesting that infants' gaze has a more pronounced social relevance. This observation seems

to militate in favor of the communicative function of gaze in a species, like humans, less concerned of predators and more concerned about cooperating with others in order to have a better fitness. Indeed, humans have a different attitude to cooperation, compared to other non-human primates, (Tomasello, 2009).

Forming coalitions it's a feature that seems the have emerged in the primate evolution, and it's still reflected in species so genetically close to humans as chimpanzees are. Indeed, chimpanzees are likely to join in groups that compete each other (de Waal, 1982). But, as pointed out by Tomasello and colleagues (2005) in these interactions anyone seems to follow its own plan without a real coordination within the group. Meat sharing after hunting looks more like a behavior extorted under threat (Gilby, 2006) or reciprocity within the coalition (Mitani & Watts, 2001). Tomasello and colleagues (2005) suggest that "it is almost unimaginable that two chimpanzees might spontaneously do something as simple as carry something together or help each other make a tool, that is, do something with a commitment to do it together and to help each other with their role if needed". For instance, Hamann and colleagues (2011) have recently demonstrated that human children, but not chimpanzees are more likely to share gains after a collaborative rather than a non collaborative task. In general, coalitions and alliances hardly pushed primate to be able to read others behaviors (Tomasello, 1998)[1]. What seems to arise from human social cognitive skills (or, rather, the reason why more prominent social cognitive skills have emerged in humans) is the fact that, while monkeys and apes understand conspecifics behaviors more in terms of regularities, humans seem to attuned to their intentions (Tomasello & Call, 1994).

Another peculiarity of the development of primates is the mother-infant interaction (Matsuzawa, 2006; Ross, 2002). "Primates had four limbs to grasp objects because they had adapted to the arboreal life. Then, based on the continuous ventro- ventral contact, mutual gazing and smiling developed in the common ancestors of humans and chimpanzees"(Matsuzawa, 2007). Indeed, chimpanzees may show many forms of dyadic interactions since the childhood (Maestripieri & Call, 1996), which include the use of eyes (Tomonaga et al., 2004). Anyway, because human infants separate from

[1] I am assuming this pattern flow just for simplicity but it can easily assumed opposite.

their mothers after birth (Matsuzawa, 2007), it can be that a more distal form of communication like gaze would assume a stronger relevance. Crucially, while triadic interaction seems to be very common in humans, especially from the 9th month of their life (Tomasello, 1999), this kind of interaction seems to occur much more sporadically in chimpanzees and bonobos (Tomasello, Carpenter, Call, Behne, & Moll, 2005) . Triadic interaction hardly relies on joint attention, which can be mostly reached by joint attention and shared attention (Tomasello et al., 2005).

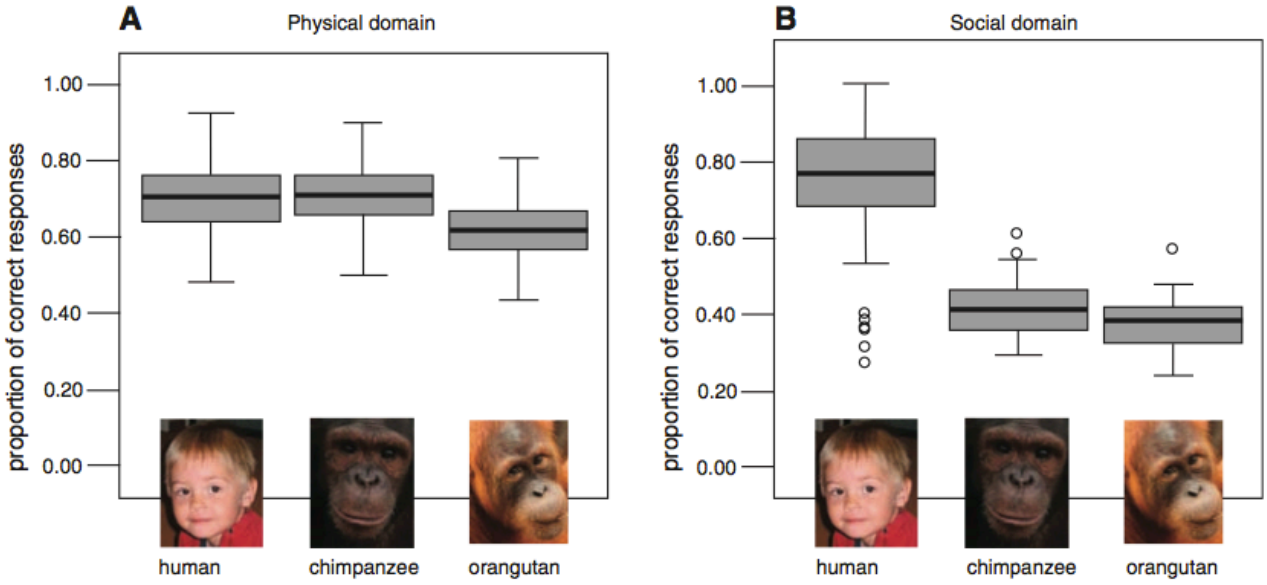

Figure 3. Human children, perform similarly to great apes in tasks within the physical domain, but outperform them in the social domain (Herrmann, Call, Hernandez-Lloreda, Hare, & Tomasello, 2007).

Importantly, these above described differences in tendency to cooperate and eye morphology yield humans and similar primate species since the very early childhood. The study from Hermann and colleagues (2007) demonstrated how, using the Primate Cognition Battery test, after one year of exposure in the social world, human children outperformed Chimpanzees and Orangutan in Social cognition tasks, even though their performance was pretty much the same in the physical cognition tasks. Importantly, one of the tasks in which outperformed both the other ape species is exactly the gaze-following task[2].

[2] Even though, in this experiment the jointed head and gaze cues were not vehicled by a conspecific, but by a human, and it may make a big difference.

3. Even our attention is (reflexively) social

3.1 Spatial attention: from its cognitive to its social relevance

The relevance of the social to our minds and brains as not left untouched one of the sciences field of research in psychology that has mostly focused its attention of human minds as individual minds, i.e. cognitive psychology. In contrast to behaviorism, which posits that mind is a sort of black box inaccessible to scientific research, cognitive psychology attempted to study how do mental processes like attention, memory and language work. But social psychologist, moving from the Kurt Lewin assumption that behavior is a function of the person in their environment (B=f(P,E), were not untouched by this paradigm shift in the field of psychology, and began to ask themselves: "are the information-processing demands made by social cognition different from those made by non-social cognition?" (Adolphs, 2001). Indeed, there's intuitively a huge difference between the physical environment and the social one. The latter is definitively much more complex, less predictable, and, crucially, more responsive to one's own behavior. Social cognition is then concerned about this intuitively difference required *ad hoc* processes, from perception of, attention to, memory for, and thinking about other people, and in a way that involves emotional and/or motivational processing. We can imagine this path beginning with the sensory processing of social information (visual perception of someone's face or body posture), stepping to formation of inferences and judgments about the social meaning and significance of this information. This path, based on innate and acquired memories, current context, and future goals and plans finally culminates in the modulation of essentially all aspects of cognition and behavior (Adolphs, 2006).

A famous example in favor of the emergence of specialized social cognitive modules (Fodor, 1983) comes from the evolutionary psychology research and relies on the fact that the way in which people solve abstract reasoning in the Wason selection task, is much different if the content of the task is inherent to social rules instead of abstract rules (Cosmides, 1989). Which means that logical reasoning is not just an abstract process that applies to everything, syntax independent from its semantics. Social content matters. And this doesn't apply just to a high order process as reasoning. The peculiarity of

processing other entities endowed with intentionality arises since the early stages of perception. Indeed, capacity to recognize biological motion and goal-directed action that emerges by around six months of age (Woodward, 1998). Research suggests that pSTS is particularly sensitive to biological motion (Allison, Puce, & McCarthy, 2000).

Among the cognitive processes that can acquire a different meaning within the social world attention plays an important role, being at the crisscross between perception (being driven by visual signals) and other processes like learning and memory (we remember better things which are under the spotlight of our attention) up to metacognitive processes ("why is this person driving my attention there?").

Attention is a cognitive tool we developed because, in front of the potentially infinite amount of information present in the environment, we have limited cognitive resources to deal with that. That's why in this intense semiotic environment, we select only a part of it.

Attention the product of bottom-up and top-down processes. We are very familiar with the competition between these different processes, it's enough to think about the fact that when I have to write a dissertation, I have to drive my external attention on the keyboard of my MacBook Pro and my internal attention to the amount of knowledge I have in my mind which is related to the topic I am writing about. That is that no matter how much nice would be the idea to think about a white bear, I have to inhibit it and think about attention! But, in the meantime, when I am writing, some Skype pop-up can abruptively appear, diverting my attention to it, at least for a moment, unless it signals me that a person I was really looking forward to talk to is finally available. Another top-down mechanism that can drive our attention is relative to our expectations, so knowledge (that may be even implicit to some extent) may drive our attention. The distinction between an active and a passive capture of our attention can be driven up to William James, in 1890, which seem to have foreseen what a huge amount of empirical evidences is now teaching to us now. Indeed, it has been largely demonstrated how our attention can be automatically captured by certain luminance and contrast changes that signal motion (e.g. Theewes, 1995), as well as stimuli that appear to be "looming" (Franconeri & Simons, 2003).

That's exactly what is called endogenous cue in the spatial attention studied with a paradigm developed by Posner (1980; Posner & Cohen, 1984).

In one of the task designed by Posner and collaborators (Posner & Cohen, 1984) a target was presented at 7 visual degrees to the left or right of fixation. Before the target, an arrow appeared centrally o the screen. The arrow pointed toward the correct target location on 80% of the trials. Which means that the subject, during the task, learnt to expect that the target could appear at the same location pointed by the arrow. Manual reaction times for the detection or discrimination of the target were faster when subjects were able to anticipate its location because the attention of the participants was driven by their expectation toward one portion of the space.

But our attention, alternatively, can be captured by the abrupt appearance of a stimulus. This happens when a cue signal appears on either on the left side or on right side of the screen. In this case, the cue is in no way predictive since it has 50% of probability to appear on the same side where the target will appear. But even though not predictive, subjects typically perform better and faster when the cue is spatially congruent with the target, at least within a certain time window (50 – 150 ms). This form of cuing strongly depends on sensory information and is not limited to the detection of supra-threshold visual stimuli, but extend to many other visual tasks, including threshold detection of luminance and discrimination of shape, size, color, and motion (Bashinski and Bachrach,, 1984; Downing, 1988). The enhancement in stimulus processing produced by spatial cueing, even without any overt eye movement, is thought to reflect the activation of a mechanism that shifts attention to the stimulus location before its appearance. I the case of the exogenous cuing, beyond a certain time window (>300ms) the facilitation is reversed to an inhibition (the so called inhibition of return, IOR), i.e. subjects perform more poorly in the incongruent condition (See Klein (2000) for a review on IOR).

Endogenous orienting of attention has been found to be subserved by a dorsal fronto-parietal network (Corbetta & Shulman, 2002) which includes the intra-parietal sulcus (IPS) and superior parietal lobule (SPL), and dorsal frontal cortex along the pre-central sulcus, near or at the frontal eye field (FEF). On the other side, exogenous orienting of attention has been proposed to be subserved by a ventral fronto-parietal network, which encompasses

temporo-parietal junction (TPJ), cortex the ventral frontal cortex (VFC), including parts of middle frontal gyrus (MFG), inferior frontal gyrus (IFG), frontal operculum and anterior Insula.

Importantly to our purpose, the distinction between endogenous and exogenous cuing of attention parallels the seminal distinction in psychology between controlled and automatic processes (Schneider & Shiffrin, 1977), being the first associated with awareness, intention, effort, and the capacity for interruption (Wegner & Bargh, 1998) while the second is unawareness and not voluntarily controllable. Exogenous orienting happens to be, indeed, even when the cue is counter-predictive.

All these experiments on visuo-spatial attention have traditionally used non animate stimuli: a quick change of luminosity on a side of the screen in the case of exogenous orienting, or a symbolic central cue as in the case of the endogenous orienting.

But a lot of other researches on different fields on attention processes have shown that the social nature of the stimuli matter.

Indeed, the power of stimuli to automatically capture attention (as it happens with threatening stimuli or stimuli that suddenly appear on our visual field) can be moderated by the state of the perceiver in a relatively top-down manner. Elderlyi (1974), for example, has shown that, in a task that required ignoring distracter stimuli, Jewish participants performed well unless the to-be-ignored stimulus was a swastika. Beyond affective states, the expectancies and goals of perceivers are also a powerful determinant for how attention is focused. For example, in the seminal Loftus and Mackworth (1978) experiment it has been found that visual attention was drawn earlier and more frequently by “oddball” objects that had a low probability of appearing in a scene (e.g., an octopus on a farm) than by contextually expected objects (e.g., a tractor on a farm). Indeed, no direct perceptual property of the stimulus drives the attention in this study, but is a high-order conceptual fluency which plays a role in it (Bodenhausen & Hugenberg, 2009).

Also, recent neuro-physiological evidence showed social categorization to have an influence on early attentional processes. Indeed, Ito and Urland (2003) found that white participants’ early waveform components (N100, P200) tended to show stronger attention to black than to in-group targets. At a later stage in the attentional process, whites’ attention appeared to shift

toward members of their racial in-group. Ito and Urland (2005) interpreted the early attentional findings as a vigilance process for potentially threatening stimuli. In line with this explanation, black men, a social category that is often negatively stereotyped by the media, elicit a stronger early vigilance effect than other social categories. Chiao and co-workers (2006) showed that the performance of biracial (black/white) individuals in a visual search task was moderated by whether or not their black or white identity had been primed. This study provided in this way a compelling evidence of the role of social categorization in attention and visual search. These biracial individuals were faster in detecting black faces when primed with the white side of their identity, compared to when they had been primed with their black identity.

3.2 Reflexive social attention

Recently, even the literature on visuo-spatial attention has began to focus its attention to the social relevance of some kind of stimuli.

Driver and colleagues (1999) tried to connect research on social cognitive skills development (Baron-Cohen, 1995b; Brothers, 1990) to the literature on visuo-spatial attention. The authors, indeed, reckoned that "these two areas of research have pursued entirely separate agendas, with entirely different methodologies. Mainstream research on attention has rarely considered orienting in response to stimuli of special social significance, and studies of social attention have not exploited contemporary advances in mainstream attention research" (Driver et al., 1999). Indeed, is plenty of evidence for the importance of gaze perception in determining the direction of attention. For example, Butterworth has shown how it happens even in 3 months infants (1991). Nevertheless, despite this evidence of the relevance of gaze perception for the attention, the authors noticed how "it is very striking that the topic goes quite unmentioned in the extensive literature on visuo-spatial orienting, within mainstream attention research on adult humans" (Driver et al., 1999). A lack of attention that seems to have overlooked Brothers' maxim (1990) that the human brain is largely a social brain. In this experiment, the authors studied for the first time not only how much our attention can be captured by a social cue, but even to which extent this capture can be described as

automatic to the point of happening even against the will of the individual to inhibit that behavior.

In order to do that, in a first experiment, subjects were required to perform an discrimination test on an object that could be cued or not cued by a still gaze appearing either 100ms, 500ms or 700ms before the target.

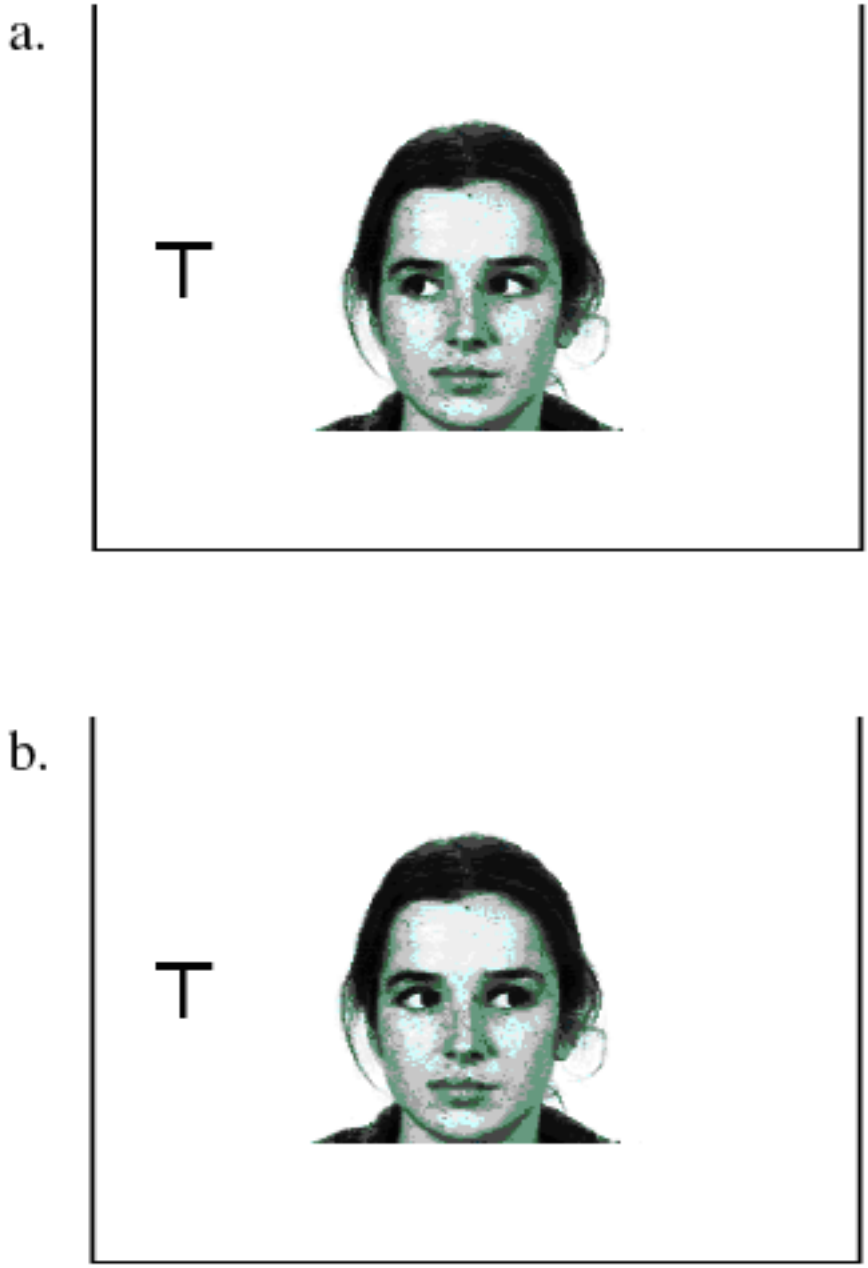

Figure 4. Instead of an inanimate signal as a flash or an arrow, Driver and colleagues (1999) have used, for the first time, a social cue as gaze. Subjects were required to do an identification task (they had to identify the target either as a T or as an L.

Even though the gaze cue was not informative at all on the forthcoming appearance of the target, subjects were slower in discriminate the target when it appeared in a portion of the screen which was the opposite of the one cued by the gaze. Interestingly, and crucially for the automaticity point, the effect was at play, at a 300ms stimulus onset asynchrony, even when the gaze cue was in fact counter-predictive, i.e. when it predicted the wrong side in the 75% of cases. This impermeability to our intentions is coherent with the definition of automaticity inherited by a long-lasting debate and research on control and automatic processes (Bargh, 1992; Schneider & Shiffrin, 1977).

The reflexivity of gaze following is at odds with the modulation of a deliberate, rational reasoning. So, if something is able to modulate this process, this has to be a process which is at its turn very important evolutionarily (Confer, Easton, & al, 2010).

The automaticity of this effect represents for the authors, a fodorian module for eye detection, as postulated by Baron-Cohen(1995a). That is, each module is considered to be encapsulated from other processes, and accordingly to operate in an obligatory manner.

According to Baron-Cohen (1994; 1995a) our Mind Reading System is organized in 4 specialized modules that develop in human infants, which contained components of the gaze communication system. The four modules were an Eye Direction Detector (EDD), an Intentionality Detector (ID), a Shared Attention Mechanism (SAM) and a Theory of Mind Mechanism (ToMM). The EDD module has its principal function in detecting every kind of eye-like stimulus and represent their direction as an Agent which is involved in a relation either with ourselves, (Agent-relation-self), with an object (Agent-relation-object) or with another person (Agent-relation-Agent).

The attunement of this EDD module to every eye-like stimulus and its informationally encapsulated function are consistent with results found on schematic faces. Friesen and Kingstone (1998) conducted a study in which participants had to perform a detection, a localization and an identification task and the appearance of the target could be preceded, at different SOAs (105, 300, 600, 1005) by a schematic face which could cue congruently, incongruently or neutrally[3] directed gaze. Participants were found to be

[3] Even if the mutual gaze, which represented the neutral condition, is still a socially meaningful signal, so its neutrality is at least questionable. Indeed, the participants' behavior in this experiment is mostly similar between the neutral and the uncued conditions.

facilitated in the congruent condition at very short SOAs, which is an evidence that speaks in favor of the automaticity of the process.

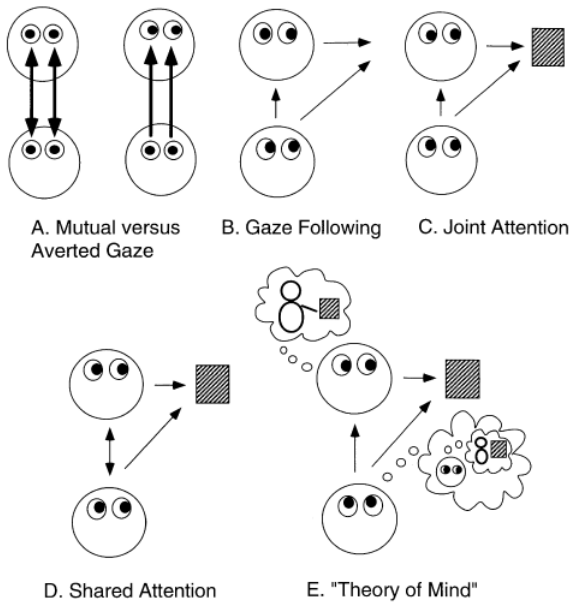

Figure 5. Gaze direction furnishes a plethora of powerful social signals wich can be used by another individual to infer either other external (other persons, objects, events) or internal states (emotions, intentions) A) Mutual gaze happens when two individuals reciprocally focus their attention each on the other. B) Gaze following happens when an individual detects that the gaze of another one is not directed toward him/her anymore and follows the line of his/her gaze toward an indefinite point on the space C) Joint attention is analogous to gaze following except to the fact that the attention of the following individual is now on the same object the other is paying attention at D) Shared attention is a conjunction between mutual and joint attention, i.e. the two persons both reciprocate attention each on the other and jointly pay attention at the same object E) 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 (Emery, 2001).

Anyway, although many evidence suggest that gaze capture our attention in a reflexive manner, many problems still remain open. The absence of IOR, which is usually a landmark for exogenous attention capture, has not been found to date. Also, some researchers have questioned if the automatic capture is a unique feature of social cues. For instance, Tipples (2002) has tried to address this issue by using non social cues as arrows and found effects, which are similar to the ones found with gaze, coherently with other studies (Eimer, 1997; Hommel, Pratt, Colzato, & Godijn, 2001; Ristic, Friesen, & Kingstone, 2002).

This suggests that orienting in response to symbolic cues is not entirely under strategic control. Instead of the social nature of the stimulus, it seems that attentional capture maybe rather accounted by the asymmetricity of the cue which allows spatial correspondence between the central cue and the target location to be automatically paired (Lambert & Duddy, 2002; Lambert, Roser, Wells, & Heffer, 2006).

On the other side, some neuropsychological data suggest that, although arrows and eyes may drive to similar behavioral results, their neural underpinnings may be quite different. A study from Kingstone and colleagues (2000) on two split brain patients has shown that the gaze cuing effect is lateralized to the face processing specialized hemisphere, while a study from Ristic and colleagues (2002) found that the cuing effect from arrows is bilateral.

Also, behaviorally, eyes - but not arrows – bring to a cuing effect even when counter-predictive, as shown by Friesen and collaborators (2004).

Neuroimaging studies from Hietanen and co-workers (2006) found further evidence for a different neural mechanism underlying social and non social cues. While the cuing effects were found for both gaze and arrows, changes of BOLD signal revealed that while gaze-cued orienting recruits occipital regions, arrow-cued orienting also recruits parietal and frontal regions. That arrow-cues related orienting activates a larger network with respect to gaze-cue related orienting is also suggested by an event- related potential study showing that changes of parietal and frontal attention-directed electrophysiological signatures are found for arrow- but not for gaze-cues (Hietanen et al., 2008). Using a perceptually ambiguous stimulus presented centrally while performing a target detection task in which participants perceived the stimulus as an eye in profile or an arrowhead, Tipper and colleagues (Tipper, Handy, Giesbrecht, & Kingstone, 2008) were able to directly compare the neural mechanisms of attentional orienting to social and nonsocial cues while holding the physical stimulus constant. The functional magnetic resonance imaging results indicated that attentional orienting to both eye gaze and arrow cues engaged extensive dorsal and ventral fronto-parietal networks. Eye gaze cues, however, more vigorously engaged two regions in the ventral frontal cortex associated with attentional reorienting to salient or meaningful stimuli endorse the hypothesis that differences in

attention to social and nonsocial cues are quantitative rather than qualitative, running counter to current models that assume enhanced processing for social stimuli reflects the involvement of a unique network of brain regions.

4. Social attention and motor resonance

4.1 Mirrors in the brain

In the 1992, Di Pellegrino and colleagues (di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992) found that neurons of the rostral part of inferior premotor cortex of the monkey discharge both when they execute during goal-directed hand movements and when the monkey observes specific, meaningful hand movements performed by the experimenters. The discovery of these Mirror neurons in monkeys triggered a huge amount of studies even in humans, where many indirect evidences of a Mirror Neuron System (MNS) have been found (Rizzolatti & Craighero, 2004).

Interactions between action execution and observation are widely reported at a behavioral level (Prinz, 1997). Behavioral, neurophysiological, and neuropsychological studies suggest that action execution and observation are represented in commensurable formats and share the same neural underpinnings (Brass, Bekkering, Wohlschlager, & Prinz, 2000; Buccino et al., 2001; Craighero, Bello, Fadiga, & Rizzolatti, 2002; Saygin, Wilson, J., Bates, & Sereno, 2004; Wohlschlager & Bekkering, 2002). Imaging studies have described somatotopic activations of premotor and parietal cortices for action observation (Buccino et al., 2001). TMS studies have shown that the excitability of the cortico-spinal system is enhanced during action observation and follows somato-topic rules, as only the muscle that would be involved in the execution of the observed action is facilitated (Fadiga, Fogassi, Pavesi, & Rizzolatti, 1995).

The MNS and mirror-like neural mechanisms have been proposed to be the possible underpinnings of the development of social cognitive skills (Gallese, Keysers, & Rizzolatti, 2004; Rochat, Serra, Fadiga, & Gallese, 2008). Indeed, -“Most of the time, our understanding of social situations is immediate, automatic and almost reflex-like”(Gallese, 2007). Also, it offers a parsimonious explanation of how we understand the actions of others: by a direct mapping of the visual representation of the observed action into our motor representation of the same action (Jackson & Decety, 2004).

Mirror like mechanism doesn't seem, indeed, to be confined only to the purely motor domain, but it can provide insight also to emotion understanding and mentalizing skills more in general:

> What makes social interactions so different from our perception of the inanimate world is that we witness the actions and emotions of others, but we also carry out similar actions and we experience similar emotions. There is something shared between our first- and third-person experience of these phenomena: the observer and the observed are both individuals endowed with a similar brain–body system. A crucial element of social cognition is the brain's capacity to directly link the first- and third- person experiences of these phenomena (Gallese et al., 2004).

In general, the contribution of the motor system in other cognitive processes has been postulated even in the case of attention. Indeed, according to the Premotor theory of attention (Rizzolatti, Riggio, Dascola, & Umiltá, 1987) there's a strong link between covert shift of attention and the ocular movement mechanism.

The premotor theory of attention posits an identity between attention and ocular movements: localization in the space would be coded by an attentional mechanism within a set of motor coordinates which specify directions and amplitude, she same mechanism involved in programming and executing saccadic movements. In the study from Rizzolatti and colleagues (1987), indeed, subjects were cued to attend to one of four possible stimulus locations, which were arranged either horizontally or vertically, above, below, to the right or left of a fixation point. It's interesting to note that, among other results, authors showed that the incorrect orienting of attention not only yielded a large and significant cost, but this cost tended to increase as a function of the distance between the attended location and the location that was actually stimulated. Also, an additional cost was incurred when the stimulated and attended locations were on opposite sides of the vertical or horizontal meridian. So, according to the authors, "attention is oriented to a given point when the oculomotor program for moving the eyes to this point is ready to be executed" and "attentional cost is the time required to erase one ocular program and prepare the next one".

Ricciardelli and colleagues (2002), capitalized both the literature on premotor theory of attention and mirroring motor behaviors to assess if the distracting power of the gaze is maximal when the task required participants

to respond with their eyes instead of pushing buttons. The task proposed by Ricciardelli and colleagues differs from the previous studies on social attention because in this case the subject didn't have to detect, localize or identify an incoming target, but were instructed to perform a saccade on a rightward or leftward target according to a signal consisting in a central square that could change color into orange or blue, respectively. In this way, authors studied the intrusive effect of a distracting gaze stimulus onto the instructed saccade was to create a conflict between the direction of the instructed saccade and the direction of a distracting, deviated gaze. This condition was compared to another one in which the distractor consisted in a symbolic arrow cue.

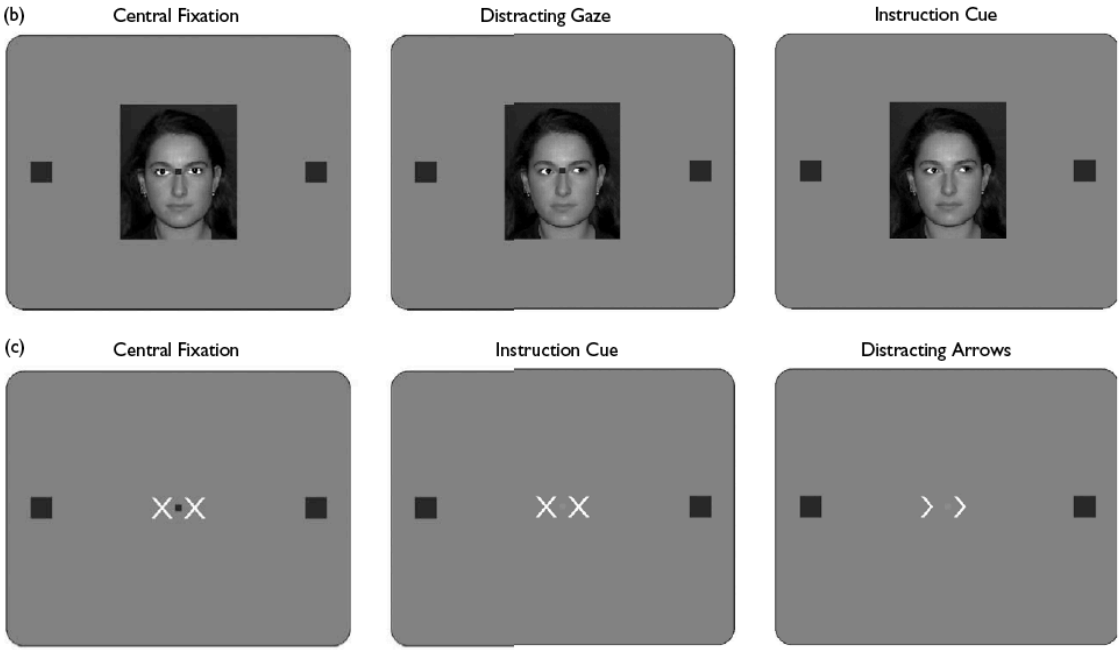

Figure 6. Stimuli used by Ricciardelli and colleagues (2002).

Results show that, especially when the distracting gaze shifted 75ms before the appearance of the instruction cue, gaze incongruently directed not only was detrimental to the task, but it was much more detrimental than the symbolic cue, which didn't bring to a cuing effect at all. This interference effect disappears when using stimuli with reverted gaze polarity that impairs perception of gaze direction (Ricciardelli, Betta, Pruner, & Turatto, 2009).

Crostella and colleagues (2009) provided further evidence of this somatotopic, interference effect of social cues by showing that, when subjects had to perform a task similar to Ricciardelli and colleagues (2002) but

responding with a hand pointing, subjects were maximally distracted by a pointing distracting cue (see figure 7).

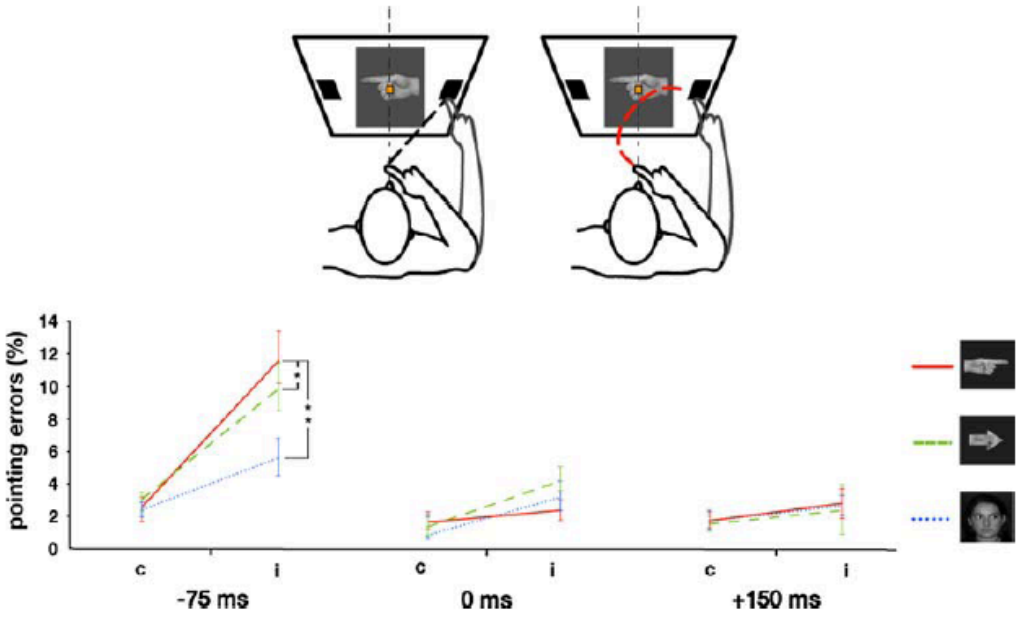

Figure 7. Crostella and colleagues (2009) showed that subjects were maximally distracted more by an incongruent (i) pointing cue, compared to other social (gaze) or non social (arrow) cues. On the top of the graph are shown an example of a correct (left) and of an incorrect (right) response.

In a similar task readapted in fMRI by Cazzato and colleague, the authors found that the neural correlates of these behavioral effects consisted in a greater activation of the Frontal Eye Filed (FEF), bilaterally, when subjects performing the task with eyes were distracted by a gaze and, conversely, by a greater acrivation in the Intra Parietal Sulcus (IPS) (see figure 8).

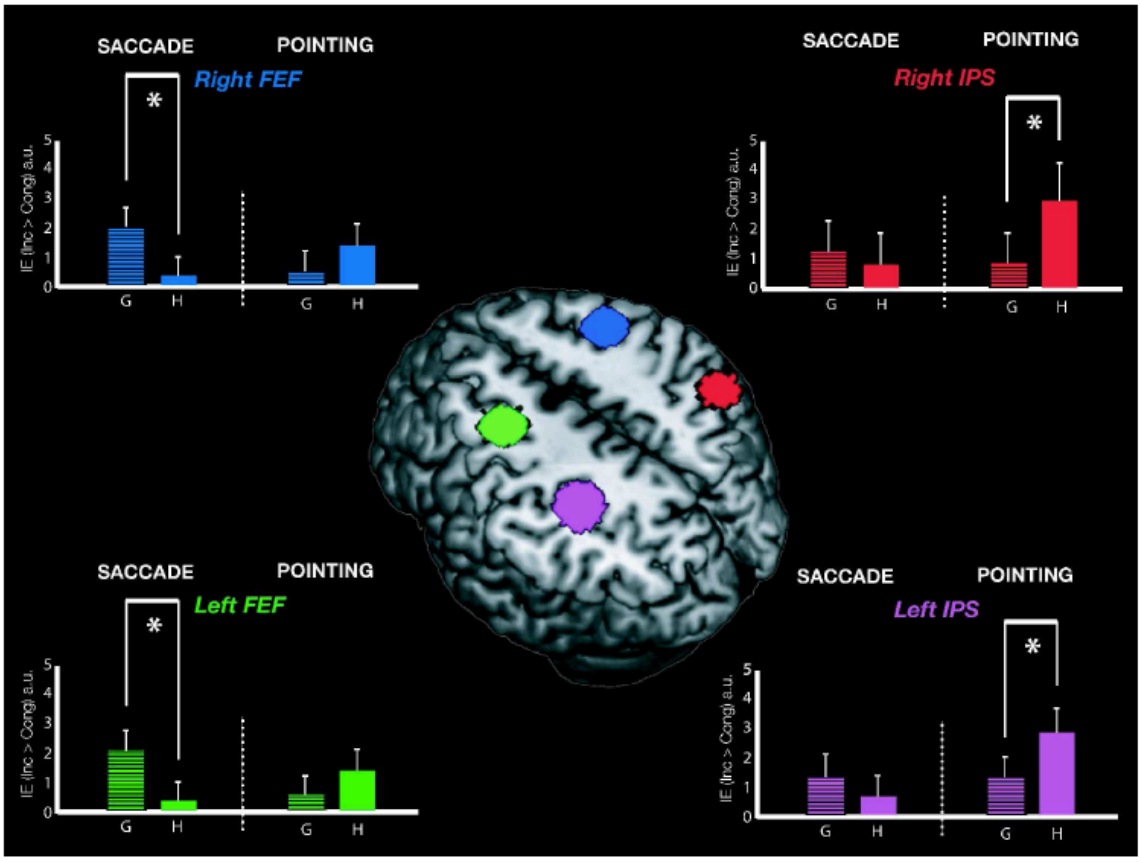

Figure 8. Activity in the bilateral Frontal Eye Field and Intraparietal Sulcus regions elicited by the Interferential Effect of the two social distracters during Saccadic and Pointing movements. Central panel: 3D rendering of the canonical MNI template showing the localization of four regions of interest (ROI) corresponding to the left (green) and right (blue) frontal eye fields [FEF] and to the left (pink) and right (red) Intraparietal Sulcus [IPS] is reported in the axial section. Left panel: signal plots for the interferential effect [IE(inc>cong)] in the right FEF (up) and the left FEF (down) as a function of the two biological distracters [G=Gaze / H=Hand] and effectors [Saccade /Pointing]. Right panel: signal plots for the interferential effect [IE(inc>cong)] in the right IPS (up) and the left IPS (down) for each biological distracter [G=Gaze / H=Hand] during saccadic and hand pointing task. In each plot, the level of activity for the four conditions represents the average amplitude of the hemodynamic response for the [IE(inc>cong)] belonging to the corresponding condition (e.g., Gaze or Hand trials, for Saccade) and expressed in arbitrary units (a.u., ± 90% confidence interval). The asterisks indicate significant ([G] vs. [H]) difference for left/right FEF and ([H] vs. [G]) difference for left/right IPS. From Cazzato and colleagues (2011).

The finding about the distracting power of a pointing hand cue in a pointing task and its underpinning in the IPS can be considered coherent with the evidences on the close link between specific visual stimuli and specific motor actions emerging by both behavioral (Craighero et al., 2002; Liuzza, Setti, & Borghi, In Press), and neurophysiological studies on the motor mirroring of observed hand (Fadiga et al., 1995; Romani, Cesari, Urgesi, Facchini, &

Aglioti, 2005; Urgesi, Moro, Candidi, & Aglioti, 2006). The notion according to a similar mirror system may exist also for the oculomotor domain is supported by the finding that similar, mainly fronto-parietal and temporal, cortical regions are recruited during execution and observation of eye movements (Grosbras, Laird, & Paus, 2005; Shepherd, Klein, Deaner, & Platt, 2009). In particular, Shepherd and colleagues found that a subset of observed neuron in rhesus monkeys lateral intraparietal area (LIP) fired both when the subject or n observed monkey looked in the preferred direction of the neuron even if the presence of this observed monkey was completely irrelevant to the task. So, the activation in FEF observed for the incongruent *vs* congruent condition, may reflect an effort of this area, deputed to the voluntarily control of saccadic movement, in inhibiting an automatic mirroring behavior.

All together, all these result may suggest that social attention may rely on a mirror mechanism similar to the one observed both in monkeys (di Pellegrino et al., 1992) and humans (Rizzolatti & Craighero, 2004) which, at its turn, seems to underpin the development of important social cognitive skills as well as gaze- following does.

Both these skills, reflexive social attention and motor resonance with observed actions, even though automatic, seems to be affected by high order factors and, most importantly, by social factors. That is, they are not only building blocks of sociality by providing very basic social cognitive skills, but they can be, at their turn, modulated by either our experience, our dispositions or by the social world we interact with.

4.2 Modulation of motor resonance and social attention: The role of experience, social world and individual differences

Bruzzo, Borghi, and Ghirlanda (2008) investigated whether observing actions similar to the actions that are part of our motor repertoire influences processing perceived actions. They used a priming paradigm and found that participants were faster to decide whether an action made sense or not when they observed a hand interacting with an object (e.g. grasping an orange) in the actor (egocentric) perspective rather than in an allocentric perspective. This shows that it is easier to put ourselves in others' shoes and to resonate

while perceiving an action when we share action-relevant characteristics, such as the viewpoint with the actor. At a neural level, Calvo-Merino et al. (2006) have shown that dancers' mirror neuron system resonated more when observing dancers of their own gender. Also, motor imagery brings to increased motor cortex excitability when actions were imagined in first person compared to third person (Fourkas, Avenanti, Urgesi, & Aglioti, 2006). Aglioti and colleagues (2008) also assessed motor cortex excitability when athletes, experts and naïve participants observed basketball throw and had to predict their outcomes. Behaviorally, athletes predicted the success of free shots at a basket earlier and more accurately than did individuals with comparable visual experience (coaches or sports journalists) and novices. Moreover, performance between athletes and the other groups differed before the ball was seen to leave the model's hands, suggesting that athletes predicted the basket shot's fate by reading the body kinematics. Both visuomotor and visual experts showed a selective increase of motor-evoked potentials during observation of basket shots. However, only athletes showed a time specific motor activation during observation of erroneous basket throws. Results suggest that achieving excellence in sports may be related to the fine-tuning of specific anticipatory 'resonance' mechanisms that endow elite athletes' brains with the ability to predict others' actions ahead of their realization.

For its fundamental role in building social cognitive skills, abnormalities in MNS functioning have been proposed to underline the social skill impairment *par excellence*, i.e. the Autistic Spectrum Disorder (Iacoboni & Dapretto, 2006; Rizzolatti, Fabbri Destro, & Cattaneo, 2009), as some structural imaging (Hadjikhani, 2005), functional imaging (Dapretto et al., 2005), electrophysiological (Martineau, Cochin, Magne, & Barthelemy, 2008; Minio-Paluello, Baron-Cohen, Avenanti, Walsh, & Aglioti, 2009; Oberman et al., 2005; Theoret et al., 2005) evidences seem to suggest. Indeed, Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by debilitating socio-emotional impairments, whose features include qualitative impairments in communication and reciprocal social interaction as well as repetitive and stereotyped behaviors (APA, 1994) (APA 1994).

One characteristic of ASD is the lack of empathy and emotional engagement with others (Baron-Cohen & Wheelwright, 2004; Gillberg, 1992). Lack of

empathy in ASD has been quantified with objective test measures, such as the Autism Spectrum Quotient (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) and the Empathy Quotient Questionnaire (Baron-Cohen & Wheelwright, 2004). Importantly, these scales are useful not only to categorically distinguish between a clinical and a normal population, but they may be used to assess individual differences as if autism can be defined as a trait in which people can differ each other on a continuous dimension. For example, people skilled in mathematics are usually higher in AQ than others even if they don't fall into the clinical population (Baron-Cohen et al., 2001).

Sonnby-Borgström and colleagues (Sonnby-Borgström & Jönsson, 2003) found that people high in dispositional empathy have less mimicry reactions to faces disposing emotions, as measured my Electro Myography (EMG) of face muscles involved in the expression of those emotions.

Avenanti and colleagues (Avenanti, Minio-Paluello, Bufalari, & Aglioti, 2009) showed that somato-motor mirror responses to others' pain are modulated by both state and trait differences in empathy. By recording motor-evoked potentials (MEPs) induced by transcranial magnetic stimulation (TMS) in healthy individuals observing needles penetrating a model's hand, authors found a reduction of cortico-spinal excitability that was specific for the muscle that subjects observed being penetrated. This inhibition correlated with sensory qualities of the pain ascribed to the model. Moreover, it was greater in subjects with high trait-cognitive empathy and lower in subjects with high trait-personal distress and in those with high aversion for the observed movies. Results indicate that somato-motor responses to others' pain are influenced by specific onlookers' personality traits and self-oriented emotional reactions.

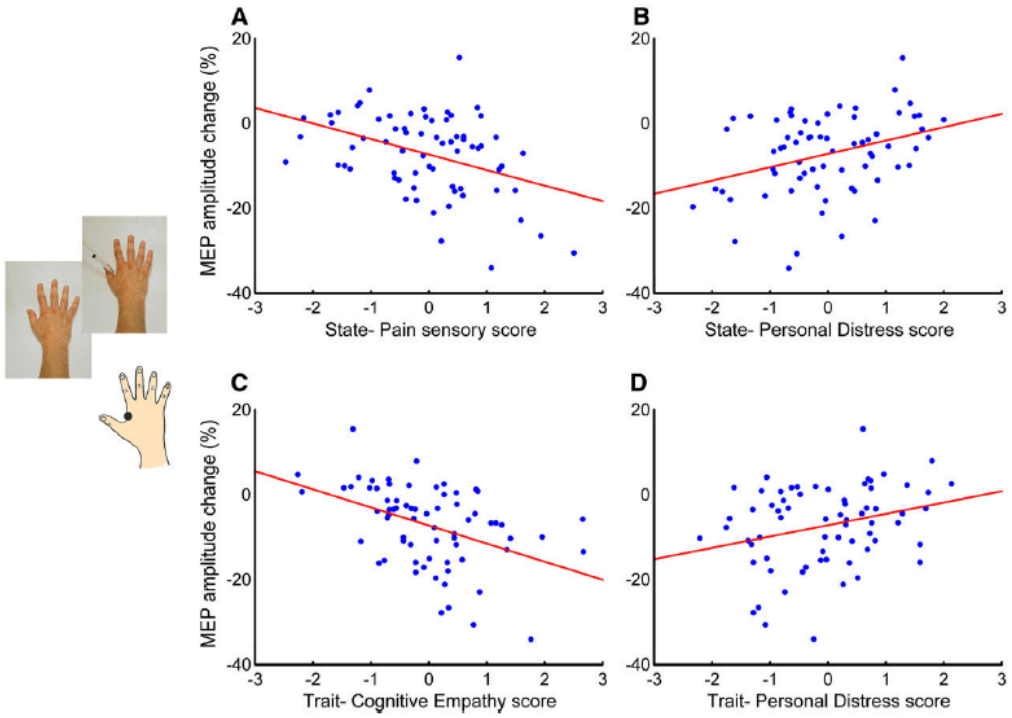

Figure 9. Correlation between state (upper scatterplots) and trait (lower scatterplots) empathy and sensorimotor empathy, as measured by motor cortex excitability suppression when watching a hand penetrated by a syringe compared to a neutral condition (e.g. touched by a Q-tip) (Avenanti et al., 2009).

Motor resonance seems to occur differently between females and males, the former resonating more electro-physiologically to observed actions more than men (Cheng et al., 2007; Cheng et al., 2008). Furthermore, Cheng and colleagues (2009) found females having significantly larger gray matter volume than matched males participants in the pars opercularis and inferior parietal lobule, two crucial nodes in the MNS. Beyond the gender difference, individual differences in empathy were tightly coupled with larger gray matter volume of the pars opercularis across all female and male participants. Gender differences may be at least partially accounted to a collinear gender difference in autistic traits, since ASD is four times more prevalent in boys than in girls (Fombonne, 2002) and males outperform females in the AQ scale (Baron-Cohen et al., 2001).

Similarity it's an important feature for our behavior within the social world. For example, Mitchell and colleagues (2006) have shown that when we mentalize about similar others, compared to dissimilar ones, we recruit different regions of the medial Prefrontal Cortex, a crucial region in the

mentalizing midline network, which is supposed to underlie our social skill to infer others mental states.

Similarity between perceiver and perceived agent has been found to modulate our resonance with others. The first form of similarity that can happen to occur is the very simple similarity between the observed action and an action which is part of our motor repertoire. Knoblich and Flach (Knoblich & Flach, 2001) presented video clips displaying either themselves or somebody' else throwing a dart at a target board and found participants more accurate in predicting the outcome when they watched themselves acting. These findings are in line with the ideomotor theories (Hommel, Musseler, Aschersleben, & Prinz, 2001), according to which perceptual features and motor plans rely on a common representational code: in other words, the more similar the action we see and the action we can perform are, the easier we simulate.

Being an important tool to imitate others, beyond understanding them, MNS has been proposed, within the framework of the new field of Cultural Neuroscience (Chiao, 2009; Chiao & Ambady, 2007) as an important mean to transmit culture, being Culture itself a set of bodily gestures (Losin, Dapretto, & Iacoboni, 2009). Culture, at its turn, is an important matrix to build similarities and dissimilarities among humans. Molnar-Szakacs and colleagues (2007) assessed the motor cortex excitability during the observation of gestures belonging to another culture or the same culture, performed either by an cultural in-group member or an out-group one. Observers resonated more with the in-group model performing an action than with the out-group one. Furthermore, they resonated more with the out-group model when he was performing a gesture, which belonged to the motor repertoire of his culture.

Interestingly, an opposite pattern has been observed in another study(Desy & Theoret, 2007): motor cortex excitability was higher when people looked at a hand belonging to an out-group, but the result was confined to the female participants. A possible source of difference between the two studies is that, in the study Desy and Theoret the stimuli represented actions that were neither goal-oriented, nor communicative, while in the study from Molnar-Szakacs and colleagues observed models performed communicative gestures. This is an important difference since mirror neurons in monkeys fire in response to goal oriented and communicative actions, but not in response to

meaningless actions. It can be that, in the case of the study from Desy and Theoret (2007). Even if in this study the authors discuss their results more in terms of physical dissimilarity than social dissimilarity, their manipulation does not allow to disentangle the two, since the observed hand could belong either to a black model o to a white one. The authors found that subjects resonated more to the dissimilar, meaningless actions, because in that case a motor simulation could have occurred to interpret an ambiguous actions, which was even more familiar because was performed by a dissimilar other.

In a previous study Setti, Liuzza, Burke, Borghi, and Newell (In Preparation) investigated to what extent motor resonance increases when participants share the same age. The authors used a priming paradigm: heavy vs. light manipulable objects followed a hand prime; participants were required to decide whether the target-object was heavy or light. They found that both young adults and older adults responded faster to hand primes of their same gender, but overall they did not respond faster when they observed hands of actors of their same age compared to a different age. This suggests they did not resonate to others' actions. A possible reason that age matters and may impact motor resonance, but only when the body schema changes substantially. Given that from youth to older adulthood only partial changes in body schema occur, the difference between the younger and older hand may have been too subtle for a difference in motor resonance to be found. In addition, the lifting actions alluded to in Setti et al. (In Preparation) study may be too simple to be susceptible to a different motor simulation between younger and older (see also Poliakoff, Galpin, Dick, & Tipper, 2009), i.e. both older and younger adults can easily simulate lifting of the objects used as stimuli.

My colleagues and I (Liuzza et al., In Press) have demonstrated by means of a visuomotor priming paradigm how motor simulation in 7–10 year old children is strengthened when a light target object is preceded by a child's hand in an action posture compared to an adult hand. This finding shows that both similarity between body schemas and motor familiarity can modulate motor resonance. Anyway, as in the case of Desy and Theoret, it is not clear if this modulation can be attributed only to physical similarity or even to a similarity related to the belonging to a social category (kids) dissimilar to the other (adults) which the hand primes could belong to. Eve if,

the lack of difference found in Liuzza et al., (in prep) with old participants observing young adult vs. old adult hand prime suggest that the social identity built on the age seems not to be as relevant as the body schema (since old adults and young adults don't differ in this dimension).

More importantly, Avenanti and colleagues (Avenanti, Sirigu, & Aglioti, 2010) studied sensorimotor empathy to pain when observing a hand from either an out-group or an in-group was picked by a syringe. In this case, to rule out the role of a mere physical dissimilarity and familiarity, beyond showing hand from black and white models to either black and white participants, showed a purple hand. Importantly, in this case, subjects were found to have a greater suppression of their motor cortex excitability (an index of their empathic reaction) to in-group and to the purple hand compared to out-group. This result, which even correlates with a well established measure of implicit attitudes (Greenwald, McGhee, & Schwartz, 1998), opens an important way to look at the relationship between motor resonance (and related processes like empathy) and the way we build our identities and categorize others in a social world. This happens even in socially much less complex species as Chimpanzees, it has been observed that a typical motor contagion as the one observed for yawning, can be stronger if the observed Chimp belongs to the same group, compared to another (Campbell & de Waal, 2011).

That is, social world has not a cognitive existence in terms of abstract categories, beliefs and values, but it modulates the ways in which we react to others in a very automatic and physiological way.

As in the case of mirror system, gaze perception, gaze following and reflexive social attention are to be considered crucial skills in our development of social cognition (Baron-Cohen, 1995a; Emery, 2000). So, not surprising, even these social cognitive skills and abnormalities in their function are considered to be related to Autism. Indeed, disturbances related to gaze processing in autistic individuals range from eye contact to gaze following.

While normally developing adults tend to scan eyes and mouth (Mertens, Siegmund, & Grüsser, 1993), people with autism tend to avoid eye contact (Baron-Cohen, 1988) (Dalton et al., 2005; Pelphrey et al., 2002). Also, normal children, compared to autistic, detect gaze contact quicker (Senju, Hasegawa, & Tojo, 2005a).

This difference in preference toward eye contact in autistic people seems to be related to a weaker amygdala and fusiform gyrus activation during eye contact compared to the activation observed in typically developed people in those core area for face and social signals processing (Dalton et al., 2005). Also, in an electrophysiological study by Senju and colleagues (2005b) it has been found that, during an oddball task in which children had to detect changes in gaze direction, eye direction elicited occipito-temporal negativity in typically developed children was lateralized to the right (right hemisphere seems to be predominant in face processing) and the amplitude of this negativity, while more pronounced in the direct gaze compared to the averted gaze condition within the typically developing sample, did not differ between the two condition within the autistic population. Interestingly, at a brain structural level, autistic children are found to have less gray matter in STS, a region crucial in gaze processing (Perrett, Hietanen, Oram, & Benson, 1992) and in social cues processing in general (Allison et al., 2000). But differences in eye contact are not found only on ASD population: even people with social phobia tend to avoid eyes when scanning faces (Horley, Williams, & Gonsalvez, 2003).

Subjects who scored high on a state anxiety score, showed a stronger attentional bias toward the art of the screen in which a fearful face with a direct (but not averted) gaze (Holmes, Richards, & Green, 2006). In the same study, high anxiety subjects were found to have a stronger gaze cuing effect with angry faces compared to low anxiety. A result similar to the one of a previous experiment by Mathews and colleagues (Mathews, Fox, Yiend, & Calder, 2003), in which high anxious subjects were found to be more interfered by the incongruent gaze of a fearful face.

Gaze cuing effect, also, has found to be as much weaker as much subjects scored high in autistic traits (Bayliss & Tipper, 2005) as measured by AQ (Baron-Cohen et al., 2001).

This finding is particularly relevant to the hypothesis according to which reflexive social attention has an important role in the development of building a theory of mind. A result that may be interpreted under this light may be the one that emerged from another study (Bayliss, di Pellegrino, & Tipper, 2005) that found a gender difference in social attention, since female were found to be more sensitive to others' gaze in a gaze cuing paradigm.

Another interpretation to this study can be linked to the finding of Shepherd and colleagues on monkeys (2006). In this study, authors provided evidence of a modulation of social attention by social status. Indeed, low-status male rhesus macaques reflexively follow the gaze of all familiar rhesus macaques, but high-status macaques selectively follow the gaze only of other high-status monkeys. So, high social status may require selective monitoring of only other high- status monkeys. Though macaque social status does not predict plasma cortisol levels (indexing anxiety), it does predict levels of testosterone (Sapolsky, 2004) which, along with the gender differences finding in humans, may suggest that individual variation in androgen-linked masculinization could have a role in differentiating the strength of reflexive and voluntary gaze-following in primates.

This finding opens an interesting scenario not only on the inquiry on individual differences in gaze-following behavior, but also on how the social features of another individual might differentially modulate conspecifics social attention.

One of the most important challenges to a possible modulation of social attention by high order variables resides on the putative anatomo-functional differentiation between brain areas deputed to gaze processing and to face processing (Hoffman & Haxby, 2000). Also, as we saw earlier, the gaze direction processing and the consequent reflexivity of social attention, is supposed to work as a fodorian module, i.e. as a function encapsulated, impermeable to other kind of information. A strong assumption like that it's at odd with what found about modulation of gaze cuing effect by emotional face expression, at least in anxious subjects (Holmes et al., 2006; Mathews et al., 2003), but emotions themselves don't seem to modulate gaze cuing, as shown by Hietanen and Leppanen (2003). So, even if information regarding gaze direction and face identity or regarding expression appears to be processed in different regions of the brain, these types of information can influence each other (Frischen, Bayliss, & Tipper, 2007). Ristic and Kingstone (2005) examined behaviorally whether reflexive social orienting was purely automatic or sensitive to top-down modulation by showing participants an ambiguous stimulus that could be perceived either as representing eyes or a car. When the stimulus was first referred to as a car and then as eyes, an attentional shift was only present for the eyes condition. However, when the

stimulus was first referred to as possessing eyes, and then later as a car, attentional shifts were observed for both conditions.

Frischen and Tipper (2006) provided a compelling evidence that identity of the face the gaze belongs to matters in the gaze cuing effect. I this study, faces of famous people could appear as distractors among many other trials in which unknown people were used as stimuli. Even after 3 minutes from the presentation of a famous face, when subjects were presented again that face they tended to have a performance conform to the former gaze cue of that character. This effect provides evidence that the identity of the face is not completely independent with the gaze direction processing at the basis of social attention.

The importance of face identity in gaze cuing effect has been shown even by an experiment by Deaner et al.,(2007), which shows that familiar faces drive visuo-spatial attention than non-familiar ones, at least in females.

Also in this case, gender differences can account for some differences in gaze-following behavior, consistently with Bayliss and colleagues results (2005) and with gender differences in motor resonance (Cheng et al., 2007; Cheng et al., 2008). But gender of participants interacts even with gender of the stimulus, (Khurana, Habibi, Po, & Wright, 2009). Indeed, male participants show a stronger gaze cuing effect when the distractor is female than when is male, while in female the gender of the character doesn't modulate the gaze cuing effect, a result which sheds some light even on the possible role of intergroup processing on gaze following behavior.

This feature has been particularly explored by Pavan and colleagues (2010). Their study demonstrated that Gaze cuing is effective on white participants (but not in black) only when an in-group face is used as distractor and when social categories are salient.

5. Social attention and politics: role of situation and dispositions in modulating gaze following behavior

5.1 Evolution of politics

Aristotle didn't hesitate to define human beings as political animals (*Zoòn politikòn*). This statement may seem a trivial matter of fact for us, but how politics evolved and why, is still a very controversial issue:

> As members of bands or tribes, humans can be quite egalitarian - particularly with respect to males. Yet we also develop degrees of despotism which, by mammalian standards, are truly staggering. This extreme range of behaviors can be bewildering. For a dwindling contingent of scholars, those who insist on unadulterated environmentalism, such disparities are taken to mean that our political nature is simply nonexistent. For many others, it remains a puzzle that must await the isolation of behavior genes in the laboratory. For still another [...], it has been a subject of unresolved, philosophically oriented debate that seems to polarize the protagonists into Hobbesian hawks and Rousseauian doves (Bohem, 1999).

Social cognitive skills and the emergence of coalitions are closely interweaved: "Coalitions are functionally crucial to individuals within these groups because they enable the animals to minimize the levels of harassment and competition" (Dunbar, 1998).
In the seminal de Waal work, *Chimpanzee politics* (1982), de Waal describes some interesting analogies between our political behavior and the one of these great apes. For example, in both species social status is a rewarding condition, and in both species individual form social alliances to achieve a higher social status.
This analogies, can have an underlying similar biological foundation, as Robert Wright points out in de Waal's *Primates and philosophers, how morality evolved* (de Waal, 2006):

> Given the close evolutionary relationship between human beings and chimpanzees, it is certainly plausible that these external behavioral parallels are matched by internal parallels - that is, that there is some inter-species commonality in the biochemical mechanisms governing the behavior and in the corresponding subjective experience.

> Facial expressions, gestures, and postures that accompany certain chimpanzee behaviors certainly reinforce this conjecture (pp. 84-85).

This importance of social non-verbal behaviors in politics has been pointed out in in *Primate Politics*(1991), edited by Schuber and Masters who, in the conclusions of their edited book, wrote:

> Like monkeys and apes, we express feelings and communicate social intentions through nonverbal cues that are both visible and audible. While communication by olfaction (pheromones) and touch also probably play an important role for all primates, the group behaviors we call politics are most likely to be associated with gestural cues of face and body seen by others or with acoustic signals heard by members of the group (p. 245).

Here, we can see you non-verbal behaviors, as the use of gaze to vehicle important information, is a good candidate to study even how political cognition works. Human politics, not so differently from chimpanzee politics, often work by forming coalitions (huge, national-wide ones in the case of humans), to achieve a higher status, so these non-verbal behaviors can change to the extent an individual belongs to our own or to a different coalition.

A big difference between humans and chimpanzees is that within the former, the belonging to one coalition or to another, at least in modern Western democracy, is also a function of political dispositions and beliefs, which largely vary across cultures and across individuals as well. The nature of human political dispositions remains in question. “Are we innately so flexible that human behavior can be reshaped ‘at will’ by environmental forces, or do some serious problems exist with regard to our definitions and the perceptions of our own political nature?” asks himself Bohem (1999). The two most important building blocks of human nature, selfish behavior and altruism, can indeed be translated in the way humans organize themselves in large society by the mean of politics. Positive attitudes toward equality or inequality, for example, are assumed to be, the very central in differentiating left-wing and right-wing, respectively (Bobbio, 1994).

5.2 Political psychology: motivation and cognition, a framework

The concept of ideology originated in the late 18th century the science of ideas, but it was with Marx and Engels that the term began to be used in ways consistent with the actual use. In particular, in Marx and Engel, the term ideology ha two important features: (a) a value-neutral sense, in which ideology refers to any abstract, internally coherent system of belief or meaning, and (b) a more critical sense in which the term captures propagandistic belief systems that are typically misleading and systematically distorted (Jost & Nosek, 2008).

A huge amount of research in political psychology has raised since, after the second world war, the phenomenon of fascism has began to be studied under the lenses of the psychology. In the 1950 Adorno, Frenkel-Brunswik, Levinson, and Sanford's(1950) wrote *The Authoritarian Personality*, in the attempt to build a bridge between personality and an ideology which just shocked the whole world, leaving behind it millions of deaths. Authors, indeed, pointed out that an individual's belief system "reflects his personality and is not merely an aggregate of opinions picked up helter-skelter from the ideological environment".

Personality itself, as ideology, is not a so plain concept: "Personality includes behavioral tendencies and systems, structures and mechanisms that regulate affective, cognitive and motivational processes. It involves internal systems and processes that guide people towards the attainment of individual and collective goals, accounts for coherence and behavioral continuity across contexts, and ultimately, explains one's personal identity" (Caprara, 2007). From the seminal work of Adorno and collaborators originate the Right Wing Authoritarianism construct (Altemeyer, 1998), which measures individual differences authoritarian submission, authoritarian aggression and conventionalism. Even though the ideological distinction between a left and right side on the political space is relatively recent in the human history, as it born during the French Revolution, at the end of the 18th century, the defining features of the right-wing ideology in terms of resistance to change and acceptance of inequality have been intertwined since the Middle Ages (Jost & Nosek, 2008). In addition to classic and contemporary approaches to

right-wing authoritarianism, other less obvious sources of theory and research on individual differences associated with dogmatism and intolerance of ambiguity, uncertainty avoidance, need for cognitive closure, and social dominance orientation (Sidanius & Pratto, 1999) insofar as each of these psychological variables contributes to a deeper and more nuanced understanding of political conservatism. Indeed, as Jost and colleagues wrote down (Jost, Glaser, Kruglanski, & Sulloway, 2003) "The measurement of individual differences is an excellent starting point for understanding the psychological basis of political ideology, but we argue that approaching political conservatism exclusively from the standpoint of personality theory is a mistake". Jost et al. performed a wide meta-analysis to explore the extent to which adopting politically conservative ideology satisfies various social–cognitive motives. Therefore, authors proposed to analyze political conservatism as motivated social cognition in order to integrate theories of personality (authoritarianism, dogmatism–intolerance of ambiguity), epistemic and existential needs (for closure, regulatory focus, terror management), and ideological rationalization (social dominance, system justification).

They found several variables as predictive of political conservatism: death anxiety, system instability, dogmatism–intolerance of ambiguity, openness to experience, uncertainty tolerance, needs for order, structure, and closure, integrative complexity, fear of threat and loss and self-esteem. According to these results, authors conclude: "the core ideology of conservatism stresses resistance to change and justification of inequality and is motivated by needs that vary situationally and dispositionally to manage uncertainty and threat".

These results have been paralleled by further findings on implicit attitudes (Jost & Nosek, 2008) as measured by the IAT for values such as tradition versus progress, conformity versus rebelliousness, order versus chaos, stability versus flexibility, and traditional values versus feminism.

It comes clear that linking ideology differences to some more basic cognitive and affective motives opens new pathways to study the possible physiological correlates of political ideology.

Oaxley and colleagues (Oxley et al., 2008), published in a study on Science in which subjects with strong attitudes toward social protective policies (as positive attitudes to military spending, war in Iraq, death penalty and

negative to gay marriage, or abortion) were exposed to scary stimuli (as a spider on a fearful face, or a sudden noise), while experimenter recorded physiological reactions to fear by mean of skin conductance resistance[4] and of the electromyography activity of the orbicularis oculi startle blink. They found that people who endorsed social protective policies, which are usually policies endorsed more by conservatives than liberals, had a more marked physiological reaction to emotigenous stimuli. One possible limitation of this study is that even if we can postulate this coherence with the framework provided by political conservatism as motivated social cognition (Jost et al., 2003), it lacks of measures that really can help to understand if the effect is mediated by more basic cognitive and effective motives as the ones used in the study from Jost and colleagues.

A neurophysiological study which digs a little bit more in depth in the relationship between conservatism and its physiological correlates is the one carried on by Amodio and colleagues (2007). Since, conservatives have been found to be more structured and persistent measures of personal needs for order, structure and closure (Jost et al., 2003), while liberals, by contrast, report higher tolerance of ambiguity and complexity, and greater openness to new experience, which is reflected in differences in the openness dimension of the Big Five, as reported by Jost (2006).

Amodio and colleagues tested how people with different ideologies make it with a task in which was required to monitor conflict in a simple Go/NoGo task while their electrophysiological activity was recorded in order to study to Event-Related Potentials (ERPs), The response-locked error-related negativity (ERN), which peaks at approximately 50ms following an incorrect behavioral response conflict between a habitual tendency (for example, the Go response) and an alternative response (for example, to inhibit behavior in response to a No-Go stimulus), and the No-Go N2 component, which is believed to reflect conflict-monitoring activity associated with the successful inhibition of the prepotent Go response on No-Go trials. They found that, behaviorally, as more the subjects where liberal, as much they succeeded in inhibiting the correct responses. Also, the amplitude of these ERPs were correlated with liberalism. Authors interpreted these finding claiming that liberals are not only better at inhibiting a preponderant response, being more

[4] A measure that assesses the activation of the autonomic nervous system, responsible for the sweating which makes the skin less resistant to electricity.

flexible, but this behavior was reflected in the a neural process that seems to be deputed to cognitive conflict monitoring, which is supposed to be localized in the Anterior Cingulate Cortex (ACC).

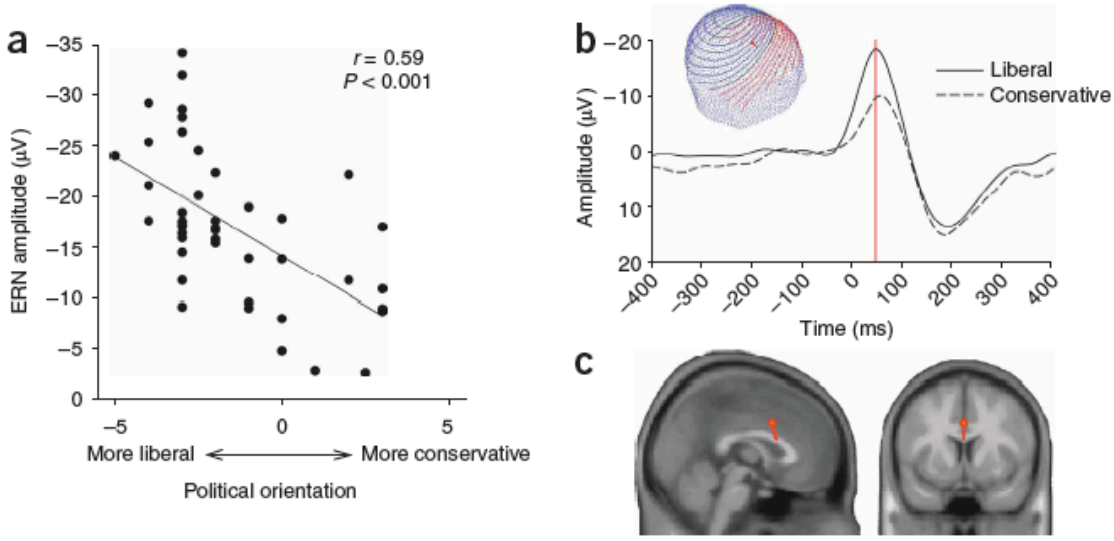

Figure 10. Amplitude of Error-Related Negativity negatively correlates with conservatism. According to source analysis the origin of this component should be located in ACC (Amodio et al., 2007).

Those two results have been strikingly mirrored by a structural study from Kanai and colleagues (2011), who found that greater liberalism was associated with increased gray matter volume in the anterior cingulate cortex, whereas greater conservatism was associated with increased volume of the right amygdala. Indeed, as ACC is deputed to conflict monitoring, Amygdala a structure putatively involved in the autonomic nervous system activation in reaction to fearful stimuli and possibly its activation could have been responsible for the finding from Oxley (Oxley et al., 2008) and colleagues. Of course, being the brain a highly plastic organ, both functionally and structurally, no causal relationship can be driven between functioning or gray matter volume of these structure and the ideologies. It can be, for example, that the higher volume of amygdala in conservatives can be the result of a less ability to cope with emotional stimuli, as suggested by research on attachment styles and ideology, which suggest that people with an insecure anxious-ambivalent attachment style (reviewed in Koleva & Rip, 2009).

5.3 Social attention and political ideology

As emerged by the studies shown in the former paragraph, Political orientation correlates with a variety of explicit and implicit preferences, and even with physiological reactions linked to basic emotional and cognitive processes. “This suggests that ideological differences between liberals (or leftists) and conservatives (or rightists) are psychologically (as well as politically) meaningful” much more than it was supposed to be (Jost & Nosek, 2008).

To date, only one experiment tried to capitalize the well known differences between liberals and conservatives to investigate how much they are reflected in the a process like the one of social attention, which relies much on non verbal communication, which seems to be at the very basis of rudimentary politics even in non-human primates (Shepherd et al., 2006).

Dodd et al. (Dodd, Hibbing, & Smith, 2011) used a gaze cuing paradigm with a schematic face, whose gaze preceded the target at different onsets (100ms, 500ms, 800ms, as shown in Figure 11).

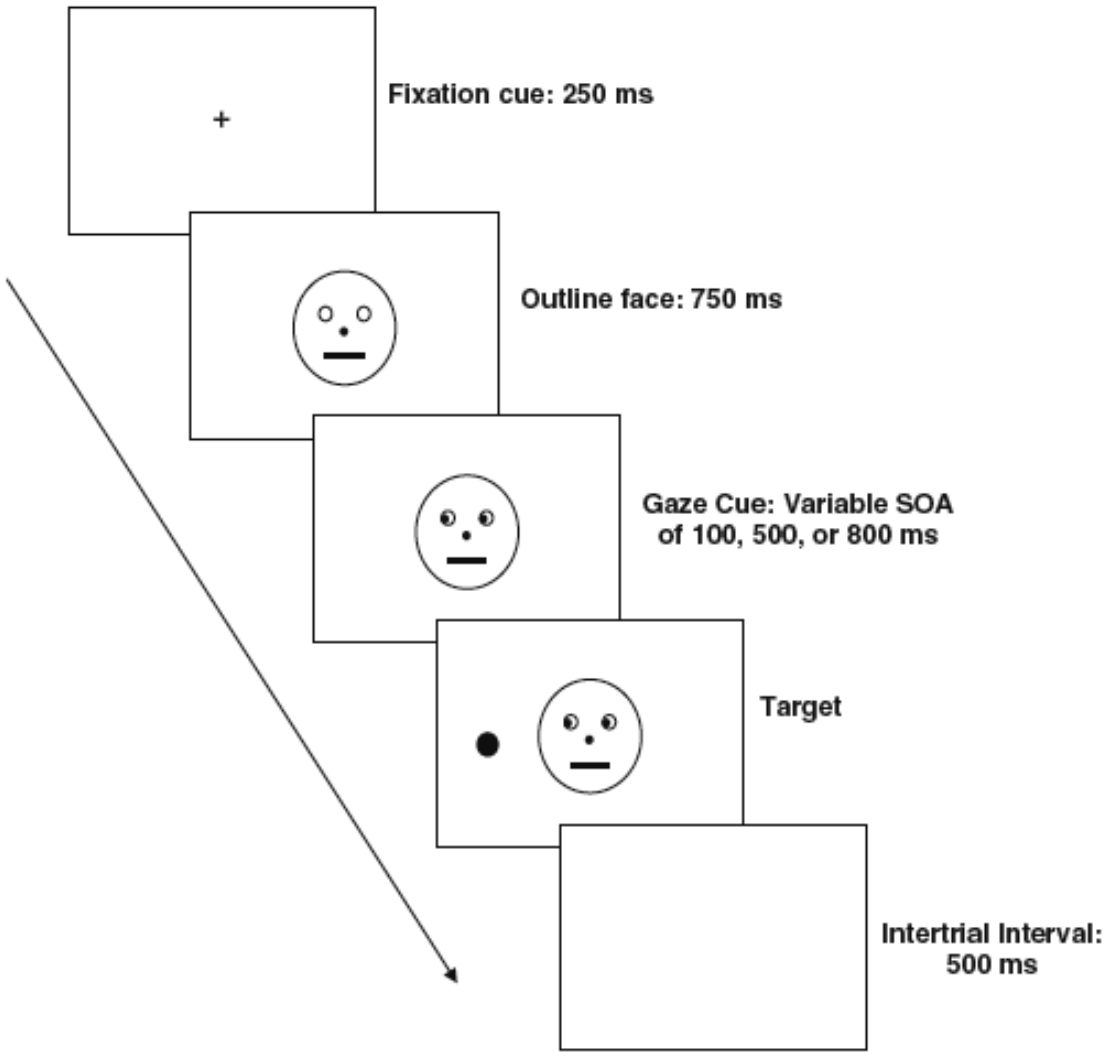

Figure 11. Procedure used by Dodd and colleagues (Dodd et al., 2011).

In order to have a more exhaustive measure of their political orientation, authors used a composite measure of participants' political ideology. Therefore, they did a median split the sample and assessed if the right leaning and the left leaning sample differed in the gaze cuing effect at different SOAs. They found liberals following the gaze more than conservatives, but only at longer SOAs (500ms and 800ms). These SOAs don't reflect any reflexive modulation of attention anymore (e.g. Driver et al., 1999; Posner, 1980). Indeed, the advantage for trials on the cued versus uncued side at the 100ms SOA, which dissipates by around 300ms, and may even reverse to become a disadvantage at the longer SOAs (Posner & Cohen, 1984). Anyway, authors discuss these results claiming that individuals on the political right tend to be more supportive of individualism than those on the left, a point evident in the philosophy of the influential conservative thinker

Ayn Rand". Moreover, "Conservatives tend to value personal autonomy more so than liberals, making them less likely to be influenced by others and, in turn, less responsive to gaze cues". This interpretation is pretty much at odd with theories and findings coming from another important line of research that attempts to link moral foundations ad political ideology.

By reviewing previous researches on morality and political ideology, Haidt and Graham (2007) found a critical point in those lines of research which assumed the ethic of autonomy (as care and fairness, which are actually endorsed more by liberals than conservatives) as the only source of morality report the ethnographic work of Richard Shweder as a possible alternative theoretical framework (1990) has long argued that:

> In the ethic of autonomy the moral world is assumed to be made up exclusively of individual human beings [...]. Rights, justice, fairness, and freedom are moral goods because they help to maximize the autonomy of individuals, and to protect individuals from harms perpetrated by authorities and by other individuals. The ethic of community [...] sees the world not as a collection of individuals but as a collection of institutions, families, tribes, guilds or other groups. The purpose of moral regulation is to protect the moral integrity of the various stations or roles that constitute a society or a community. [...] Key virtues in this ethic are duty, respect, loyalty, and interdependence (Haidt & Graham, 2007).

Haidt and Graham proposed five psychological foundations of morality, which we label as harm/care, fairness/reciprocity, in-group loyalty, authority/respect, and purity/sanctity. Harm/care deals with our tendency to react negatively to people harmed by other people and feel a prosocial need towards them. This moral principle has in Empathy its underlying affective process. has its evolutionary roots in "the long history of mammalian evolution has shaped maternal brains to be sensitive to signs of suffering in ones own offspring" (Haidt & Graham, 2007). Fairness is our sensitivity to unequal distribution of richness and has its evolutionary roots in "long history of alliance formation and cooperation among unrelated individuals in many primate species has led to the evolution of a suite of emotions that motivate reciprocal altruism" (Haidt & Graham, 2007). These two are the moral principles traditionally considered as the core principles by the studies on moral reasoning and ideology since the seminal research of Kohlberg on the development of moral reasoning (1969) to even the theory of

conservatism as motivated social cognition proposed by Jost and colleagues (2003). These two principles belong to the ethic of autonomy and are the ones typically more endorsed by liberals. Beyond those, Haidt and Graham proposed other two principles that express the ethics of community, in-group loyalty and authority acceptance, and another principle, called purity, which expresses the ethics of sanctity. In-group loyalty consists to the aversion to all the values and behaviors (as dissent) that may undermine the unity and the cohesion of a community. Loyalty, patriotism and heroism are usually the expression of this moral principle, which has its evolutionary roots in a long history of living in kin-based groups which has led to special social-cognitive abilities backed up by strong social emotions related to recognizing, trusting, and cooperating with members of ones co-residing in-group while being wary and distrustful of members of other groups. Authority acceptance is related to dominance and feelings of respect for and obedience to dominant figures or recognized authorities within our groups. Its evolutionary roots reside in "the long history of living in hierarchically-structured in-groups, where dominant males and females get certain perquisites but are also expected to provide certain protections or services, has shaped human (and chimpanzee, and to a lesser extent bonobo) brains to help them flexibly navigate in hierarchical communities" (Haidt & Graham, 2007). Finally, purity resides on the emotion of disgust in reaction to physical as well to moral objects and events. Indeed, argue the authors, "disgust appears to function as a guardian of the body in all cultures, responding to elicitors that are biologically or culturally linked to disease transmission (feces, vomit, rotting corpses, and animals whose habits associate them with such vectors). However, in most human societies disgust has become a social emotion as well, attached at a minimum to those whose appearance (deformity, obesity, or diseased state), or occupation (the lowest castes in caste-based societies are usually involved in disposing of excrement or corpses) makes people feel queasy. In many cultures, disgust goes beyond such contaminant-related issues and supports a set of virtues and vices linked to bodily activities in general, and religious activities in particular".

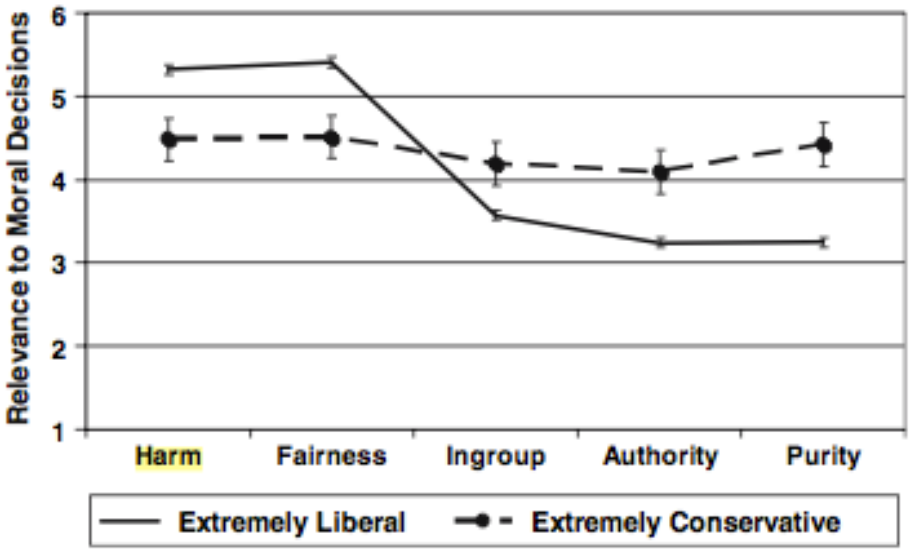

Figure 12. Haidt and Graham survey shows how Moral relevance. (1 = not relevant at all, 6 = always relevant) by foundation differed for extreme liberals and conservatives (Haidt & Graham, 2007).

So, interpretation provided by Dodd and colleagues seems to be at odd with the findings from Haidt, whereas Conservatives, rather than Liberals, should have endorsed ethics based on community. Also, the finding from Dodd and colleagues seem to be inconsistent with the findings stressing the fact that liberals should be better at managing cognitive conflicts (Amodio et al., 2007; Jost, Federico, & Napier, 2009; Jost et al., 2003). Also, linking the conservatism to the Rand ideology is not completely correct in my point of view. The thought of Rand can be rather ascribed to the libertarian philosophy, a blend of social liberalism (pro minorities, anti-autoritarianist) ad economic conservatism (pro-free market). Please notice that this distinction is not only philosophical, but is reflected in the psychological endorsement of different moral principles, as shown by Haidt and colleagues (2009) that, according to their five moral foundations were able to cluster a wide sample into four clusters that go beyond the unidimensional Left-Right distinction: secular liberals, libertarians, religious leftists and social conservatives.

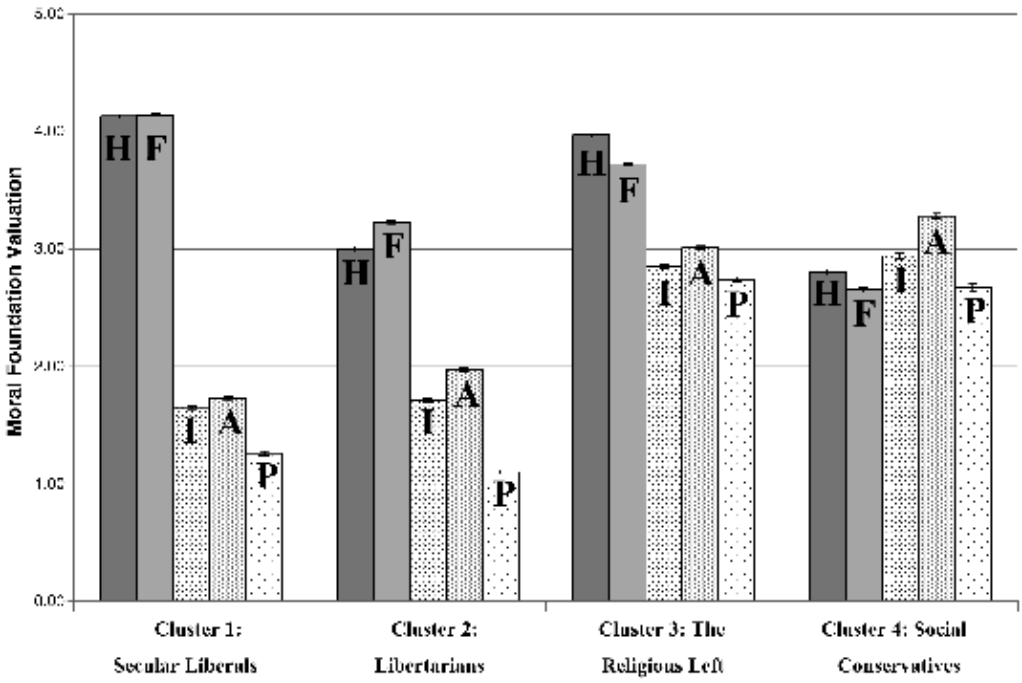

Figure 1. Moral foundation patterns in four clusters. *Note.* H = Harm; F = Fairness; I = Ingroup; A = Authority; P = Purity. Total sample sizes for each cluster are as follows: 5,946 (Cluster 1), 5,931 (Cluster 2), 6,397 (Cluster 3), 2,688 (Cluster 4). Error bars represent ± 2 S.E.

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Figure 13. Haidt and colleagues have shown that, according to the moral principle endorsement, we can create four clusters of people, secular liberals, libertarians, religious leftists and social conservatives. H=Harm/Care, F=Fairness, I=In-group Loyalty, A=Authority acceptance.

> Cluster 1 is clearly the prototypical *secular liberals* we have described in previous publications. People in this cluster had, on average, the highest scores on Harm and Fairness, and very low scores on In-group, Authority, and Purity. They had the highest scores on Openness to Experience and the lowest scores on Right-Wing Authoritarianism and Social Dominance Orientation", while "Cluster 4 is clearly the prototypical *social conservatives* we have described elsewhere: they had the *lowest* scores on Harm and Fairness, and very high scores on In-group, Authority, and Purity. They had the lowest scores on Openness and the highest scores on Right-Wing Authoritarianism and Social Dominance Orientation"(Haidt et al., 2009).

Interestingly, these results point out that exist two other clusters that, rather than being just the expressions of moderate, intermediate positions between the two, have pretty much unique features: a religious left which, eve though similar to liberals in terms of autonomy ethics, endorses more community and sanctity principles. Also, a libertarian cluster exists, which is similar to conservatives in terms of autonomy principles, but is much lower than

conservatives (and similar to liberals) in both community and sanctity principle.

So, the results from Dodd and colleagues, or at least their interpretation, can be confused by an uncovered difference in these important principles. Also, the simple median split of participants could not really pick up two representative samples of the conservative sample. College student samples are typically skewed toward liberalism and it can be that the supposed conservative sample can have included just moderate liberals or libertarians, which may explain better why they followed the gaze less than a liberal sample that may have been formed by more extreme liberals and maybe by religious leftists (since their measure pick up more the attitudes inherent to social justice than the ones on community-based values).

Also, other important limitation of this studies are linked to the use of a schematic, politically neutral face. First because is much less ecologically valid than a real face, secondly because some moral principles are more likely to be activate if the face belonged to an in-group *vs*. out-group, causing them to modulate social attention behavior by the mean of moral emotions linked to in-group loyalty. The same applies to authority acceptance, which can be at play only with a dominant in-group member.

That's why we (Liuzza et al., 2011) decided to use character faces from portrayed well-known, current or former political leaders and opinion makers, in order to disentangle the possible modulating role of the actual influence on the political landscape and/or the media exposure. For these reasons we chose the pictures of the following personalities: Silvio Berlusconi (the most important centre-right wing, current prime minister, political leader), Bruno Vespa (centre-right wing, opinion maker), Antonio Di Pietro (centre-left wing, current political leader) and Romano Prodi (centre-left wing, former prime minister, no longer active as political leader). We recruited participants on the basis of a questionnaire assessing political preference and voting behavior (see below for more details), 15 participants were assigned to the left wing 13 subjects to the right wing group (See the paper in Appendix for more details) In this case the criterion was not a simple median split but, since we used a self-reported 1 to 7 scale to self report their political orientation (where 1=extremely left-wing, 4= centrist and 7= extremely right wing) and coded the voted parties accordingly (e.g.

communist parties as “Partito Comunsita dei Lavoratori” were coded as 1 and xenophobic parties parties as “Forza Nuova” were coded as 7), we assigned people who averaged more than 4 (the political centre) to the right-wing sample and people who scored below this threshold to the left-wing one. In this way, the political orientation of the participants could interact with the political orientation of the stimuli.

In this study we capitalized together the findings about the permeability of motor resonance to social and disposition factors along with evidences about social attention by using the paradigm previously used in this lab (Cazzato et al., 2011; Crostella et al., 2009; Ricciardelli et al., 2002) to study the gaze-following behavior. This task, eve if oculomotor in its nature (since provides an index of the automatic oculomotor imitation of a conspecific gaze), studies a behavior which is at the basis of social attention (Emery, 2000), an sheds some lights on the premotor components of social attention itself.

The study was performed in a quiet room with medium illumination. Subjects sat on a comfortable chair in front of an LCD monitor, positioned at about 57 cm from their eyes. Eye position and eye movements were measured monocularly in real-time by means of an infrared video-based system.

Each trial started with the appearance of a black central fixation square presented on a light gray background, and of two larger black squares presented at 10.2° of eccentricity in the left and the right visual field. The fixation square was presented on the between-eyes point of the face of a political character with straight gaze. After 575ms, the color of the central square changed to either blue or red). This was the imperative signal for the participants to make a fast and accurate saccade toward the left (change into blue) or the right (change into orange) target square. The colored cue remained visible until the end of the trial. 75ms before the onset of the instruction-cue (stimulus onset asynchrony, SOA) the distracting character made a left- or right-ward saccadic movement. This interval was chosen because we demonstrated that gaze following behavior is maximal at this interval (Crostella et al., 2009; Ricciardelli et al., 2002). At the data collection time (i.e. between 24th of July, 2009 and 24th October, 2009) the index of the trust in Berlusconi, varied between 55% (August 2009) and 60% (October 2009), as emerged by the “CRESPI Ricerche” phone CATI method survey

(available at http://www.sondaggipoliticoelettorali.it/) on a 1,000 people sample stratified for sex, age, geographic area and population center size.

For each character-face we prepared a RGB digital photography (6.76° x 6.76°). The original pictures were collected by searching in Internet and modified by means of the Adobe Photoshop software (Adobe Systems Incorporated). To enhance their saliency, the stimuli were animated by two frames presented in rapid sequence. The first frame (lasting 500 ms) was replaced by a second frame lasting 875 milliseconds. The first frame depicted a straight gaze. The second frame depicted a gaze that could be oriented leftward or rightward. The direction of the character gaze and that one indicated by the instruction-cue could be congruent (e.g. both leftward) or incongruent (e.g. one leftward and the other rightward). Importantly, subjects were instructed to ignore the distracting stimulus and to focus their attention on the central square color change. Subjects were tested in four separate blocks, each associated with a character face. In each block, the two instruction cues (leftward or rightward) and the two distractors (congruent or incongruent) were equally probable and were presented in a random sequence. Each of the 4 possible combinations was equally probable and was repeated 12 times. Thus, a total of 48 trials per block was run. We analyzed the participants' directional accuracy by focusing on the first horizontal saccade that followed the instruction cue and had an amplitude larger than 2°. Saccadic RTs were also collected. Only RTs for correct trials were considered. The trials in which there was no clear evidence that a saccade occurred were excluded (725 out of 5376, 13.5%). A trial was rejected from the analysis described below if the latency was either less than 100ms (anticipations) or greater than 500ms (delays). The proportion of rejected trials was 3.4% of the total trials.

As mentioned above, a lot of interest has been raised on how personality can be linked to ideology and voting behavior (Caprara, Francescato, Mebane, Sorace, & Vecchione, 2010; Caprara, Barbaranelli, Consiglio, Picconi, & Zimbardo, 2003; Caprara & Zimbardo, 2004; Jost & Nosek, 2008). By using questionnaires that captured the five factors models (Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism, (Digman, 1990)), these author showed that conservative and liberal voters differed each other even if with some subtle differences. Indeed, across US and Italy,

conservatives tended to be higher in conscientiousness, ad lower in openness, compared with liberals. But, while in Italy right-wingers showed to be higher in extraversion (Caprara et al., 2003), the opposite happens in the US. Moreover, in Italy, Agreeableness seems to be another core feature of liberals compared to conservatives, while in the US there's not such a difference. Interestingly, the differences among voters seem to be paralleled among the politicians themselves, as recently demonstrated on a sample of both female Italian voters and female members of the Italian Parliament (Caprara et al., 2010). Also, Caprara and colleagues (Caprara, Barbaranelli, & Zimbardo, 2002), compared the responses provided on a Big Five Questionnaire (BFQ, Caprara, Barbaranelli, Borgogni, & Perugini, 1993) about themselves and about each politician and found a greater similarity between voters' self-reported personality and their appraisals of politicians belonging to their preferred coalitions than with their appraisals of the politicians of the opposite coalitions (Caprara & Zimbardo, 2004). Caprara and colleagues (2007) directly assessed the similarity between voters and politicians by providing a unique index of similarity which ranged from 0 to 1 and showed that not only, despite of the cultural differences in the relationship between voters personality and political preferences and even in the appraisal of conservative *vs*. liberal politicians between the to nations, in both cases voters perceived themselves as more similar to the preferred politicians and this result was replicated while taking into account voters' future and actual electoral behavior, providing a compelling evidence to the congruency model posited by Caprara & Zimbardo. Results like these may be interpreted related to assimilation and dissimilation processes (Sherif & Hovland, 1961), which exaggerate similarities with liked people and dissimilarities with disliked ones. This findings drove Caprara and Zimbardo (Caprara & Zimbardo, 2004) propose a *congruency principle* which rules the relationship between voters and politicians:

> Voter–politician congruency operates as the humanizing glue linking affect, cognition, and action at different stages of political transactions. First, it operates in how voters activate schematic knowledge to appraise politicians' personality, selecting those attributes perceived to be most relevant to the political office, the current political–economic conditions, and then subsuming under them other. Next, it operates in how politicians, through their "media image crafters," convey to the public the set of expressive behaviors that form an image highlighting those traits the electorate most

> values and shares. Further, it operates in how the self-reported personalities of leaders and followers are similar but differ from their opponents' self-reported personalities. Finally, it operates in how the distinctive personality characteristics reported by leaders and followers of opposite coalitions can be traced back to common values at the roots of ideals of their respective political agendas. This congruency element underscores the commonality of feelings, thoughts, values, and intentions of partisans, while accentuating the contrast with opponents. (Caprara & Zimbardo, 2004).

These results are particularly interesting to our purposes, in the light of the findings about how similarity can affect several social cognitive processes, eve at a neural level, from mentalizing (Jenkins, Macrae, & Mitchell, 2008; Mitchell et al., 2006) to empathy, (Cheon et al., 2011; Harada, Li, & Chiao, 2010; Hein, Silani, Preuschoff, Batson, & Singer, 2010; Mathur, Harada, Lipke, & Chiao, 2010) to motor resonance (Liuzza et al., In Press; Molnar-Szakacs et al., 2007).

To capitalize the knowledge provided by these findings, we asked participants rated themselves and separately each the four political characters on the Five Factors of personality (Energy/Extraversion, Agreeableness, Conscientiousness, Emotional stability, Openness) using a list of 25 adjectives (Caprara & Perugini, 1994). The list included five markers of: Energy/ Extraversion (happy, determined, dynamic, energetic, active); Agreeableness (cordial, generous, loyal, sincere, unselfish); Conscientiousness (efficient, scrupulous, precise, conscientious, diligent); Emotional stability (optimistic, self-confident, solid, relaxed, calm); and Intellect/Openness to experience (sharp, creative, innovative, modern, informed). The adjectives were selected from a larger list of adjectives that have previously been identified in the Italian lexicon as being among the most frequently used to describe human personality and also the most representative of each of the dimensions of the Big Five. Each adjective was rated for how characteristic it was of each target on a 1 ("not at all") to 5 ("very much so") scale. We measured the perceived personality similarity in personality traits with each character by adopting procedure used in other studies (Caprara & Vecchione, 2007)et al., 2007, (Vecchione, Gonzalez Castro, & caprara, In Press). We started computing the Euclidean distance between the ratings for the self and the four political characters for each item (e.g. the square root of the squared difference of item 1 referred to self and item 1 referred to Berlusconi). We obtained a normalized dissimilarity score by

summing the Euclidean distance of all the items and divided it for the maximum value (being 4 the maximum distance for each item, and having 25 items, we divided the sum for 100). This procedure allowed us to obtain a dissimilarity score between the voter and each politician. Dissimilarity scores of 1 and 0 indicate maximal difference and absence of difference, respectively. By subtracting the dissimilarity score from 1, we obtained the perceived similarity score which ranged from 0 (no similarity) to 1 (complete similarity). This score was entered in the correlation analyses. On the basis of accuracy results (for further details on results, see Appendix) we found that the stronger catching power of the in-group political character gaze on voters occurred only in the right-wing voters, who were influenced by Berlusconi and Vespa more than by Di Pietro and Prodi (see Figure 14).

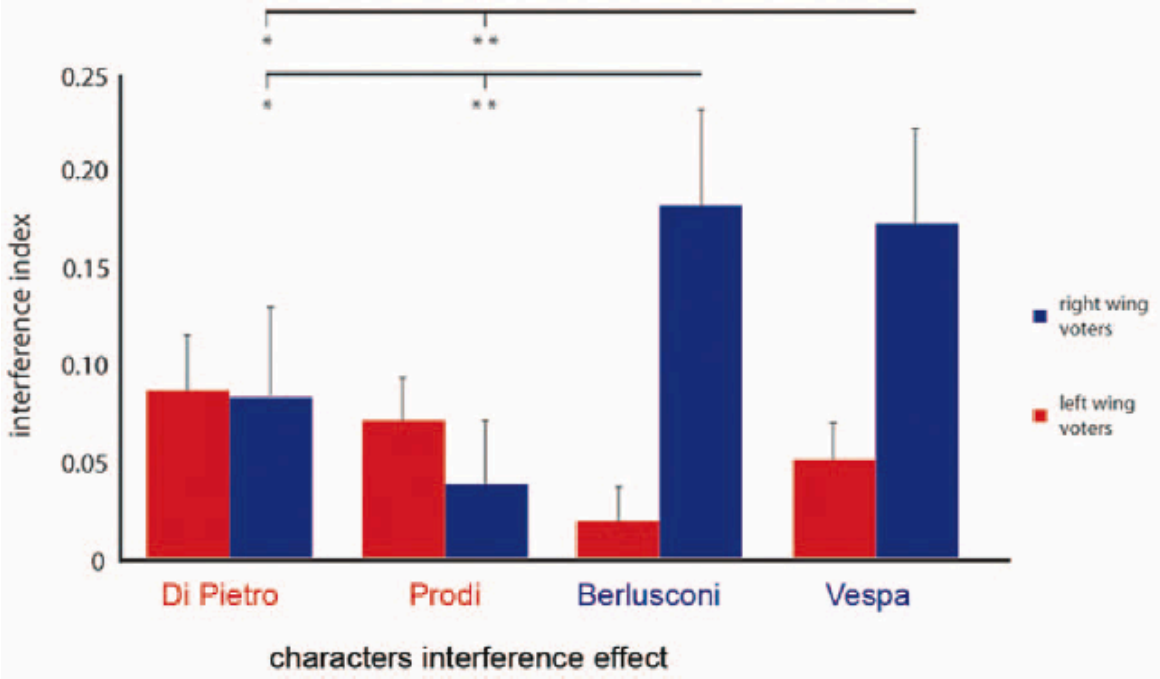

Figure 14. Influence of the political characters' gaze on the voters' oculomotor response. On the y axis is represented the interference index, deducted by the difference between the accuracy (percentage of correct responses) in congruent minus incongruent trials. Error bars represent Standard errors of mean (SEM). We reported significance (* = p <.05, ** = p<.01) only for the post-hoc comparisons between the characters' interference effect within the groups(Liuzza et al., 2011).

Interestingly, some out-group characters' gaze did not induce significant gaze following effects in right-wing voters (p =.24, for Prodi). On the other hand a lack of significant gaze following was found for Berlusconi's gaze left-wing

voters ($t(13)= 1.24$; $p = .23$). We ran the same analysis on the interference effect on RTs. In this case, all the characters induced a significant interference effect in both groups ($ts >.2.76$, $ps <.05$).

Even though these two characters have been judged as having a different media exposure and power in the political landscape (not surprisingly, since Berlusconi was the leader of the centre-right coalition and Prime minister in charge at the time of the experiment), they do not differ each other in their gaze interference power, suggesting that the result might have to deal more with the group affiliation than with the status. By contrast, no significant effects of in-group political characters' gaze were found in left-wing voters. A possible explanation of the difference between left-wing and right-wing voters may involve personality differences in in-group loyalty (Haidt & Graham, 2007).

Furthermore, conservatives are thought to be more sensitive to authoritarian figures and rely more on authority acceptance (Altemeyer, 1998; Haidt & Graham, 2007). It is thus possible that they followed the ruling group, more than simply the group they felt affiliated to. Since, at the time of data collection the center-right group was fundamentally ruling the country, this alternative explanation cannot be disregarded. Finally, the gaze interference effect exerted by the right wing leader was correlated to the voters' perceived similarity (see Figure 15), in keeping with the evidence that Berlusconi is the leader that mostly capitalized on the personalization of politics strategy that has characterized several modern democracy systems in recent years (Catellani & Corbetta, 2008).

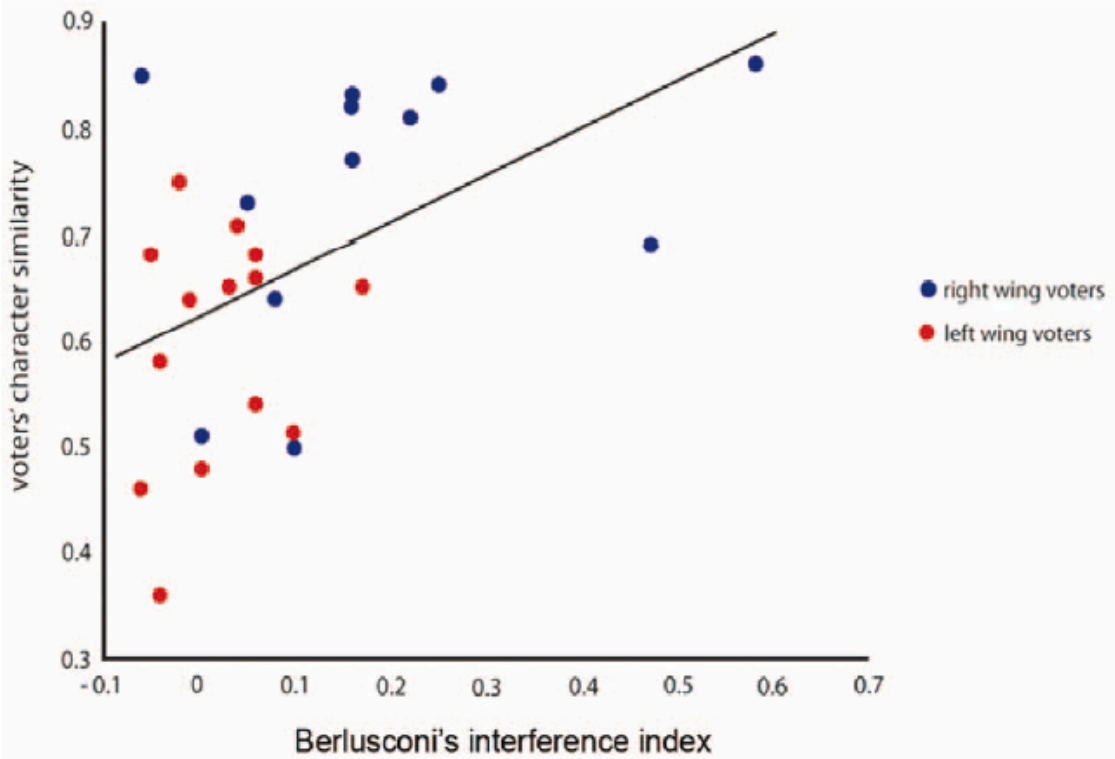

Figure 15. On the y axis, the similarity scores, ranging from 0 (not similar at all) to 1 (completely similar) computed as described in the Methods. On the x axis, the interference index deducted by the difference between the accuracy (percentage of correct responses) in congruent minus incongruent trials.

Unlike studies that investigated the behavioral and neural correlates affected by political variables by focusing on the dispositions of the participants, we demonstrate that a sophisticated blend of situational and dispositional factors underlies the capture of reflexive gaze following exerted on voters by the gaze of politicians.

5.4 Gaze following as an implicit measure

Implicit attitudes measurement techniques, even if not necessary unveil an attitude we are unaware of, can be defined as implicit to the extent the way they measure them is not under voluntarily control (Fazio & Olson, 2003). A variety of different implicit measurement techniques have been employed.
One such technique involves various priming procedures that have proven useful in the past as a mean of assessing what is activated from memory by the presentation of some attitude object (Fazio, Sanbonmatsu, Powell, &

Kardes, 1986; Gaertner & McLaughlin, 1983; Greenwald, Klinger, & Liu, 1989; Perdue, Dovidio, Gurtman, & Tyler, 1990). For example, Fazio et al. (1995) found that showing participants photos of black versus white undergraduates had a priming effect in facilitating or interfering with the judgment of the connotation of an evaluative adjective. This priming implicit measure doesn't differ so much by the probably best known one, the Implicit Association Test (IAT), developed by Greenwald et al. (Greenwald et al., 1998). IAT assesses the strength of an association between a target concept and an attribute dimension by considering the latency with which participants can employ two response keys when each has been assigned a dual meaning. The participants' task is to categorize stimuli as they appear on the screen. (See an example on Figure 16).

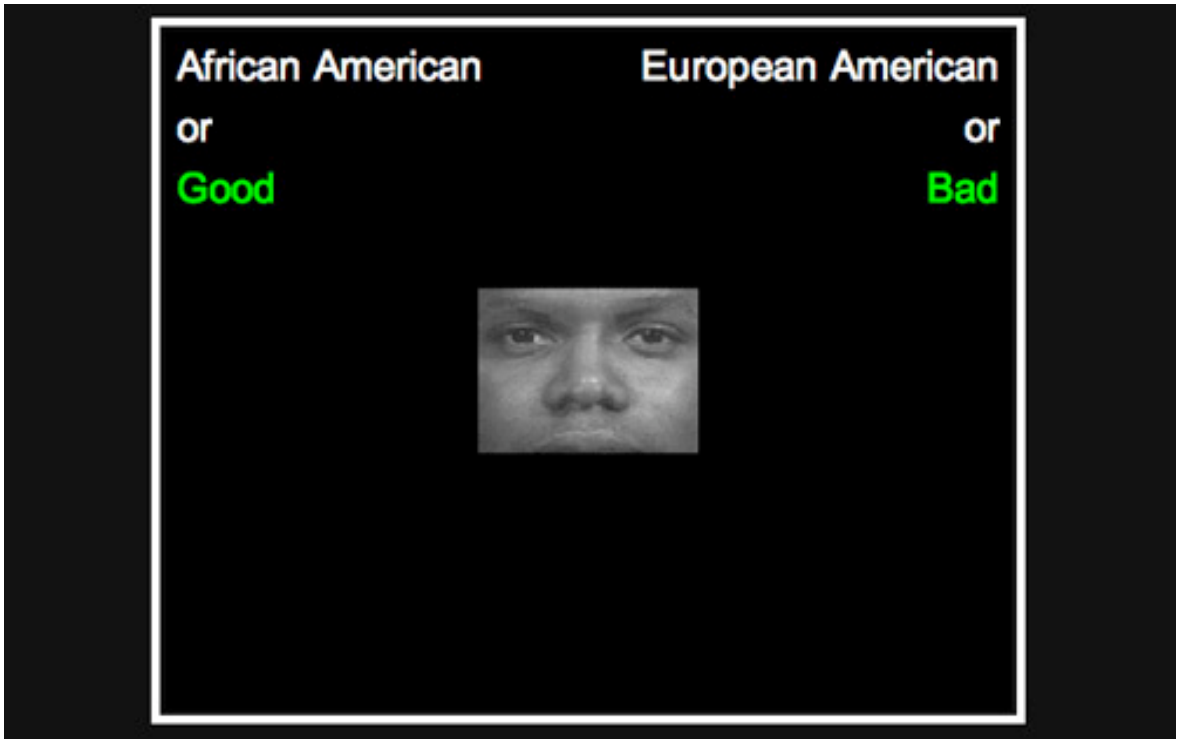

Figure 16. An example of a typical IAT trial in which subjects are required to press a button to categorize the stimulus as a member of the category African American OR as a good adjective (when it appears a word instead of a picture) and another button to categorize the stimulus as a member of the category European American OR a bad adjective.

For it's automatic nature that can potentially give some clue about the possible attitude toward a politicians (or at least our political similarity with

him/her), gaze-following behavior can be a good candidate to be a sort of embodied implicit measure (Fiske & Taylor, 2008).

In the following research, we relied on an our behavioral paradigm (Liuzza et al., 2011) to assess gaze following behavior of voters with respect to two Italian candidates (Emma Bonino and Renata Polverini) of the most important political coalitions (the center-left and the center-right) who ran for the governorship of the Lazio Region during the month that preceded the local elections (March 2009). Participants of the study also underwent to some explicit measures as their voting intentions, in order to assess the extent to which the gaze following effect is predictive of voters' proneness toward one of the two candidates. In particular, we predicted that the more voters tend to follow the gaze of a given candidate, the more they are likely to vote for her. We also measured participants' implicit attitudes toward the two candidates, using the IAT, a measure that has already shown to predict election outcomes (Arcuri, Castelli, Galdi, Zogmaister, & Amadori, 2008). We predicted that both these measures have incremental validity over each other in predicting the likelihood to vote for one of the two candidates.

In this case, Fifty-four participants took part in both the gaze-following paradigm and the IAT.

The most important result of this study is represented by the fact that an automatic behavior as the gaze-following vehicles important cues about the preference toward a group or a single politician. This result, compared with the one relative to a well-known implicit measure as the IAT, is particularly striking, since the gaze following is a behavior apparently independent by the association between the semantic representation of a group or of a single person and an emotional valence. To rule out that a significant part of the predictability of the gaze-following behavior can be explained by the strength of this semantic-affective link measured by the IAT (Fazio & Olson, 2003), we entered both these measures in a multiple regression analysis. The results (see Figure 17) showed that the gaze behavior effect remained significant even after an implicit measure of attitudes toward the candidates had been partialled out.

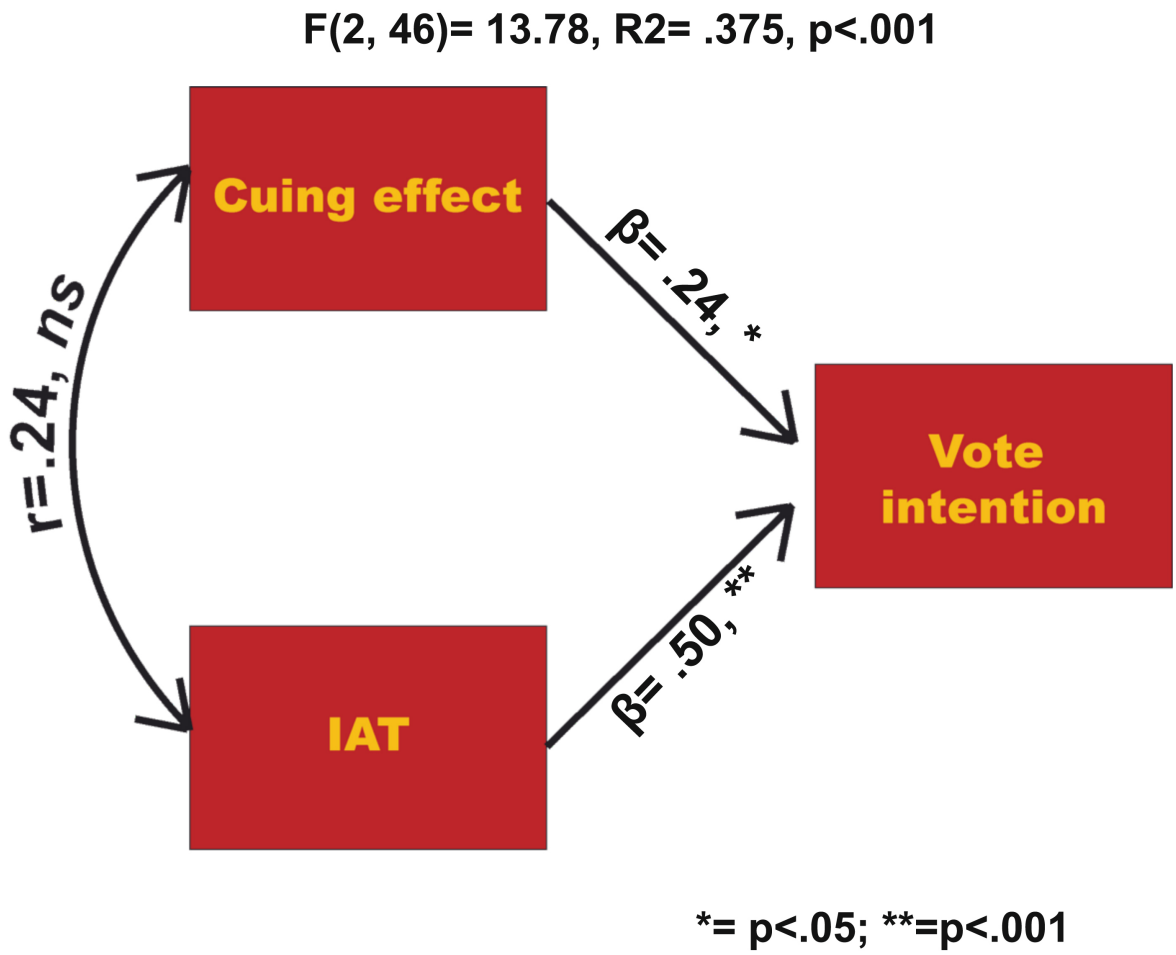

Figure 17. Relationship between the strength participants followed the gaze of one candidate compared to the other and the IAT (in Pearson's *r*) and their independent strength (in Beta) in predicting voting intention.

The implicit attitudes itself has also a unique contribution, coherently with results from previous studies (Arcuri et al., 2008). Not surprisingly, the IAT has a stronger predictability (R^2=.32) than the gaze following effect since, as underlined by Fazio and Olson (Fazio & Olson, 2003), it can be only partially be considered implicit because the subjects can be aware of what is measured, even though the way in which is measured is indirect. Even though the variance explained by the gaze-following behavior toward the two candidates is smaller (R^2=.06), it represents an original contribution because, to our knowledge, this is the first study which uses an automatic oculomotor behavior to predict voting intention.

5.5 The neural correlates of the gaze-following modulation by political similarity

Our first behavioral study on this topic suggested us that gaze following behavior can be modulated at least by a sort of political similarity that underlies the quick identification of a member of a political group as an in-group or an out-group. This act of categorization may be made consciously or unconsciously (Perdue et al., 1990).

Anyway, once established the outcome behavior, still little is known about the process, which causes, or at least is related to, this behavior. A huge debate has raised o the effective utility in looking at the neural correlates of certain behaviors and processes in order to unveil ho d these processes really work. (Legrenzi & Umiltà, 2009). Critics of this so called "neuromaniac" approach that distinguishes especially the social neurosciences, claim that results like the ones provided by correlational techniques based on subtractive methods like fMRI are, in the best of the hypotheses, redundant. On the other side, other authors (Cacioppo & Visser, 2003; Cacioppo & Decety, 2011) consider the use of neuroimaging techniques as useful to unveil subcomponents of processes that could not be observed at a mere behavioral level.

In the case of our study, for instance, a lot of issue would remain open if not addressed through a neuro-imaging technique, which would allow us to open the "black box".

In the behavioral study, no one of the explicit measures (which encompassed familiarity, emotions and hierarchical status) provided us any clue about which are the processes that may underlie the effect we found.

First of all, it would be interesting to assess if the gaze-following network found in a previous study (Cazzato et al., 2011), would the same for the incongruent minus congruent condition between the two groups. Indeed, if the hypothesis of Amodio and colleagues of a stronger activity of ACC in monitoring a conflict in liberals (2007), we should find this area included in left-wing but not right-wing participants or, if present in both, a stronger activation in the former group than in the latter when performing an analysis on ACC as Region of interest (ROI).

Also, it would be interesting to note if the region, which is supposed to exert the final control on the saccadic behavior (i.e. FEF) reflects the different behavior for the in-group vs. the out-group participants.

If a difference in within the basic neural network subserving the gaze-following behavior was found, the data provided by neuro-imaging technique may be useful in providing us some more clue about which cognitive, affective or social process would modulate it.

We suspect that similarity and affiliation may play an important role. We know that intergroup processing affects a huge amount of social processes and their correlates, from social perception to empathy and mind reading in general (see Amodio, 2008 for a review). At a very basic level, the simple perception of an in-group member, compared to an out-group. For example, Hart and colleagues (Hart et al., 2000) showed by fMRI that amygdala reacts more to racial out-group than in-group faces. Anyway, this result is the outcome of a second presentation of the stimulus, so has to be interpreted more to a stronger bilateral amygdala adaptation to the in-group faces than for the out-group. Golby and colleagues (2001) found individually defined FFA regions in 19 subjects as reacting more to in-group than to the out-group.

Another putative process that may underlie our behavioral findings can be linked to dominance. Even if the ratings about the questionnaire about the influence of each politician on the political landscape didn't correlate to the strength of the gaze following behavior, it can be that, being all the stimuli pretty much powerful in the political landscape, the explicit judgment would not have been sensitive enough. Neural activation differences can, instead, provide some cue, even if should be always taken very cautiously, about the possible involvement of hierarchy processing. Indeed, there's some evidence in the processes that may subserve hierarchy dominance (see Chiao, 2010 for a review). Studies on patients with brain within the ventromedial prefrontal cortex, for example show deficits in arrange of socio-emotional tasks, but have an intact social status recognition (Karafin, Tranel, & Adolphs, 2004). Other neuroimaging studies reveal a distinct network of brain regions associated with social status inference which encompass the inferior parietal lobe (IPL), dorsolateral and ventrolateral prefrontal cortices (DLPFC and VLPFC), and portions of occipito-temporal lobe (OG), including fusiform and

Lingual Gyri (Chiao et al., 2009; Marsh, Blair, Jones, Soliman, & Blair, 2009; Zink et al., 2008).

To explore these hypotheses, we (Cazzato, Mancuso, Liuzza, Caprara and Aglioti, in prep, see Annex) first divided 28 participants in two groups, left-wing (N=14) and right-wing (N=14), on the basis of a questionnaire in which they reported their political orientation and their voting behavior, as in Liuzza et al.(2011). Procedure was the same one used in Liuzza et al. (2011). The stimuli slightly differed because this time we wanted to better control, beyond the difference between in-group and out-group, the difference between politicians and non-politicians, to better address if an effect related to the belonging to political world which supposedly may boost the perceived dominance and/or similarity). So, we selected the following stimuli: Silvio Berlusconi (right-wing political leader), Bruno Vespa (right-wing opinion-maker), Pier Luigi Bersani (left-wing political leader) and Giovanni Floris (left-wing opinion-maker).

In this study, accuracy data failed to give significant results. This is probably due to the fact that, for methodological reasons concerning data analysis in fMRI (see Appendix for more details), before starting the fMRI acquisition each participant was asked to perform outside the scanner a training task in which they had to learn with 100% accuracy on 48 consecutive trials. So, the most critical dependent variable, i.e. accuracy, was minimized. So, participants didn't show a clear behavioural result, if not just in the first functional session, and only for the inverse efficiency, a composite measure, which accounts both for reaction times and accuracy, as explained in the paper in Appendix. Anyway, we were interested to check if even in front of a lack of behavioural findings, we could neural markers for the bigger effort in inhibiting gaze following for in-group compared to out-group. The contrast for the main effect of congruency showed the expected network found in previous experiments (see Fig. 18).

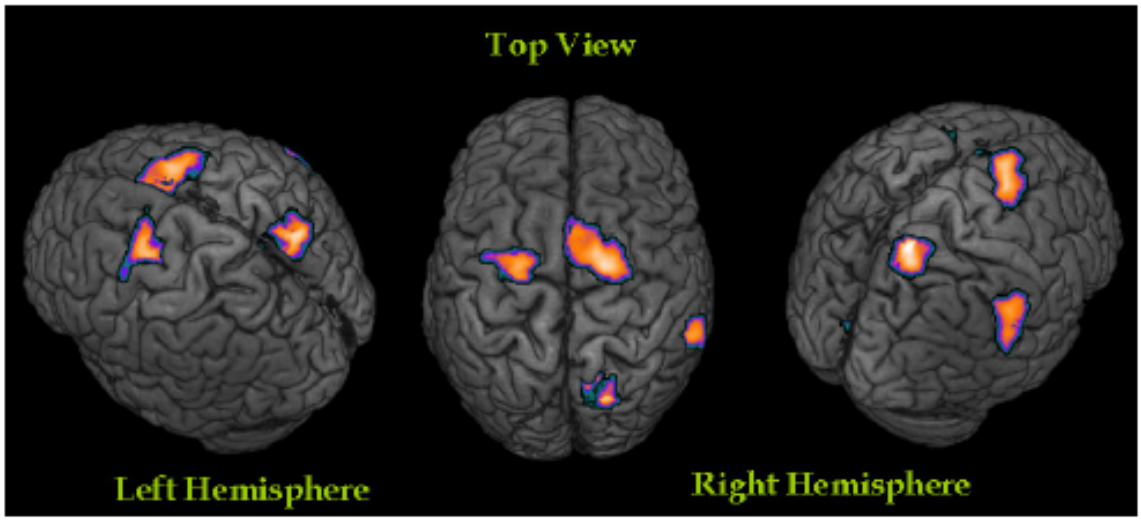

Figure 18. Main effect of congruency, i.e. Interference effect (IE). Clusters showing higher activity in the incongruent than congruent condition irrespective of observed-faces and political affiliation of voters are rendered on 3-dimensional (3D) views of the SPM template.

This contrast revealed the activation of dorsal and central attentional fronto-parietal networks. The regions included the Middle Frontal Gyrus (MFG) i.e. the Frontal Eye Fields (FEF) bilaterally, and posterior parietal regions as the right Superior Parietal Lobule (SPL) and bilateral Precuneus. Frontal regions also included the Superior Frontal Gyrus (SFG), the Supplementary Motor Area (SMA) extending to the middle portion of the Cingulate Cortex in the right hemisphere and left Insula. Furthermore, right parietal portion included Supramarginal Gyrus (SMG) extending to Superior Temporal Sulcus (STS). Finally, a wide cluster in bilateral occipital areas spreading bilaterally from the Calcarine Scissure to the Lingual Gyri was also activated. These regions were used as regions of interest to assess any differential influence of distracter/instruction signal incongruence on the brain responses (SPM thresholds are set to p(FWE-*corr)* = 0.05 at voxel level).

As predicted, left FEF activation mirrored the political similarity between voters and politicians (see Figure 19).

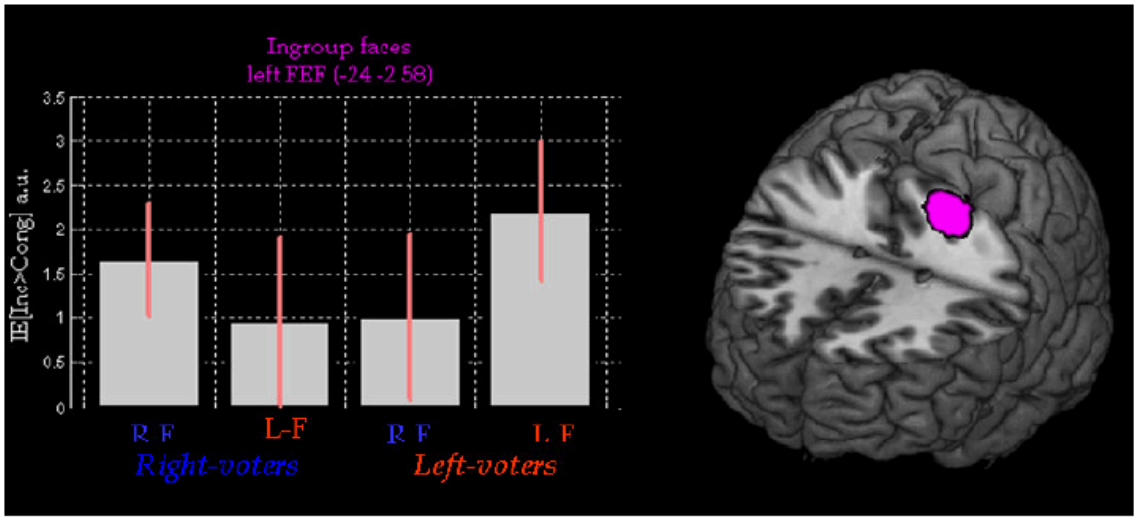

Figure 19. The relative plot shows the mean Interference Effect [IE(inc<cong)] of the Right- and Left-wing Faces in Right- and Left-wing participants. A significant interaction was observed in this ROI: Right-wing In-group faces [R-F = Right-wing Faces] interfered on shifts of attention more than the Out-group Left-wing faces [L-F = Left-wing faces] distracter. Exactly the opposite pattern was found for Left-wing voters. The level of activation is expressed in arbitrary units (error bars: ±90%confidence interval).

This means that, even though behaviorally opaque, the effect is at play at a neural level: stronger activation of FEF may reflect, indeed, a stronger effort in inhibiting the reflexive oculomotor imitation. Also, the fact that FEF is more strongly activated in left-wing voters may suggest that these voters don't show a behavioral effect only because the neural mechanism of inhibiting an automatic behavior is more efficient in liberals, as suggested even by the higher N2P and ERN amplitudes found by Amodio and colleagues (2007) in liberals than conservatives which paralleled also a more accurate behavior.

In order to understand the possible processes, which modulated gaze following in a politically congruent manner, we performed analysis on the simple face observation. The main effect of face observation (incongruent and congruent conditions collapsed) activated a wide network (see Figure 20) which encompasses, among the others, Inferior Occipital Gyri (which includes occipital Face Area, OFA) bilaterally, areas falling within the frontal lobe, (Precentral and Middle Frontal Gyri), and within the parietal cortex (Superior Parietal Cortex, bilaterally and the left Inferior Parietal Lobe).

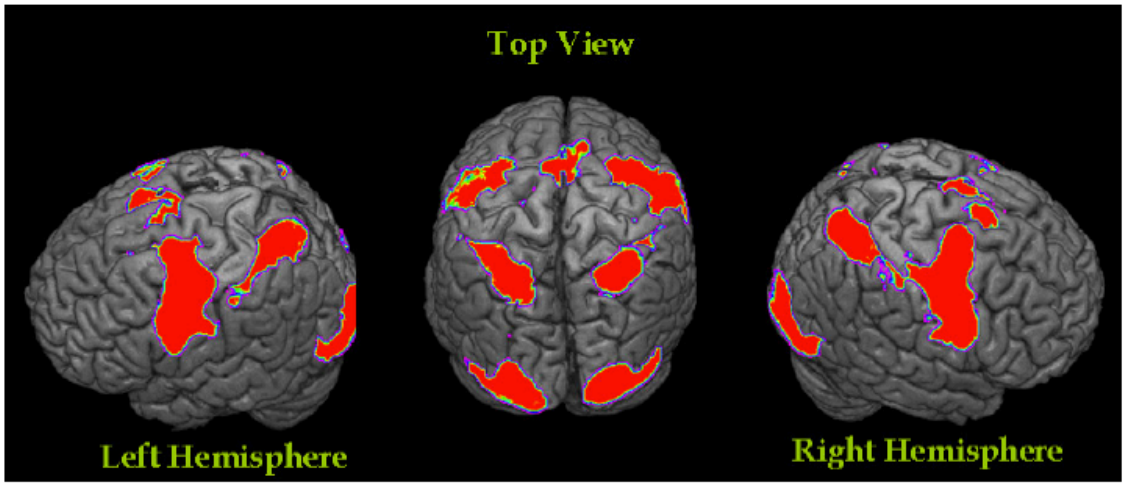

Figure 20. Clusters showing higher activity in the incongruent plus congruent condition irrespective of observed-faces and political affiliation of voters are rendered on 3-dimensional (3D) views of the SPM template.

These regions were used as regions of interest to assess any interaction between the observations of character according to the same or different political affiliation. (SPM thresholds are set to *p*(FWE-*corr*) = 0.05 at voxel level).

Interestingly, in right wing voters, faces evoked a higher activation in left Superior Parietal Lobe for politicians versus Opinion makers (see figure 21)

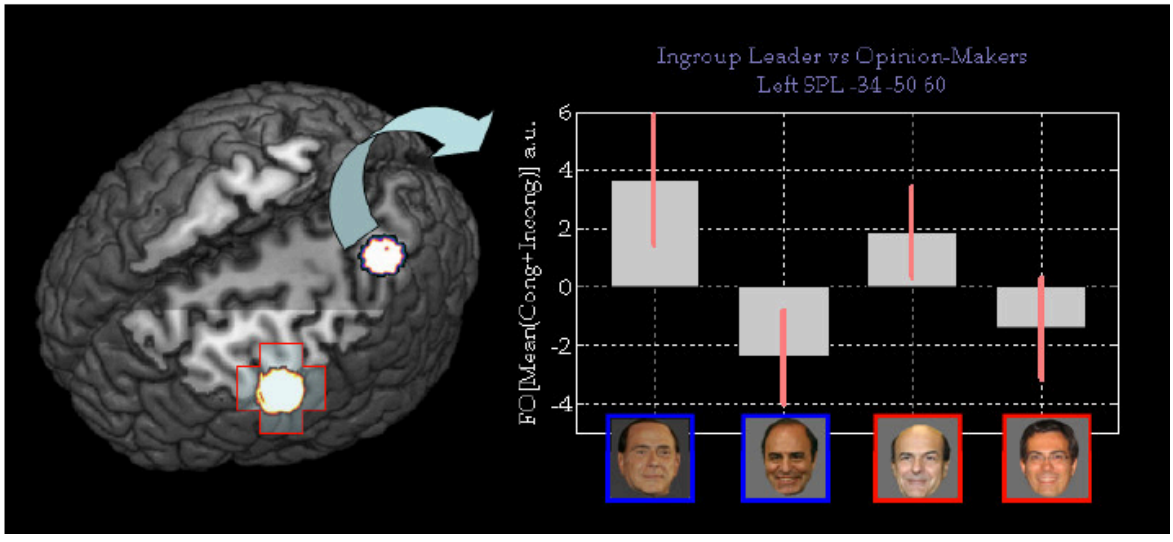

Figure 21. Brain responses in left Superior Parietal Lobe elicited by the "Observation" of Ingroup and Outgroup Faces only in Right-wing voters. Observation effect of the Right- and Left-wing Faces in Right-wing Participants only for Left SPL (MNI coordinates: -34, -54, -60). We depicted a "cross" on Left Precentral Gyrus to indicate no significant modulation for this area. A significant interaction was observed in L SPL ROI: Right-wing In-group faces enhanced greater FO effect more than Out-group left-wing faces.

Interestingly, this effect was also specific and greater for Right-wing Leader Berlusconi than In-group Opinion-maker and Out-group Faces. The level of activation is expressed in arbitrary units (a.u., ±90% confidence interval).

These results are striking if we consider that this area has been found involved in social status hierarchy inferences in humans(Chiao et al., 2009). His finding suggest that, even if at an explicit level stimuli weren't considered different, the implicit hierarchy evaluation may differ, at least in right-wingers. The fact that the result is confined to these subjects is very consistent with he hypothesis that people endorsing conservative values are more sensitive to authority.

So, by using a neuro imaging technique, we were able to extent our findings and our knowledge about the modulation of a very automatic gaze-following process by higher level social cognitive dimensions. Also these data gave us some clue that different dispositions underlying ideological differences are reflected by differential neural processing of authority ranking, one of the most important forms of human sociality (Fiske, 1992).

6. A broader view

6.1 Participants dispositions

In all the studies presented here - and in other studies in progress - we collected the subjects self-rated personality traits by using a list of 25 adjectives (Caprara & Perugini, 1994) that included five markers of: Energy/ Extraversion, Agreeableness; Conscientiousness; Emotional stability and Intellect/Openness to experience. Previous studies on behavior showed gender differences and autistic-trait differences in reflexive social attention (Bayliss et al., 2005; Bayliss & Tipper, 2005). According to these findings it may be speculated that Agreeableness may be correlated to gaze following, since this trait can be conceptually assimilated to and strongly correlates with empathizing (Nettle & Liddle, 2008). Also, other studies have shown that individuals with high AQ scores tend to score low on the traits of extraversion and agreeableness and high on the trait of neuroticism (Austin, 2005; Wakabayashi, Baron-Cohen, & Wheelwright, 2006). There's some evidence that even extraversion may be, even if more weakly, related to empathizing, so we would expect even a contribution from this trait to gaze-following behavior. To my knowledge, nobody has addressed how personality traits, as measured by the five factors model affect gaze-following behavior. Especially for the case of Agreeableness and Extraversion, this data can be important in linking this behavior to the development of social cognitive skills.

Another study addressed a different relationship between personality and gaze cuing, i.e., how the predictability of one's gaze can affect our perception of the personality. Indeed, Bayliss and Tipper (2006), performed a gaze cuing experiment in which some faces never shifted the gaze in a predictive manner. They found that faces whose gaze never indicated the target location were judged as being less trustworthy than were faces exhibiting cooperative gaze behavior. The processes underlying the encoding of facial identity and the formation of person impressions from the face are dissociable: evaluation of trustworthiness is not unpaired in prosopagnosic patients (Todorov & Duchaine, 2008), which suggests even a subcortical processing of this dimension (Johnson, 2005). Also, trait judgment appears within the 100ms of exposure and can predict election outcomes (Chiao, Bowman, Gill, & Santos, 2008; Olivola & Todorov, 2010; Todorov, 2005). The rapidity of this

process makes it very likely to modulate a fast process as the reflexive social attention. Some preliminary evidence came from a study in which the perceived dominance of a face was manipulated (Jones et al., 2010) and was found that dominant faces (e.g. male masculinized male) cause greater gaze cuing than non dominant ones.

Beyond the Fig Five related adjectives questionnaires, all the considered subjects (with the exception of sub-sample of 26 American participants) fulfilled self-reported political orientation. The final sample included a total of 175 subjects.

A first correlational analysis to check the relationship between personality traits and ideology revealed that, as predictable, Openness correlated with liberalism (N=175, r = .19, p = .01). This result, indeed, replicates pretty much previous findings (Ekehammar & Akrami, 2007; Ekehammar, Akrami, Gylje, & Zakrisson, 2004; McCrae, 1996). Unexpectedly, Emotional stability (the inverse of Neuroticism), correlated with conservative ideology (N= 175, r=.23, p=.001). This result may be surprising on the light that an aforementioned review by Koleva & Rip (2009) reported conservatism as endorsed more frequently by people with an insecure attachment style. Also, as reported by the study from Oxley and colleagues (2008), conservative attitudes seem to be related to fear. Anyway, a recent survey, whose results are available online, seem to suggest similar patterns (one from the Pew Research Center, available online: http://pewresearch.org/pubs/301/are-we-happy-yet).

This survey reports, indeed, that Republican voters usually report a higher level of happiness. Carney and colleagues, who found neuroticism correlating with liberalism, found a similar result also. A study from Napier & Jost (2008) specifically addressed this effect. Specifically, in three studies using nationally representative data from the United States and nine additional countries, they not only found that conservatism is indeed associated to greater subjective well being, but also that the relation between political orientation and subjective well-being is mediated by the rationalization of inequality rather than a cognitive motive like need for cognition. A third study showed that increasing economic inequality (as measured by the Gini index) from 1974 to 2004 has exacerbated the happiness gap between liberals and conservatives, apparently because conservatives (more than liberals)

possess an ideological buffer against the negative hedonic effects of economic inequality. Future studies may be needed to unveil to which extent this hypothesis would be experimentally testable, providing a causal, rather than merely correlational, explanation.

We entered all the individual differences (which can be clustered in demographic, traits and ideology) in a forward model multiple regression with gender and age as demographic variables, the five personality dimension measured by the 25adjectives (Extraversion, Agreeableness, Conscientiousness, Openness and Emotional Stability) and the self-reported ideology. The model that better predicted the gaze following (R^2= .03, F(2, 534)=8.30, p < .001) included the political orientation (β = .10, t = 2.26, p = .02) and, importantly, subjects Agreeableness (ß = .14, t = 3.32, p = .001). The result on Agreeableness confirms our hypothesis that, agreeableness, being an dimension which is closely connected to empathizing system (Nettle, 2010) whose dysfunction, along with high systemizing, contribute to the understanding of autistic traits and to their links to gender differences (Baron-Cohen, Richler, Bisarya, Gurunathan, & Wheelwright, 2003). The result about orientation, independently from the kind of stimulus, can either be interpreted as a lack of conflict monitoring in conservatives as well as a higher social sensitivity related to an higher endorsement of community principles as in-group loyalty and authority acceptance. Unfortunately, we haven't used measures that addressed the endorsement of these moral principles. Anyway, with the exception of a smaller American sample, all the other samples fulfilled the Right-Wing authoritarianism scale (Altemeyer, 1998), which measures also authority acceptance and conventionalism, which can be related to the two community related principles. A forward multiple regression on this sub-sample of subjects, with RWA as further predictor, indeed, revealed a predictive model (R^2 = .04, F(2, 404) = 7.70, p = .001) in RWA (β = .13, t = 2.58, p = .01), but not political orientation *per se*, strongly predicts gaze-following behavior, along with Agreeableness (β = .14, t = 2.92, p < .005). This result suggests the hypothesis that the endorsement of certain moral principles seems to play a role that may be later reflected in a behavioral worse performance in this task. Anyway, this hypothesis has to be tested further with stimuli which may be a good control in terms of hierarchy,

since all of the stimuli used, belong to powerful people within the Italian and American societies.

6.2 Stimuli low-level features

Following stimuli were used in studies not reported above: Umberto Bossi (right-wing leader of La Lega), Jerry Scotti (an Italian showman) Hillary and Bill Clinton (two democratic party US politicians), John McCain and Sarah Palin (two conservative US politicians).

Each of the stimuli received the ratings described above on several dimensions (emotions, influence, exposure). Also, for each face (except for Bossi), we collected data from two samples of independent Italian and American raters (N=12, N=16 respectively) who rated how each one of the American and Italian stimuli respectively evoked gut instinct judgment of Dominance, Trustworthiness, Competence and Approachability on a Likert 1 to 5 scales.

Rating in each dimension for each stimulus (See Table 1) was inserted as predictor for the dependent variable (gaze following behavior).

	dom	**com**	**app**	**tru**
Berlusconi	3.69	3.31	3.00	2.75
Vespa	4.38	2.94	1.75	2.31
Di Pietro	3.25	2.88	2.94	2.69
Prodi	3.19	3.69	3.00	3.31
Bonino	2.75	3.44	4.00	3.63
Polverini	2.56	3.13	3.75	3.38
Bersani	3.63	3.50	2.38	2.69
Floris	2.31	3.13	3.38	3.13
Clinton B	3.25	2.83	2.67	2.33
Clinton H	3.75	3.08	2.58	2.33
McCain	3.08	2.50	2.50	2.42
Palin	2.58	2.17	2.17	2.33

Table 1. Mean ratings from an independent sample on the perceived traits of each face in each of the dimensions of interest on a I to 5 Likert scale (dom=dominance, com=competence, app=approachability, tru=trustworthiness).

These variables were inserted in a forward multiple regression model, which revealed a significant model ($R^2 = .04$, $F(2, 506) = 11.94$, $p < .001$) in which dominance ($\beta = .17$, $t = 3.12$, $p < .005$) and trustworthiness ($\beta = .27$, $t = 4.89$, $p < .001$) are the best predictors. These influence of dominance in gaze following behavior is a further demonstration that people are highly sensitive to individuals whose low level facial features cue dominance (Jones et al., 2010), as it happens with non-human primates (Shepherd et al., 2006). The finding about perceived trustworthiness is not only even stronger, but is quite new in the literature either on motor resonance, reflexive social attention and gaze following.

The evaluation of trustworthiness from emotionally neutral faces engages the amygdala (Todorov & Engell, 2008), a subcortical brain region critical for the evaluation of novel stimuli (Davis & Whalen, 2001; Phelps & LeDoux, 2005; Vuilleumier, 2005). Crucially to interpret our data in a prior study from Engell and colleagues (2007), participants were presented with blocks of novel faces and asked after each block to indicate whether a test face was presented in the block. Although this task did not demand explicit evaluation of the faces, activation in the amygdala changed as a function of the trustworthiness of the faces, as assessed by judgments of a group of participants different from the participants in the fMRI study. The judgment of trustworthiness, also, seems to rely on a subcortical pathway of face processing as shown in a study with prosopagnosic patients who even if unable to explicitly recognize faces, provided trustworthiness ratings very similar to the ones provided by a control group (Todorov & Duchaine, 2008).

This neuroimaging data are coherent with the speed of the trustworthiness judgments, which have shown to happen within the first 100ms (Willis & Todorov, 2006), or even 38ms (Bar, Neta, & Linz, 2006). The time course and the structures involved make the trait inferences processes a good candidate to modulate a fast process as gaze following and reflexive social attention which, also, are supposed to rely on a subcortical pathway (Klein, Shepherd, & Platt, 2009).

The relation between perceived trustworthiness and gaze following as well as the relation between dispositional agreeableness and gaze-following converge to suggest the function of gaze following as a social skill that's particularly important to a species like humans, who are at the same time the most cooperative among the primates (Tomasello, 2009) and have the eye morphology which seems to be shaped by this strong need to cooperate (Kobayashi & Kohshima, 2001).

Anyway, these findings have a strong limitation because some of the stimuli (especially Hillary and Bill Clinton) were rated by a sample that in its most part (more than 50%) knew them and so may have not answered on a basis of purely gut instinctive basis. Also, we lack of similar ratings for other two stimuli, Umberto Bossi and Jerry Scotti.

6.3 Stimuli high-level features

Finally, we performed an analysis on the high-level features of the stimuli and their interaction with similar features of the participants. Which is, actually, the main hypothesis that informed all the present line of research. To this purpose, we coded both the stimuli and the voters according to their broad political affiliation (0=liberals, 1=conservatives, centrist and independents were not coded at all) and entered them as fixed factors data in a Univariate Analysis of Variance. The analysis revealed a significant effect ($F(1, 516) = 12.06$, $p < .001$) of the voters' group (which parallels the finding that conservatives follow the gaze of politicians more than liberals), a main effect of the stimulus ideology which approaches significance ($F(1, 516) = 3.66$, $p = .056$) and the crucial interaction between participants affiliation and stimuli affiliation which approaches significance as well ($F(1, 516) = 3.53$, $p = .06$).

To check if other high order stimuli perception processes influenced the data, we inserted media exposure as a covariate, since familiarity has showed to strengthen reflexive social attention (Deaner et al., 2007). Importantly, once added this covariate, the main effect of stimulus orientation ($F(1, 512) = 4.11$, $p = .04$) , as well as the crucial interaction ($F(1, 512) = 4.11$, $p < .05$), reached significance.

Since low level features which drive traits inferences and participants agreeableness also predict the gaze-following behavior, we repeated the Univariate analysis of variance with agreeableness, inferred trustworthiness and dominance as covariate and, still, we found the crucial interaction significant ($F(1,493)= 4.07$, $p = .04$, see Figure 22).

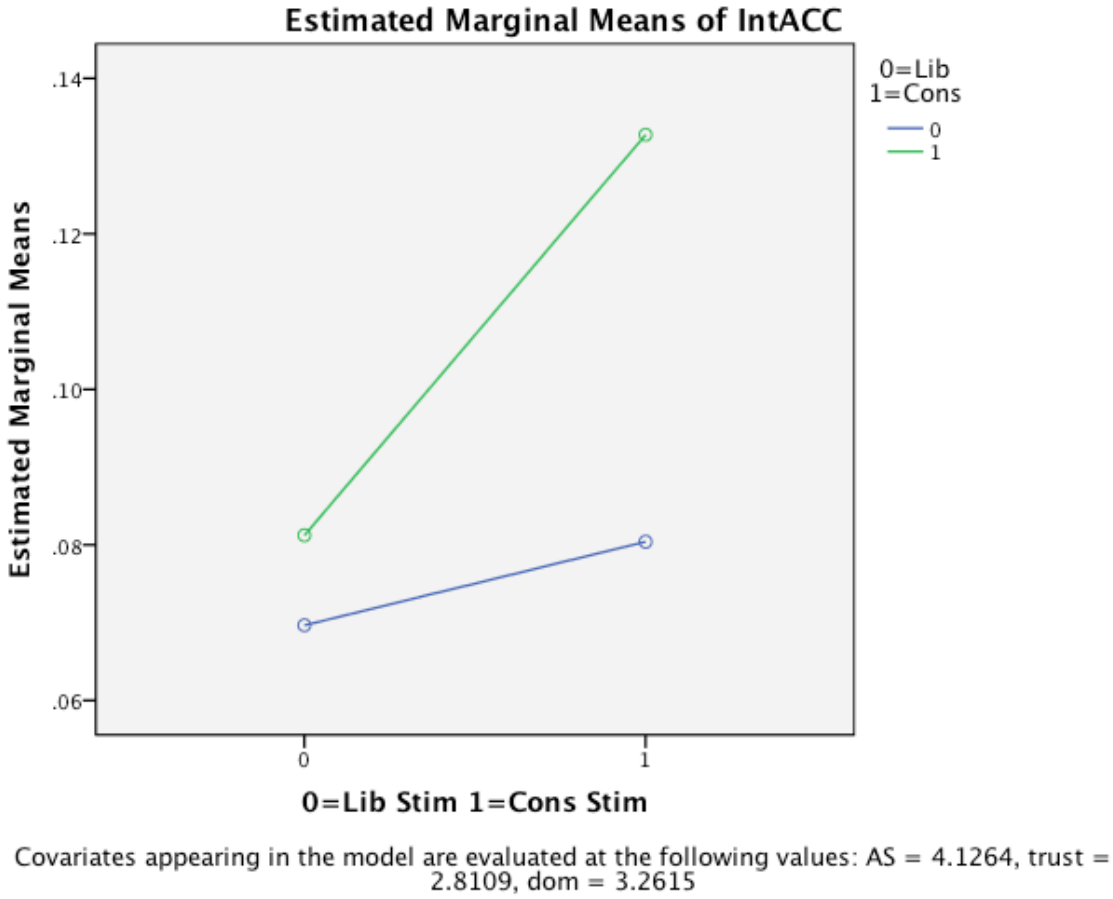

Figure 22. After controlling for agreeableness (AS), inferred trustworthiness (trust) and inferred dominance (dom), the crucial interaction between participants political affiliation and stimuli political affiliation has been found to be significant. This interaction is explained by the fact that conservative voters (green line) are more distracted by conservative characters (1) then liberal characters (0). Also, the magnitude of the interference of conservative characters on conservative participants is higher then the interference of the same characters on liberals.

Post-hoc T-Test revealed that, while liberals didn't show any difference in gaze following toward conservative vs. liberal faces ($t(304)= -.03$, $p = .97$), the difference is significant within the conservative sample ($t(209)= -2.25$, $p=.03$).

Also, conservative stimuli interfered to conservatives' task performance more than to liberals' task performance (t(264)= -3.74, *p* <.001). All of these values differed significantly from zero (*t*s > 6.9, *p*s < .001), meaning that all of the political groups of distractors evoked a significant gaze-following effect in all of the political groups of participants. It means that these findings don't replicate the lack of gaze following found in high status monkeys when attending at lower status ones (Shepherd et al. 2006), even though in a single study ran in Verona (Italy) among political activists and local politicians from the PD (Democratic Party, centre-left), PDL (People-s Freedom Party, centre-right) and Lega Nord (extremely right-wing), it emerged that left-wingers don't follow the gaze of right-wingers leaders (Berlusconi from PDL and Bossi from Lega) significantly (t(15) = 1.66, p >.1). Curiously, in the US, conservative participants didn't show a gaze following effect at all, (*t*s < 1.6, *p*s > .1), bit this result can be due to the small sample size (N=8).

Finally, I entered all the variables which have shown to significantly predict the gaze-following behavior in a unique hierarchical regression model in which, at each step, I entered different clusters of determinants (individual differences, low-level stimuli features, high level stimuli features in interaction with the same).

Model	**R2**	**Change Statistics**			
		ΔR^2	ΔF	df1	df	*p* of ΔF
Individual differences (A, RWA)	0.037	0.037	7.21	2	376	0.001
Inferred traits (dom, tru)	0.077	0.04	8.04	2	374	< .001
Political similarity (OrStim, OrStimXOrVot)	0.092	0.016	3.21	2	372	0.041

Table 2. Change statistics from the hierarchical regression model (A=Agreeableness, RWA= Right wing authoritarianism, dom= inferred dominance, tru=inferred

trustworthiness, OrStim= political affiliation of the stimulus, OrVot=political affiliation of the voters) participants' ones).

As evident from the Table2, the main contribution to this behavior is provided by individual differences and inferred traits. The contribution of individual differences is also linked to ideology, since it includes RWA, along with a personality trait linked to pro-sociality as Agreeableness. A huge contribution is provided also, by low-level features which drive our impression formation about the personality of people. Also, this finding is not completely surprising since these dimensions can have an adaptive function since trustworthiness judgment is crucial for a cooperative animal like us and dominance inference is still important in a social animal that, even if more motivated to achieve equality (Bohem, 1999), still relies on less or more pronounced hierarchies in his society.

What overall analysis confirms is that, controlling for familiarity, the interaction of high-order dimensions as our social identity and the social identity of conspecifics in a complex domain as politics poorly relies on physical features and has a nature which is mostly semantic-affective (unlike other more basic social identity as race, ethnicity, gender or age). It is important to notice that, even if one possible limitation of the studies taken alone can be that they are limited to few stimuli, the final analysis includes 12 different stimuli (14 when inferred traits are not taken in account), which is a sample that may be considered more reliable in order to infer conclusions about the mechanism under investigation.

7. A gaze to the future

7.1 Gaze following behavior as an implicit measure

An interesting result we found in the experiment ran during the local elections campaign points to two possible important related characteristics of this process: its capability to be, at least partially, predictive of voting intention and it's likelihood to not only change, but eventually precede changes in explicit attitudes this process may be linked to.

The first suggestion can be addressed in a setting similar to the one used by Todorov and colleagues (2005). In this study, authors asked naive participants to evaluate candidates for the U.S. Senate (2000, 2002, and 2004) and House (2002 and 2004) on competence and found that the candidate who was perceived as more competent won in 71.6% of the Senate races and in 66.8% of the House races. Inferences of competence not only predicted the winner but also were linearly related to the margin of victory. We could show subjects candidates who competed each other (for instance second turn competitors for city mayor elections and assess if the stronger gaze following behavior for one compared to the other a) predicts the real outcome of the previous elections (of course, participants should not know neither the identity nor the political affiliation of the candidate and also) b) predicts their own vote in a simulated election. Inferred trait judgment may be useful to assess which inferred trait would eventually mediate this effect.

IAT has been found to predict formation of attitudes in undecided participants which had to vote on the enlargement of a U.S. military base in Vicenza (Galdi, Arcuri, & Gawronski, 2008). Indeed, they found implicit association predicted their future choice better than explicit ones in undecided (but not in decided) participants. Moreover, being both implicit and explicit attitudes taken at two different times, authors showed how the former predicted change in the latter in the undecided sample but not in the decided one. Analogically, it would be measured gaze following toward some

candidate in undecided voter and check if this behavior predicts future voting behavior in a similar vein.

7.2 The role of dominance and similarity in gaze-following and politics

As pointed out in different experiments, the real nature of the processes underlying our results are still to be provided, even if the results on the neural correlates gave us some clue.

Research on gaze direction and face processing has traditionally suggested that these two processes are independent by means of both behavioral (Frischen & Tipper, 2004) and anatomo-functional evidences (Hoffman & Haxby, 2000).

Despite of this previous evidence some of the most recent findings are showing that identity processing should not be functionally independent from identity processing neither in monkeys (Shepherd et al., 2006), nor in humans (Deaner et al., 2007; Frischen & Tipper, 2006; Khurana et al., 2009) (Liuzza et al., 2011).

My line of research contributed to understand that this modulation happens even in presence of more complex features of our identity as an identity immersed in a social and political world. Anyway, these findings still lack of a causal anatomo-functional prove that gaze-following behavior can be modulated by the elaboration of faces and their complex identities. The best way to test a causal hypothesis like that would be to study a clinical case of patients impaired in identity face processing (associative prosopagnosia) because of a brain lesion that may involve face processing areas like FFA and the right occipital face area (rOFA). Alternatively, an online repetitive TMS paradigm (online rTMS) can be used to cause a transient virtual brain lesion by artificially activating pools of neurons on the cortex under the coil. Right OFA is an area easy to be temporally interfered by the release of 15Hz impulses at the 60% of output intensity at the appearance of the target (Pitcher, Charles, Devlin, Walsh, & Duchaine, 2009). Online rTMS on rOFA has shown to interfere to face processing (Pitcher et al., 2009; Pitcher, Walsh, Yovel, & Duchaine, 2007). I hypothesize that interfering to face processes may dampen all the differences in gaze following linked to the face identity.

Since inferred traits, as well as emotions, would still modulate gaze processing by the mean of a subcortical way, these dimensions may be strictly controlled. A better control of the stimuli may also allow us to better clarify the role of the two putative processes that may play an important role in our findings: status and social similarity.

Data from non-human primates suggested us that social status may play a crucial role in modulating gaze following in the domain of politics, which is, by definition, the domain which emerged from the competitions between coalition to achieve an higher social status within a society to be able to take crucial decision about the distribution of resources (that, in a complex social animal like us, can be either material or symbolic). Even if in this case we haven't tested social status at an individual level, it would have happened that the competing group, and the individuals who belonged to that group, would have been perceived as belonging to inferior status, as suggested by studies showing that stereotypes can even yield to a de-humanization of some out-groups (Harris & Fiske, 2006a; Harris & Fiske, 2006b). Alternatively, the group in power would have perceived itself and its members as higher status, and the others a lower status. This would predict a lack of gaze following in response to an out-group distractor only among the ruling group. Furthermore, since in some experiments we used non-politicians, we hypothesized that those would have perceived as lower status compared to politicians. This last hypothesis doesn't seem to be supported by our behavioral data, as we saw, even if a differential activation that a higher activation in IPS when observing politicians compared to opinion makers, suggested an automatic activation of social status inferences in an area traditionally involved in magnitude comparisons (Chiao et al., 2009). Anyway, our results don't even suggest a group hierarchy effect related to the actual ruling group. Indeed, when a lack of gaze following has been found in my studies, it was present in the left-wing group (which at that time was at the opposition, both at a national and local level in the places we collected our data). When found in conservative, this lack was present only for a single former politician (Prodi), so we cannot really rule out if it has to be explained I terms of his political social identity, or to an additive effect of his affiliation and his lower status within the actual political landscape. This is to say that, as a future direction, I want to better test this status hypothesis.

To do that, it would be important also to assess the subjects perceived status, as assessed not only by more objective socio-economic status measures (SES), but by more subjective ones, as suggested by a recent review from Kraus and colleagues (2011), in a recent review on studies on social class. So, I can use members of low status groups *vs.* high status groups. Alternatively, to assess status at an individual level, I could recruit subjects belonging to high hierarchical groups (priests, soldiers, boy-scouts) and show them individual higher or lower in their status. This study would be interesting to be done in fMRI since, if a parametric activation in IPS in function of the status of the person observed would be at play and functionally connected with structures involved in the gaze-following.

The second putative process at play in the modulation of gaze following behavior can be related to a pure social similarity process. To investigate his process cleared from other confounding variable linked to semantic knowledge on a famous character and from other personality cues from the low-level features, we may use controlled stimuli from unknown who subjects are informed being similar or dissimilar on the basis of political attitudes, values or personality similarly to what done by Mitchell and colleagues (2006).

Also, it would be interesting to assess the possible neural correlate to se if, even in a task in which face processing should be irrelevant, medial prefrontal cortex activation, as an important contribution to the midline mentalizing system (Amodio & Frith, 2006), would be differentially involved when looking at a similar vs. dissimilar face across these different domains (from attitudes to personality).

Since there's some evidence suggesting that conservatives differ from liberals in terms of in-group loyalty, I would explore this hypothesis by using primes that may subjects endorse more collectivistic values. There's a huge literature, indeed, showing that cultural values shape psychological processes is in how people define themselves and their relation to others in their environment (Markus & Kitayama, 1991; Nisbett, Penng, Choi, & Norenzayan, 2001; Oyserman, Coon, & Kemmelmeier, 2002; Triandis, 1995). These classic cultural priming studies have shown that bi-culturals primed with an individualistic orientation were more likely to describe themselves using general descriptions (e.g. I am honest), whereas bi-culturals primed with a

collectivistic orientation showed a stronger propensity to describe themselves using contextual self descriptions (e.g., When talking to my mother, I am honest)(Gardner, Gabriel, & Lee, 1999; Oyserman & Lee, 2008). Remarkably, individuals from both individualistic and collectivistic nations (e.g., U.S. and Hong Kong) have shown similar effects of cultural prime on self concept (Gardner et al., 1999). Taken together, these behavioral studies demonstrate that regardless of nationality or cultural affiliation, people can readily acquire and carry knowledge of multiple kinds of cultural schemas simultaneously. Hence, when primed to orient more towards either an individualistic or collectivistic schema, people will think about themselves in a way that is consistent with the cultural schema temporarily brought to mind. As suggested by Haidt and Graham (2007), conservatives endorse more community-based, interdependent oriented values. So, I would like to test if, even in people who don't strongly identify as liberals or conservatives or don't strongly endorse community oriented vs. individual oriented values, a cultural priming which may bring them to focus more on the individual as individual vs part of a group may boost gaze following 1) in general 2) only for very relevant in-groups (e.g. family) 3) in in-groups in general.

Crucial to this hypothesis is the possible role of Oxytocin a) in social cognition in general (Andari et al., 2010; Domes, Heinrichs, Michel, Berger, & Herpertz, 2007; Rodrigues, Saslow, Garcia, John, & Keltner, 2009) b) in promoting in-group favoritism in particular (De Dreu, Greer, Van Kleef, Shalvi, & Handgraaf, 2011) c) in promoting trust (Baumgartner, Heinrichs, Vonlanthen, Fischbacher, & Fehr, 2008; Kosfeld, Heinrichs, Zak, Fischbacher, & Fehr, 2005). Of course, these hypotheses may be not mutually exclusive. We may test if intranasal oxytocin inhalation may boost gaze-following a) in general b) only for in-group members c) only for trustworthy people.

The first hypothesis may confirm the role of gaze following in the phylogenetic evolution and ontogenetic development of social skills. The second would support the hypothesis of the peculiar role of gaze following within our own group, or, in the terms of the anthropologist Alan Fiske (1992), within a communal sharing form of sociability. The third would militate in favor of the role of inferred trust in strengthening the gaze-following. We could explore this relationship going beyond the automatic inference of trustworthiness, trying to build the trustworthy reputation of a

peer in a simulated Trust game (Berg, Dickhaut, & McCabe, 1995). In the Trust Game, two anonymous players are involved in dividing a certain amount of money. The first player (trustor) has two options. One option is to divide the money according to a predetermined scheme; the other option is to trust the second player (trustee) and to give him/her the choice to divide the money. The latter option potentially leads to a higher pay-off for both players. If trusted, the second player has two options: (1) reciprocate the trust given by the first player (e.g. 11 for first player and 10 for second player) or (2) defect and maximize personal gains (e.g. 5 for first player and 17 for second player). We may predict that, after a Trust game, a trustworthy partner gaze would interfere to our saccadic task when looking at an incongruent direction more than an untrustworthy peer would do.

All together, these future research would provide us a clear and final picture of an amazing process that always remind us the chiasmatic nature of our being social and in society.

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Appendix: Published papers and drafts under preparation

1) **Liuzza, M. T**. & Aglioti, S.M (2011) “Neuroscienze in società: come lo studio del cervello sociale ci aiuta a capire chi siamo” (Social and cultural neuroscience: at the intersection between brain and social sciences), Sistemi intelligenti, Cognizione e socialità, 2° numero 2011.

2) **Liuzza, M. T**., Candidi, M. & Aglioti, S.M (2011). "Do not resonate with actions! Reading action-related, negative polarity sentences modulates cortico-spinal facilitation”, PlosOne, doi:10.1371/journal.pone.0016855

3) **Liuzza, M.T.**, Setti, A., Borghi, A.M. (In Press) “Kids observing other kids' hands: Visuomotor priming in children”. Consciousness and Cognition, doi:10.1016/j.concog.2011.09.015

4) **Liuzza, M. T.**, Cazzato, V., Vecchione, M., Crostella, F., Caprara, G. V., Aglioti, S. M. (2011) “Follow My Eyes: The Gaze of Politicians Reflexively Captures the Gaze of Ingroup Voters”, PLoS ONE, 6(9), e25117. doi:10.1371/journal.pone.0025117

5) **Liuzza M.T.**, Vecchione M., Dentale F., Crostella F., Barbaranelli C., Caprara G.V., Aglioti S.M. (In preparation). “A look into the ballot: gaze-following behaviour toward a candidate predicts vote intention”.

6) Cazzato V., Macaluso E., **Liuzza M.T.**, Caprara G.V., Aglioti S.M. (In Preparation). “Neural Responses to In-group and Out-group Political Party predict proneness to the gaze of politicians”.

Social and cultural neuroscience: at the intersection between brain and social sciences

In spite of the intrinsically social nature of human beings, research in Cognitive Neuroscience has mainly focussed on the individual. Only recently have studies started to explore the neurobiological basis of our social abilities and their evolution and thus gave birth to Social Neuroscience (SN), a new research field at the intersection of the Social sciences and Neurosciences. SN mostly inquires how evolutionary pressure has favoured the emergence of the specialized social brain networks that allowed humans to build up complex societies. Related to SN is the field of cultural neuroscience (CN) a discipline aimed at understanding how society and the Culture shape our minds and brains.

Scepticism about the possibility of studying the above complex behaviours using the reductionist and oversimplifying methods of Neuroscience has been expressed by traditional scholars of brain and mind. However, we believe that the increasing sensitivity of neuroscience techniques and theoretical approaches will ultimately allow us to understand the neuroplastic processes that allow social interactions to shape of our brains. It has been demonstrated,, for example that even very basic behaviours like reflexive social attention, are influenced by higher-order variables such as social status and political affiliation. This shows how our tendency to form groups on the basis of dispositions, preferences and ideologies can affect fundamental cognitive processes. We believe that neural ad behavioural implicit markers of social preferences and bias complement and extend the knowledge deriving from surveys based on explicit responses. Thus, the SN and CN new approach, promises to be very important for both neuroscience and social psychology. L'ambiente dell'essere umano, e in misura minore anche quello di molti altri animali, specie dei primati non umani, è fortemente sociale. Tuttavia, la complessità

dell'ambiente sociale umano richiede che l'essere umano sia anche un animale politico (*Zoòn politikòn*, come ebbe a definirlo Aristotele. Solo da poco le scienze che studiano la mente e il suo rapporto con il cervello hanno iniziato a tener conto della natura sociale dell'essere umano (per le prime rassegne sull'argomento si leggano Brothers, 1990, Cacioppo e Bernston, 1992 Adolphs, 1999). Il tema di cosa significhi avere una mente che consenta all'uomo di essere un animale politico in tutti i sensi non ha ancora ricevuto l'attenzione adeguata da parte della ricerca neuroscientifica e sociale. Queste discipline, all'inizio, si sono concentrate sui processi cognitivo-sociali, ossia su quei processi cognitivi (percezione, memoria, attenzione, categorizzazione, inferenze) finalizzati all'elaborazione di stimoli sociali (volti, stati mentali altrui). Si sono quindi soffermate principalmente sulle condizioni di possibilità del nostro stare in società: ad esempio, inferire stati mentali dalla direzione dello sguardo altrui, quindi rendere possibile una comunicazione al fine di cooperare oppure di competere[1]. Tuttavia, solo recentemente, è stata presa in considerazione la relazione inversa: possono variabili di natura sociale, culturale o politica influenzare le nostre abilità socio-cognitive?

I comportamenti sembrano, infatti, essere modulati da fattori sociali, che quindi potrebbero agire come variabili confondenti. Ad esempio, il gruppo di Michael Platt e colleghi ha a lungo studiato il comportamento dell'inseguimento automatico dello sguardo altrui, prerequisito di altre abilità socio-cognitive che vanno dall'attenzione condivisa (si veda il contributo di Ricciardelli e colleghi su questo stesso numero di Sistemi Intelligenti) alla teoria della mente (Baron-Cohen, 1995). In base alle predizioni del modello modularista adottato da Baron-Cohen, l'inseguimento dello sguardo altrui sarebbe un comportamento automatico, funzionalmente e neuralmente "incapsulato", dunque impermeabile a

1 Sulla supremazia della cooperazione nell'animale umano si legga l'ultimo libro curato da Tomasello, 2009.

informazioni di natura sociale che non riguardino direttamente la codifica dello spostamento dello sguardo.

Tuttavia, il gruppo di Michael Platt e colleghi ha scoperto come questo comportamento possa perdere la sua natura riflessa quando macachi maschi di *status* sociale alto osservano individui di *status* sociale basso, mentre i membri di quest'ultima categoria sociale inseguono sempre lo sguardo di individui a loro familiari, indipendentemente dallo *status* sociale. Dai risultati di questo studio emerge con chiarezza quanto sia importante tener conto di variabili sociali.

Lo stesso gruppo ha scoperto che negli esseri umani la familiarità di un volto rafforza l'inseguimento automatico dello sguardo, almeno nelle donne (Deaner, Shepherd et al. 2007). Il perché di questa differenza tra maschi e femmine è tutta da indagare e le risposte possono andare dall'impatto del testosterone nel funzionamento del cervello sociale (si veda la discussione in Deaner, Shepherd e Platt, 2007 per maggiori dettagli) a ipotesi che individuano nella cultura e nei ruoli di genere assegnati da essa una possibile ragione per una maggiore sensibilità delle donne ai segnali sociali. Sempre più condivisa è la constatazione che la cultura abbia un forte impatto nel funzionamento dei processi mentali e delle reti neurali da cui dipendono. In questo clima le neuroscienze culturali si stanno affermando come disciplina autonoma (Chiao e Ambady, 2007, Chiao, 2009). Il concetto di cultura non va, però, necessariamente inteso in senso statico (Vogeley and Roepstorff 2009) e coestensivo di identità macroscopiche come Oriente e Occidente. Anche l'ideologia, in quanto sistema di valori (Jost, Federico et al. 2009) può essere vista come una "matrice di identità culturale" che a sua volta è in grado di modulare (o almeno correlare con) comportamenti, processi cognitivi e affettivi.

Attenzione sociale riflessa modulata dall'orientamento politico

Lo spostamento automatico dell'attenzione nella direzione in cui guarda un'altra persona può essere considerato come un effetto di *mirroring* oculo-motorio (Bristow, Rees e Frith 2006) specie se consideriamo che processi attentivi e oculomotori sono molto legati a livello della loro rappresentazione neurale (Corbetta *et al.*, 1998), in accordo con la teoria premotoria dell'attenzione (Rizzolatti *et al.,* 1987) (a questo proposito si veda il contributo di Ricciardelli e Riggio, in questo volume).

Dodd, Hibbing e Smith (2010) hanno cimentato soggetti sani in un compito di attenzione in cui la consegna sperimentale era quella di premere un pulsante posto a destra nella tastiera quando vedevano apparire un quadrato nella parte destra dello schermo, oppure un pulsante sinistro quando vedevano il quadrato apparire nella parte sinistra. I soggetti dovevano compilare anche dei questionari per rilevarne l'orientamento politico. Gli autori di questo studio, apparso recentemente su *Attention Perception and Psychophysics* hanno dimostrato che i soggetti di sinistra tendono a rispondere più lentamente quando una faccia schematica guarda in direzione incongruente rispetto a quella in cui apparirà lo stimolo target 500 o 800 millisecondi più tardi. Quelli di destra, invece, sembrano essere assai meno sensibili allo sguardo altrui. Gli autori spiegano questo risultato basandosi sulla teoria politica della pensatrice conservatrice Ayn Rand (discussa in Burns, 2010), secondo la quale i conservatori supportano un'ideologia che deifica l'individuo e quindi sarebbero meno sensibili ai segnali sociali. C'è da dire che, in verità, il pensiero di Rand è più ascrivibile all'ideologia *libertarian*[2] che al conservatorismo in generale. Infatti, gli studi di Jonathan Haidt sui fondamenti morali dell'ideologia politica (Haidt e Graham, 2007), evidenziano come, in base al questionario sui fondamenti morali (si veda il sito

2 Si ricordi che nel contesto politico americano il libertarismo, che in Europa è quasi sinonimo di anarchia, è un'ideologia che coniuga posizioni estremamente favorevoli al libero mercato in campo economico e posizioni antiautoritarie che contrastano l'intervento dello stato in qualsiasi aspetto della vita, mentre i conservatori auspicano un forte intervento dello stato in difesa dell'ordine pubblico e della morale.

www.youmorals.com), i libertari possano formare un gruppo a sé stante (Haidt, Graham e Craig, 2009). Anzi, in base agli studi di Haidt i conservatori tradizionali darebbero più importanza a valori legati a una visione comunitaria o interdipendente della società (Shweder, Much, Mahapatra e Park, 1997), come la lealtà al proprio gruppo. La scelta di una faccia schematica lascia inesplorata invece una dimensione importante nello studio di fenomeni come l'attenzione sociale riflessa[3]: il tipo di interazione che intercorre tra i soggetto e lo stimolo. L'esperimento in questione non permette di comprendere come i fattori disposizionali dei soggetti interagiscano con le caratteristiche sociali dello stimolo, quali la sua identità sociale (se appartiene al proprio gruppo o a un gruppo avverso), o se occupa uno *status* sociale più o meno elevato nella gerarchia di un gruppo.

Disposizioni e orientamento politico

In uno studio del gruppo di Amodio, suggestivamente intitolato "Neurocognitive correlates of liberalism and conservatism" e pubblicato su Nature Neuroscience nel 2006, gli autori dimostrano come in un compito in cui bisogna inibire una risposta prepotente (nel senso di automatica e difficilmente sopprimibile) i soggetti di sinistra se la cavino meglio. Inoltre, le ampiezze di alcuni indici eletrofisiologici (Potenziali Evento Relati, ERP) correlati al monitoraggio del conflitto correlano con l'orientamento politico dei soggetti. Ne emerge un quadro in cui l'orientamento politico progressista, spesso correlato anche con tratti di personalità - come l'apertura mentale - o con stili cognitivi - come una maggiore tolleranza dell'ambiguità (si veda Jost, 2009 per una rassegna), vada di pari passo con una effettiva capacità di monitorare e gestire il conflitto tra risposte in competizione tra loro e con il "marcatore neurale" di questo comportamento.

3 anche se è alquanto dubbio, come ammettono gli stessi Dodd e colleghi, che in un intervallo di 500 millisecondi o superiore si possa ancora parlare di comportamento riflesso

Un altro dato che cerca di dare una spiegazione fisiologica della differenza tra destra e sinistra è quello pubblicato nel 2008 da un gruppo che coinvolge studiosi di dipartimenti di Scienze politiche, Psicologia, Psichiatria e Genetica comportamentale (Oxley, Smith et al. 2008). In questo esperimento, ai soggetti con forti posizioni favorevoli o contrari alle politiche protettive nei confronti della nazione, della famiglia e delle tradizioni venivano presentati degli stimoli, visivi o auditivi, capaci di indurre paura (ad esempio, un ragno su un volto di una persona spaventata, oppure un suono improvviso). Venivano, quindi, misurate delle risposte fisiologiche come la conduttanza cutanea (che misura lo stati di attivazione del sistema nervoso autonomo) o l'attività elettirca del muscolo facciale preposto allo sbattere delle ciglia. In questo modo, gli autori hanno potuto rilevare che gli individui con atteggiamenti più favorevoli a politiche come l'aumento delle spese militari, la guerra in Iraq, la pena di morte e più sfavorevoli a temi come l'immigrazione, i matrimoni gay, il controllo di armi, l'aborto o la poronografia presentavano le risposte fisiologiche più marcate.

Proprio questo studio è stato uno dei maggiori obiettivi polemici del celebre pamphlet *Neuromania* (2010) in cui Paolo Legrenzi e Carlo Umiltà attaccano i nuovi filoni di ricerca proliferati soprattutto a partire della diffusione della risonanza magnetica funzionale (fMRI) nello studio dei correlati neurali dei processi mentali. Gli autori dedicano un paragrafo proprio alla "neuropolitica", sostenendo che "una semplice correlazione, e non certo stupefacente, nel senso che chi prova più paura [...] è anche più aperto nei confronti dell'altro, più chiuso rispetto ai bisognosi"(Legrenzi e Umiltà, 2001, p. 97). Le ampiezze della contrazione dei muscoli coinvolti nella reazione emotiva allo stimolo (ad esempio quelli degli occhi) e l'aumentata capacità della pelle di condurre elettricità a causa della sudorazione, a sua volta regolata dal sistema nervoso autonomo, sono misure abbastanza dirette, che non derivano, come nel caso dell'fMRI, da complesse modellizzazioni o

confronti statitistici tra migliaia di voxel[4]. Inoltre, tale correlazione sembra essere tutt'altro che ovvia, visto che mette in relazione una risposta fisiologica a stimoli emotigeni abbastanza di base, politicamente neutri, con atteggiamenti su temi molto complessi, che riguardano le politiche per proteggere o meno una certa comunità. Insomma, che tra la paura fisiologica e la paura sociale (che si traduce poi in domanda di sicurezza) ci sia una relazione significativa al di là dell'estensione per metaforizzazione del significato della parola paura all'ambito della politica, non ci sembra una cosa da poco. Ancor più cruciale, invece, è il nodo dell'interpretazione da dare a questa correlazione. Da questo punto di vista, è vero, il dato dell'esperimento di Oaxley condivide con molti studi di fMRI il fatto di poter trarre solo conclusioni sulla correlazione tra due variabili, e non sulla loro causalità. I due autori di *Neuromania* denunciano infatti, giustamente, come nell'*abstract* dell'articolo gli autori sembrano suggerire che questa evidenza è da intepretare come una predisposizione biologica ad avere determinate posizioni politche. Tuttavia, come riconoscono anche Umiltà e Legrenzi, gli autori dello studio sono molto più cauti nella discussione, riconoscendo la natura correlazionale dei loro dati e ipotizzando che il rapporto tra la paura fisica e quella sociale potrebbe non essere causale né in un senso né in un altro, ma potrebbe essere spiegata da una sorta di "fattore latente" da cui potrebbero dipendere entrambe. Forse, questo fattore latente andrebbe ricercato in una dimensione come la personalità, la quale emerge dall'interazione tra disposizioni stabili - anche biologiche - e l'ambiente.

D'altronde, molti dei più recenti studi sulla psicologia della politica sottolineano proprio come ad esempio alcuni tratti misurati da uno dei più usati test per l'analisi della

4 Unità minima di analisi della fMRI, corrispondente a cubetti ci circa 3 millimetri cubici in cui viene ripartita la scansione del cervello per analizzarne l'attività in specifiche aree.

personalità (*Big Five)* tendano a spiegare la maggior parte delle scelte politiche degli elettori (Caprara e Vecchione, 2007).

A cosa possono servire le neuroscienze sociali?

Il dibattito è aperto. La tesi di *Neuromania* è, sostanzialmente, che le neuroscienze sociali non aggiungono nulla a quello che la psicologia già aveva scoperto con i suoi metodi tradizionali. Se partiamo dagli studi sui correlati neurali della cognizione sociale, invece, scopriamo che l'elaborazione di stimoli di natura sociale è differente da quella di stimoli di natura non sociale, proprio perché ad essi sono dedicate strutture cerebrali almeno parzialmente differenti. Una caratteristica importante dell'elaborazione di stimoli sociali, ad esempio, è la loro intima connessione con la dimensione affettiva (Fazio e Towles-Schwenn, 1999; Fazio, 2001). A ciò si ispirano molti dei più famosi test per misurare gli atteggiamenti impliciti come l'*Implicit Association Test* (IAT; Greenwald, McGhee e Schwartz, 1998; Greenwald, Nosek e Banaji, 2003), ampiamente utilizzato non solo per studiare *bias* razziali, ma anche per predire il comportamento di voto (Arcuri et al., 2008; Galdi, Arcuri e Gawronski, 2008). Lo IAT è un compito di categorizzazione in cui ai partecipanti vengono presentati dei volti, che devono essere classificati come appartenenti a due categorie (es: "bianchi" o "neri"), oppure delle parole, che devono essere giudicate come positive o negative, usando gli stessi tasti del computer per i due compiti. Se si ha un atteggiamento negativo verso un determinato gruppo, si tende ad essere più lenti quando si usa lo stesso tasto sia per attribuire quel volto a quella categoria sia per giudicare una parola come positiva (es: "gioia"). Ad esempio, Avenanti, Sirigu e Aglioti (2010) hanno sottoposto a IAT sia partecipanti bianchi che partecipanti neri e hanno trovato che entrambi questi gruppi esibivano una preferenza implicita per il proprio gruppo (anche se questo *bias* è più marcato per i bianchi). Quando si osserva la mano di un membro del

proprio gruppo penetrata da un ago, la soppressione dell'eccitabilità corticospinale[5] è tanto maggiore quanto più si ha un atteggiamento implicito favorevole al proprio gruppo (e sfavorevole all'altro). Va rilevato che gli atteggiamenti espliciti non correlavano con lo IAT, né con la soppressione dell'eccitabilità corticospinale dovuta all'empatia per il dolore altrui. Questo esperimento dimostra come con tecniche di neuro-indagine si possano espandere le nostre conoscenze sui *bias* impliciti, che probabilmente condizionano i comportamenti quotidiani e persino la nostra reattività di fronte al dolore altrui. Dati come questi non devono però essere confusi con una predisposizione innata al razzismo. Probabilmente sono i modelli culturali che circolano nella società (Fazio and Olson 2003) a causarli e alcune prime evidenze dimostrano che si possano anche attenuare (Lebrecht, Pierce, Tarr e Tanaka, 2009).

Quindi, i metodi delle neuroscienze applicati allo studio di fenomeni che interessano l'uomo nella sua natura eminentemente sociale, non solo possono aiutare a comprendere meglio alcuni fenomeni, ma in alcuni casi possono anche fornire strumenti utili alla politica, ad esempio per combattere discriminazioni che spesso si apprendono e si mettono in atto in maniera implicita, non visibile (neanche alla nostra stessa coscienza), ma non per questo meno insidiose. Sempre che la politica abbia voglia e interesse ad affrontare questi problemi.

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Keywords: Social neuroscience; Cultural neuroscience; Political cognition; Implicit association test; Social attention.

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ricerca presso il Laboratorio di Neuroscienze cognitive e sociali (http://w3.uniroma1.it/aglioti/SCNL/People/Marco%20Tullio%20Liuzza.html), nel quale si occupa principalmente della relazione tra differenze individuali, affiliazione politica e processi automatici come l'attenzione sociale riflessa. Secondariamente, attraverso l'uso della Stimolazione Magnetica Transcranica (TMS), si occupa del ruolo della corteccia motoria in processi che vanno dall'elaborazione sintattica al giudizio morale.

Attualmente e' *visiting scholar* presso la Northwetern University di Chicago, dove collabora con il Social Affective and Cultural Neuroscience Lab (http://culturalneuro.psych.northwestern.edu/Lab_Website/Welcome.html).

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PLoS one

Do Not Resonate with Actions: Sentence Polarity Modulates Cortico-Spinal Excitability during Action-Related Sentence Reading

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Abstract

Background: Theories of embodied language suggest that the motor system is differentially called into action when processing motor-related versus abstract content words or sentences. It has been recently shown that processing negative polarity action-related sentences modulates neural activity of premotor and motor cortices.

Methods and Findings: We sought to determine whether reading negative polarity sentences brought about differential modulation of cortico-spinal motor excitability depending on processing hand-action related or abstract sentences. Facilitatory paired-pulses Transcranial Magnetic Stimulation (pp-TMS) was applied to the primary motor representation of the right-hand and the recorded amplitude of induced motor-evoked potentials (MEP) was used to index M1 activity during passive reading of either hand-action related or abstract content sentences presented in both negative and affirmative polarity. Results showed that the cortico-spinal excitability was affected by sentence polarity only in the hand-action related condition. Indeed, in keeping with previous TMS studies, reading positive polarity, hand action-related sentences suppressed cortico-spinal reactivity. This effect was absent when reading hand action-related negative polarity sentences. Moreover, no modulation of cortico-spinal reactivity was associated with either negative or positive polarity abstract sentences.

Conclusions: Our results indicate that grammatical cues prompting motor negation reduce the cortico-spinal suppression associated with affirmative action sentences reading and thus suggest that motor simulative processes underlying the embodiment may involve even syntactic features of language.

Citation: Liuzza MT, Candidi M, Aglioti SM (2011) Do Not Resonate with Actions: Sentence Polarity Modulates Cortico-Spinal Excitability during Action-Related Sentence Reading. PLoS ONE 6(2): e16855. doi:10.1371/journal.pone.0016855

Editor: Manos Tsakiris, Royal Holloway, University of London, United Kingdom

Received September 22, 2010; **Accepted** January 17, 2011; **Published** February 11, 2011

Funding: S.M.A. was funded by the Istituto Italiano di Tecnologia (IIT) SEED (Prot. Num. 21538) and the European FP7 grant Tango. The project Tango acknowledges the financial support of the Future and Emerging Technologies (FET) programme within the Seventh Framework Programme for Research of the European Commission, under FET-Open grant number: 249858. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing Interests: The authors have declared that no competing interests exist.

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Introduction

According to standard cognitive theories, language is processed amodally [1,2] and in higher-order anatomo-functional systems largely unrelated to sensory and motor networks [3]. However, growing behavioral [4–7], neuroimaging [8–10], neurophysiological [11–15] and neuropsychological [16–20] evidence indicates that sensorimotor simulation is at play during a variety of language related tasks. Such evidence brought experimental support to the Embodied Cognition framework [21] according to which action-related concepts are represented within the same brain circuitry responsible for executing the actions linked to the expressed concepts. Beside action-related concepts, also language may be embodied [22,23,24], and common representational formats may underpin linguistic and sensorimotor processes [25,26]. Strong support to the experiential-simulative account of language processing comes from studies on action simulation and posits that the automatic and rapid [27] reactivation of the sensorimotor copy of an action is crucial to enable one to understand its linguistic meaning [22]. Coherently, deficits in reactivating the sensorimotor copy of an action should bring about, for example, impaired performance in semantic tasks. Although the robustness of the classical dissociation between apraxic and aphasic deficits (e.g. [28–30]) is not at stake here, many studies have shown that such a pattern has indeed been observed in a variety of patients showing sensorimotor deficits associated to Parkinson disease [31,32,20], cortico-basal degeneration [18], subcortico-frontal diseases [33], left frontal atrophy [34] and motor neurone disease [16,17].

Many of the studies on embodied language processing have focused thus far on the semantics of single words (nouns or verbs) (for instance [12,35–37]). Language comprehension, however, is inherently linked to processing whole sentences that are typically made of different semantic units (at least two, noun and verb) and are organized according to specific syntactic rules. Only recently, have researchers begun to investigate the link between motor knowledge and sentence processing based on grammatical cues [7,38–41].

Relevant to this issue is the case of sentential negation, the basic syntactic feature that reverses the truth value expressed by a

sentence. Two recent fMRI studies have explored the effect of action negation on brain activity [39,41]. Tettamanti and colleagues [39] showed that passively listening to negative action related sentences brought about a selective decrease of the BOLD signal in the same fronto-parietal network that was activated by the affirmative form of the same sentences. This decrease was not observed when participants were engaged in abstract sentences listening. In a similar vein, the visual presentation of hand action-related verbs induced higher neural activity in the motor and premotor cortices when the stimuli were positive rather than negative imperatives [41].

S-p TMS studies showed that imagination [42,43] or direct observation of actual [44–48] or implied [49–51] actions induced an increase of MEPs amplitude. Such a facilitation effect was highly specific for the muscles that would be involved in actual execution of the observed action [43–47,50,15] and was likely due to the activity of the fronto-parietal mirror system [48,52,53]. This may seem at odds with neurophysiological and behavioral results showing that listening to limb action verbs (e.g., grasp or kick) inhibits the corticomotor representation of the limb involved in the execution of the represented action [14]. However, while the former condition typically provides explicit cues about the properties of a specific action (e.g., movement direction or the specific muscle involved in the action), verbs may typically involve a number of different ways of performing a given action. Therefore, while the facilitation during direct observation may derive from a resonant mirror mapping between model and onlooker, the inhibition during higher-order linguistic derivation may arise from the competition between different motor schemata associated with what is heard or read [14]. In the present study we tested, for the first time using TMS, whether reading sentences that negate or affirm the execution of an action would differentially influence the excitability of the cortico-spinal system.

Using Transcranial Magnetic Stimulation (TMS) we tested the effect of sentential negation on the reactivity of the motor system by assessing any selective modulation of the cortico-spinal excitability during reading affirmative and negative hand action-related sentences. We recorded the amplitude of Motor Evoked Potentials (MEPs) from a hand muscle (First Dorsal Interosseus, FDI) of healthy participants who silently read affirmative and negative polarity, hand action-related and abstract sentences. Furthermore, to functionally characterize any neurophysiological effect contingent upon linguistic negation, we used paired-pulse (pp-) instead than single pulse (sp-) TMS. It is worth noting that, while the effect of sp-TMS may take place at both the motor cortex and the spinal cord level [54], pp-TMS provides a reliable index of selective motor cortical activation. Indeed the MEP facilitation to pp-TMS likely occur at the cortical level and reflects the activation of excitatory cortical interneurons without affecting spinal circuits [55]. Moreover, we chose to use the pp-TMS procedure also on the basis of a previous study showing that pp-TMS (and not sp-TMS) was able to detect modulations of the cortico-spinal system contingent upon processing of hand-action related nouns and verbs [35]. The task was based on the visual presentation of written sentences in order to test the cortico-spinal excitability while subjects were reading the whole sentence (i.e. compositional mechanisms of language) instead of hearing the verb, as in [14].

Materials and Methods

Ethics statement

The experimental procedures were approved by the Fondazione Santa Lucia Ethics Committee (24/11/2008) and were carried out in accordance with the principles of the 1964 Declaration of Helsinki.

Participants

Fourteen individuals (8 males) participated in the study (mean age 23±2.5 SD). All participants were Italian native speaker, were right-handed according to the Standard Handedness Inventory [56] and had normal or corrected-to-normal visual acuity. All participants gave their written informed consent prior to their inclusion in the study and were naive as to its purpose. Participants were compensated for their time, and specific information concerning the study was provided to them only after they had finished all experimental sessions. None of the participants had a history of neurological, psychiatric, or other medical problems or any contraindication to TMS [57]. No discomfort or adverse effects during pp-TMS were noticed or reported.

Stimuli

During the experimental sessions participants were presented with Italian four-words sentences (see Table 1 for a complete list of stimuli). The sentences were chosen from a set of 60 sentences used in a previous study [39] and adapted to the purpose of the study. The sentences could refer to either abstract activities or hand-action related actions (''Io sogno la pace'' which translated in English reads as ''I dream the peace'', ''Io colgo la mela'' which translated in English reads as ''I grasp the apple''). Each sentence was presented in both affirmative or negative polarity (''Io spremo il limone'' which translated in English reads as ''I squeeze the lemon'' and ''Non spremo il limone'' which translated in English reads as ''I don't squeeze the lemon''). It is important to note that, in Italian, the negative version of these sentences implicitly includes reference to the first person and thus affirmative and negative sentences are matched for length and reference to the agent of the action. To further control for any possible difference between motor hand-related and abstract items that could affect sentence reading speed we controlled that the frequency of the verb, frequency of the object complement, number of the syllables of the verb, number of syllables of the sentence were accurately matched between categories (according to the corpus provided by the CoLFIS (Corpus e Lessico di Frequenza dell'Italiano Scritto) elaborated by the Computational Linguistics Insititute, National Centre of Research (CNR) and available at http://www.ge.ilc.cnr.it/lessico.php on a database of 3.798.275 words). Conversely to control that items of the two categories differed for their imageability and motor relatedness we asked an independent group of 20 individuals (mean age 27.15±3.87 SD) to rate each experimental item, by marking a 1 to 7 Likert scale, for 1) how fast is the sentence in evoking a mental image, a visual representation, a sound or other perceptual experiences, and 2) how much movement is implied by each sentence (all mean values of these measures are reported in Table 2 and Table S1 of the Supporting Information). Crucially for the purposes of our experiment, action related sentences were more imaginable (6.06±0.89 SD vs 2.44±1.06 SD; $t(19) = 18.40$, $p<0.001$) and more motor related (5.74±1.14 SD vs 1.08±0.15 SD; $t(19) = 18.04$, $p<0.001$) than abstract ones.

Electromiographic Recordings and Transcranial magnetic stimulation. Electromyography (EMG) - MEPs to pp-TMS of the left motor cortex were recorded from the right FDI. Silver/silver chloride surface electrodes were placed over the muscle belly (active electrode) and over the associated joint or tendon of the muscle (reference electrode). A ground electrode was placed on the right wrist. A CED Power 1401 (Cambridge Electronic Design Ltd, Cambridge, UK) was connected to an

Table 1. List of all experimental stimuli.

Abstract		Hand action-related	
Positive	**Negative**	**Positive**	**Negative**
Io invidio la bellezza	Non invidio la bellezza	Io afferro la maniglia	Non afferro la maniglia
I envy beauty	*I don't envy beauty*	*I grab the handle*	*I don't grab the handle*
Io sogno la pace	Non sogno la pace	Io spremo il limone	Non spremo il limone
I dream the peace	*I don't dream the peace*	*I squeeze the lemon*	*I don't squeeze the lemon*
Io rispetto il patto	Non rispetto il patto	Io avvito il bullone	Non avvito il bullone
I respect the deal	*I don't respect the deal*	*I screw in the bolt*	*I don't screw in the bolt*
Io tollero lo sgarbo	Non tollero lo sgarbo	Io impugno la spada	Non impugno la spada
I tolerate the rudeness	*I don't tolerate the rudeness*	*I clasp the sword*	*I don't clasp the sword*
Io perdono la colpa	Non perdono la colpa	Io colgo la mela	Non colgo la mela
I forgive the guilt	*I don't forgive the guilt*	*I pick the apple*	*I don't pick the apple*
Io ricordo il passato	Non ricordo il passato	Io ritaglio la foto	Io ritaglio la foto
I remember the past	*I don't remember the past*	*I cut out the picture*	*I cut out the picture*

In *italic* the English translation of each sentence used as stimulus.
doi:10.1371/journal.pone.0016855.t001

Isolated Amplifier System Model D360 (Digitimer Limited, Hertfordshire, UK) and interfaced with CED Spike 2 software. The second-order Butterworth filter was set between 20 and 2.5 kHz (sampling rate, 10 kHz). Signals were displayed at a gain of 1000. Auditory feedback of the electromyography signal was used to help subjects maintain voluntary muscle relaxation during electrophysiological preparation.

Transcranial Magnetic Stimulation (pp-TMS). The optimal scalp position (OSP) for inducing MEPs in the right FDI muscle was found by moving the coil in steps of 1 cm over the left primary cortex until the largest MEPs were found. Then, the position was marked with a pen on a bathing cap worn by participants. The coil was held tangential to the scalp with the handle pointing backward and laterally at 45° from the midline. Resting motor threshold (rMT) was defined as the lowest stimulus intensity that evoked at least 5 MEPs out of 10 consecutive magnetic pulses with an amplitude $>50\,\mu V$. During the experimental blocks, two pulses of TMS were delivered over the individual OSP by connecting two Magstim Model 200 stimulators with a Bistim module (The Magstim Company), producing a maximum output of 1.75 T at the coil surface (stimulus attenuation, 22%; duration, 1 ms; rise time, 110 μs). The two pulses were delivered by means of a 70 mm figure eight stimulation coil (Magstim polyhurethane-coated coil). In standard pp-TMS protocols, a conditioning stimulus (CS) below the rMT, is followed at short interstimulus intervals (ISIs) by a suprathreshold test stimulus (TS). At ISIs of 7–20 msec the CS produce an MEP facilitation which is thought to take place at the cortical level reflecting the activation of excitatory cortical interneurons without affecting spinal circuits [55]. In our study, the CS stimulus was set to 80% of the rMT while the TS pulse was set at 120% of rMT. Mean rMT was 50±SD 9% of maximum stimulator output. The time delay between the first conditioning pulse and the test one was set to 10 ms as this interval has been proven to measure the effect of facilitatory interneuron connections [55]. EMG recording started 100 ms before the test magnetic pulse in order to control for the absence of muscular preactivation in each trial. MEPs' peak-to-peak amplitudes (in millivolts) were collected and stored in a computer for off-line analysis.

Procedure

Participants sat with their right and left arm and hand resting on a pillow on their lap. The participants were comfortably seated in a dimly lit room at a distance of 80 cm from a computer screen. Eighteen abstract and eighteen motor (nine positive and nine negative) sentences were randomly presented within each of the two experimental blocks, intermingled with the presentation of nine black squares which enabled us to measure the baseline cortico-spinal excitability of the hand muscle (45 trial per block for a total of 18 trials per condition). At the beginning of the experiment, subjects were instructed to pay attention to the visual stimuli presented on the screen as, during the inter-trial interval,

Table 2. List of frequency, length and subjective ratings' mean values of all stimuli.

	V F	O C F	V No S	S No S	IMAG	MOT R
Hand Action-related sentences	70.5±73.7	99.8±127.8	2.7±0.5	7.2±0.8	**6.1±0.9**	**5.7±1.1**
Abstract content sentences	353.5±517.7	294.3±212.0	2.8±0.4	7.2±0.8	**2.4±1.1**	**1.1±0.2**
T value	*1.33*	*1.92*	*0.62*	*0*	***18.4****	***18.03****
P value	*0.21*	*0.08*	*0.55*	*1*	***<0.001***	***<0.001***

Values represent mean ± standard deviations of stimuli of all experimental conditions.
In *italic* T-tests and *p* values. In bold means that differ significantly between abstract and hand-related sentences**. V F** = Verb Frequency; **O C F** = Object Complement Frequency; **V No S** = Verb Number of Syllables; **S No S** = Sentence Number of Syllables; **IMAG** = Imageability; **MOT R** = Motor Relatedness.
doi:10.1371/journal.pone.0016855.t002

they would be asked questions concerning the last read sentence (ITI 10 s). For example subject could have been asked whether the sentence was positive, negative, whether the last word ended with an "a" or not and to answer to questions about the meaning of the sentence as "Do you grasp the apple?", "Do you respect the deal?". The choice of the duration of this inter-trial interval was based on research [58] that showed no change in cortico-spinal excitability after repetitive TMS at 0.1 Hz for 1 h. This procedure allowed us to rule out that effects of TMS per se influenced the results. Each trial started with a fixation cross lasting 10 s followed by the presentation of the sentence or the fixation square which lasted 800 ms. During the presentation of each sentence (or black square) a paired-pulse TMS was delivered at randomly variable time intervals ranging between 500 and 700 ms after stimulus onset. The decision to stimulate the cortico-spinal system in this time window was based on Pulvermüller's neurophysiological research showing early (200 ms) EEG modulations over central sites during action related-verbs and nouns reading respectively, and later (500–800 ms) high frequency (30 Hz) modulations recorded from central sites (C3/C4) for action verbs compared to nouns [12]. A schematic representation of two different-stimulus category trial events is shown in Figure 1.

Data Analysis

MEP amplitudes that fell 3 SDs above or below each individual mean for each experimental condition or single trials contaminated by muscular preactivation were excluded as outliers and precontracted trials, respectively (5% of total). Raw MEP amplitudes for each condition were normalized (divided) by baseline MEP amplitudes. Normalized MEP amplitudes were entered in a 2 (sentence Type: Abstract, Hand-related) X 2 (Polarity: Negative, Positive) repeated measures ANOVA. Post-hoc analysis was performed with Duncan test. All statistical tests were performed with the software STATISTICA 8 (StatSoft, Tulsa, OK, USA).

Results

Analysis of MEP amplitudes revealed a main effect of Polarity ($F(1,13) = 4.94$, $p = 0.045$, $\eta^2 = 0.27$) which was accounted for by smaller MEP amplitudes during reading positive than negative sentences (0.97±SD 0.12 vs 1.01±SD 0.13, note that in Figure 2 the MEP amplitudes are reported with respect to the baseline value, normalized MEP-1). The sentence Type main effect was non significant ($F(1, 13) = 2.88$, $p = 0.113$, $\eta^2 = 0.18$). Importantly, the sentence Type by Polarity interaction was significant ($F(1,13) = 5.77$, $p = 0.032$, $\eta^2 = 0.31$) (see Figure 2).

Post-hoc comparisons revealed that the interaction was entirely accounted for by a suppression of cortico-spinal excitability during hand related positive sentences. Indeed, reading positive hand related sentences induced lower cortico-spinal excitability (0.93±SD 0.13) with respect to both reading positive abstract sentences (1.02±SD 0.09, p = 0.047, Cohen's $d = 0.88$) and negative hand related sentences (1.04±SD 0.14, p = 0.030, Cohen's $d = 0.84$). Furthermore, the almost significant trend showed by the T-test against baseline (value 1) ($t(13) = -2.13$, $p = 0.053$) indicated that the MEP suppression during reading positive hand related sentences was a genuine inhibition of the cortico-spinal excitability. All other conditions did not differ from one another (all $ps > 0.15$) and did not differ from baseline ($ps > 0.1$).

Discussion

Cortico-spinal signatures of motor simulation are found when reading action-related but not abstract sentences

The first result of our study is the decrease of MEP amplitudes when subjects silently read positive action-related sentences compared to positive abstract sentences. This is in keeping with a previous sp-TMS study where subjects listened to auditory verbal stimuli and they received a single pulse at the end of the verb [14]. Our pp-TMS results expand previous knowledge by

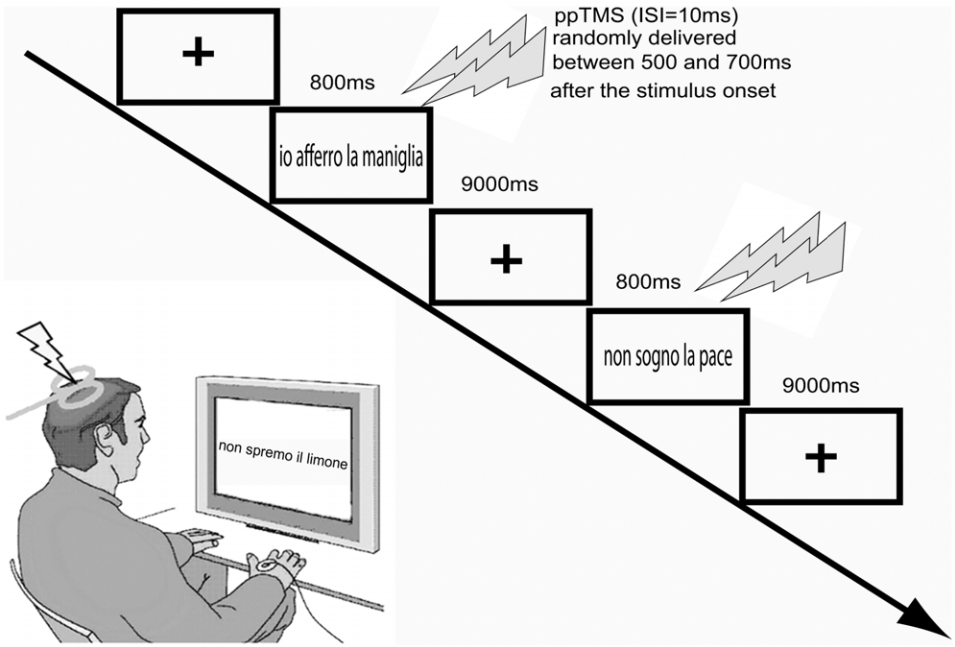

Figure 1. Experimental Procedure. Timeline and subjects' posture during the experimental procedure. Paired-pulse Transcranial Magnetic Stimulation (p-pTMS) was delivered on average 600 ms (±100 ms) after each sentence appeared on the screen. Stimulation intensity was based on individual resting motor threshold (rMT) for the first dorsal interosseous (FDI). The Conditioning Stimulus (CS) was set at an intensity of 80% of rMT while the Test Stimulus (TS) at 120% of rMT with an Inter Stimulus Interval (ISI) of 10 ms over FDI Optimal Scalp Position (OSP).
doi:10.1371/journal.pone.0016855.g001

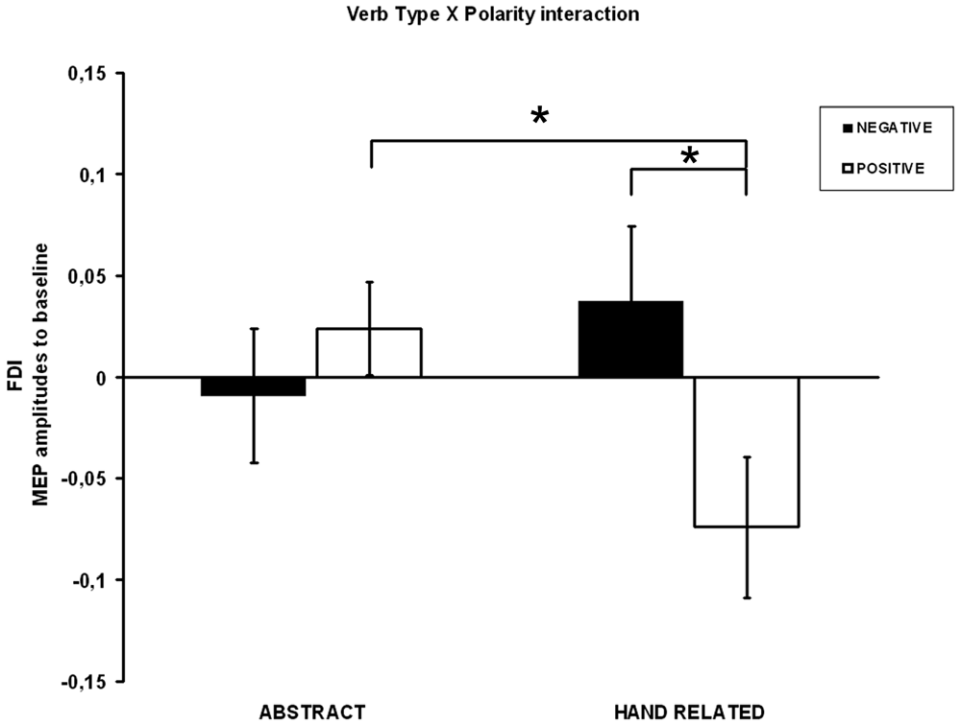

Figure 2. MEP amplitudes in all experimental conditions. MEP amplitudes are represented with respect to their baseline value of excitability recorded during the observation of a black square (normalized MEP-1). Motor potentials evoked during positive hand action related sentences were significantly inhibited with respect to the ones evoked during positive abstract sentences and with respect to baseline. MEPs were modulated by linguistic polarity during hand action related sentences comprehension but not during abstract sentences. Vertical bars denote standard error means.
doi:10.1371/journal.pone.0016855.g002

demonstrating that the effect has to do more with to cortical interneurons than with modulations at any other level of the cortico-spinal pathway [54]. Moreover, unlike a previous study using auditory presentation of single words [14], we used visual presentation of sentences that allowed us to test language processing at the sentence level and thus the effects of the compositional mechanisms of language more than the processing of the single verb [14]. This latter aspect of our study is crucial in order to test the theories postulating that sensorimotor simulation contributes to language processing.

Lack of action simulation during processing of negative polarity, hand action-related sentences

The key result of our TMS study is that sentential polarity selectively modulates cortico-motor reactivity only when the sentence refers to hand actions. Psycholinguistic studies show slower reactivity to stimuli referred to in a negative sentence suggesting a sort of experiential based language comprehension [59]. Studies on the neural basis of negation were performed mainly using functional neuroimaging techniques [60,61]. An fMRI study focusing on the neural basis of bilingualism, for example, reported that neural activity in parietal and frontal regions was higher when listening to negative action-related sentences with respect to positive ones [61]. However, the study did not use non action-related, control stimuli. Moreover, the effect was present only when processing the participants' second language and it was interpreted as being related to the difficulty of the task and not in terms of motor simulation vs. no-simulation [61]. More recently, two fMRI studies specifically tested the effect of sentential negation in relation to the language-mediated embodiment of actions [39,41]. Passive listening of action-related or abstract sentences uttered in affirmative or negative polarity demonstrated that processing of negative action-related sentences brought about a reduction of neural activation and cortical connectivity in a left-hemispheric frontoparieto-temporal network [39]. Using a region of interest (ROI) analysis, it has also been shown that visual presentation of negative polarity, imperative action-related verbs induced a reduction of neural activity in motor and premotor regions [41]. Our study complements and expands previous fMRI results for a number of reasons.

By using a pp-TMS procedure we have been able to highlight the specific role played by facilitatory cortico-cortical connections in the action simulation process associated to the representation of grammatical features. More specifically, we found a suppression of MEP amplitudes during positive hand action sentences reading compared with baseline.

Many of the previous findings on the involvement of the motor system in action-related word comprehension have been explained by an associative learning model [11,37,62,63] which posits that action-related verbs automatically co-activate neuronal ensembles dedicated to language and actions. This co-activation would be developed during individuals' ontogenesis as we learn to utter action-related verbs while performing the same actions. However, we show here that such "language-to-motor" neural spread of co-activation is not observed when reading negative forms of action verbs.

Assuming that effective use of cognitive and neural systems is based on the implementation of the exact amount of resources required by the task at hand, it has been postulated that language-mediated motor simulation occurs only when the action is within the linguistic focus [7,64]. The Linguistic-Focus Hypothesis, in fact, postulates that engagement of the motor system during

language comprehension is mediated by the focus of the linguistic message [64]. Taylor and Zwaan [64] used an action compatibility effect experimental paradigm (ACE, [4]) in which participants had to read sentences like "The runner/was very/thirsty./A fan/ handed him/a bottle/of cold/water/which he/opened/quickly" in a self paced manner and had to turn a knob in order to proceed in reading the sentence either in a clockwise or in a counter-clockwise direction. The action described in the sentence could either match or mismatch the action that subjects had to perform in order to proceed in reading the sentence. For instance, since opening a bottle of water requires a clockwise action, reading a sentence which describes this action, should induce slower reading times when the knob has to be turned in a counter-clockwise direction because the motor resonance, activated by the verb, interferes with the action to perform in order to execute the task. Importantly, adverbs should modulate the ACE effect only if they deal with the action itself by increasing the linguistic focus on the motor content of the sentence. In fact, their results showed that when a verb was modified by an adverb, compatible motor responses were facilitated when reading the adverb only if the adverb primarily modified an action-related feature (e.g., quickly and slowly) and not when some other element of the referential situation was modified (e.g. happily, eagerly, or nervously). Within this theoretical framework, we propose that sentential negation is a powerful grammatical cue that could suppress the sensorimotor simulation of the (negated) action. The neural counterpart of such mechanism may be the lack of reduction of cortico-motor resonance for negative action verbs.

Psychophysical studies on the effects of the representation of linguistic negation suggest that the temporal characteristics of the experimental task (i.e. fast or delayed decision) have different effects on the processing of 'what is negated' [65]. On the basis of this and other behavioral findings [66], Kaup and colleagues [66,59] have proposed a two-step model of negation processing in which comprehenders first create a representation of 'what' is negated and than shift their attention towards the actual state of affairs (the state implied by the negation) at a later point in the comprehension process. On the basis of their data, the first step seems to occur within the first 1500 ms after the sentence onset, the second step should occur after 1500 ms or later. Interestingly, the fine-grained temporal resolution provided by TMS allowed us to provide neural indexes of the lack of simulation contingent upon negation even in the time window where affirmative and negative sentences should not differ on the basis of the model proposed by Kaup and colleagues [59] (500–700 ms after stimulus presentation).

Conclusions

In conclusion, our results demonstrate a selective modulation of the cortico-spinal excitability during: i) reading positive action related sentences with respect to positive, non-action related sentences; and ii), more importantly, reading positive hand action-related sentences compared with action-related negative sentences. Thus, we show that negation does not play a non-specific role in sentence representation but it does act as a gate that inhibits cortico-spinal sensorimotor simulation.

Supporting Information

Table S1 List of all experimental sentences. Each sentence is reported with its associated value of: **V F** = Verb Frequency; **O C F** = Object Complement Frequency; **V No S** = Verb Number of Syllables; **S No S** = Sentence Number of Syllables; **IMAG** = Imageability; **MOT R** = Motor Relatedness. In *italic* the English translation of each sentence. Frequencies are absolute values in the CoLFIS database (http://www.ge.ilc.cnr.it/lessico.php).
(DOCX)

Acknowledgments

We would like to thank Dr. Alessandro D'Ausilio, Prof. Anna Borghi, Dr. Laura Barca and Prof. Alessio Avenanti for useful discussions.

Author Contributions

Conceived and designed the experiments: MTL MC SMA. Performed the experiments: MTL MC. Analyzed the data: MTL MC. Contributed reagents/materials/analysis tools: MTL MC. Wrote the paper: MTL MC SMA.

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Consciousness and Cognition xxx (2011) xxx–xxx

Contents lists available at SciVerse ScienceDirect

Consciousness and Cognition

journal homepage: www.elsevier.com/locate/concog

Short Communication

Kids observing other kids' hands: Visuomotor priming in children

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ARTICLE INFO

Article history:
Received 22 December 2010
Available online xxxx

Keywords:
Motor resonance
Motor simulation
Visuomotor priming
Body schema
Body ownership
Embodied cognition

ABSTRACT

We investigated motor resonance in children using a priming paradigm. Participants were asked to judge the weight of an object shortly primed by a hand in an action-related posture (grasp) or a non action-related one (fist). The hand prime could belong to a child or to an adult. We found faster response times when the object was preceded by a grasp hand posture (motor resonance effect). More crucially, participants were faster when the prime was a child's hand, suggesting that it could belong to their body schema, particularly when the child's hand was followed by a light object (motor simulation effect). A control experiment helped us to clarify the role of the hand prime. To our knowledge this is the first behavioral evidence of motor simulation and motor resonance in children. Implications of the results for the development of the sense of body ownership and for conceptual development are discussed.

1. Introduction

The body mediates all the interactions we have with objects and other organisms in our world. Our own body determines our perception of objects, for example perception of slant and distance change if we are carrying a heavy backpack (Proffitt, Stefanucci, Banton, & Epstein, 2003). We also use our body to perceive and understand other people's actions, for example we process perceived actions that we can perform and ones that we cannot perform differently (Calvo-Merino, Grèzes, Glaser, Passingham, & Haggard, 2006). Highly important for our sense of body is the capability to differentiate our own body from the body of others (Borghi & Cimatti, 2010). There is evidence that our brain "resonates" when we see others performing actions. This 'resonance' mechanism is modulated by the similarity between the actions we observe and the actions we are able to perform. The neural underpinnings of motor resonance are thought to reside in the mirror neuron system (MNS) and canonical neuron system, discovered originally in the monkey premotor cortex (Di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Murata et al., 1997). Mirror neurons fire both when a grasping action is perceived and performed; canonical neurons fire when a given action is performed and when the subject sees an object that the action can be performed upon. Neurophysiological and neuroimaging studies suggest that a similar system and resonant mechanisms are also present in humans (for a review see Rizzolatti & Craighero, 2004). These mechanisms are modulated by the similarity between the perceived actions and the actions we are able to execute. Brain imaging and behavioral studies have shown that, when participants observe others dancing, climbing, or playing basketball, resonant mechanisms are evoked, and that this motor resonance is stronger when expert athletes rather than novices observe other experts (e.g. Aglioti, Cesari, Romani, & Urgesi, 2008; Cross, Kraemer, Hamilton, Kelley, & Grafton, 2009; Pezzulo, Barca, Bocconi, & Borghi, 2010). Behavioral

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doi:10.1016/j.concog.2011.09.015

Please cite this article in press as: Liuzza, M. T., et al. Kids observing other kids' hands: Visuomotor priming in children. *Consciousness and Cognition* (2011), doi:10.1016/j.concog.2011.09.015

evidence has shown that, when the actions observed are part of the motor repertoire of the perceiver, actions are recognized more easily (Knoblich & Flach, 2001). These findings are in line with the ideomotor theories (Hommel, Muesseler, Aschersleben, & Prinz, 2001; Prinz, 1997), according to which perceptual features and motor plans rely on a common representational code: in other words, the more similar the action we see and the action we can perform are, the easier we simulate.

Bruzzo, Borghi, and Ghirlanda (2008) investigated whether observing actions similar to the actions that are part of our motor repertoire influences processing perceived actions. They used a priming paradigm and found that participants were faster to decide whether an action made sense or not when they observed a hand interacting with an object (e.g. grasping an orange) in the actor (egocentric) perspective rather than in an allocentric perspective. This shows that it is easier to put ourselves in others' shoes and to resonate while perceiving an action when we share action-relevant characteristics, such as the viewpoint (egocentric or allocentric) with the actor.

We think it would be worth to distinguish between motor resonance and motor simulation, given that in the literature contrasting definitions have been provided (for a brief overview see Borghi & Cimatti, 2010; for different definitions see Gallese, 2009; Jeannerod, 2007).

In this paper we will use the term "motor simulation" to refer to the fact that observing objects activates a simulated motor action. In other words, observation of graspable objects, such as notebooks and dictionaries, should activate a motor simulation, the underlying neural basis of which is probably the canonical neuron system. Motor simulation refers to the process of internally simulating an action when perceiving an object that can be acted upon (first person perspective). Motor resonance, the neural basis of which is the mirror neuron system, instead, would be activated during observation of others interacting with objects – for example, when we observe somebody lifting a dictionary with the hand. Our mirror neuron system seems to resonate with differing intensity depending on the similarity between the actions we observe and the actions that are part of our motor competence. For example, Calvo-Merino et al. (2006) have shown that dancers' mirror neuron system resonated more when observing dancers of their own gender. Motor resonance refers to the overlap of characteristics between the perceiver's actions and the perceived actions.

In spite of the large body of evidence obtained (Aglioti et al., 2008; Buccino et al., 2001; Fadiga, Fogassi, Pavesi, & Rizzolatti, 1995; Urgesi, Moro, Candidi, & Aglioti, 2006), some mechanisms underlying motor resonance are still poorly understood. Results have shown that motor resonance increases when participants and the observed actor share the same culture (Molnar-Szakacs, Wu, Robles, & Iacoboni, 2007) and perspective (Bruzzo et al., 2008), and when they have a similar motor competence (Calvo-Merino et al., 2006). So far, however, few studies (Cattaneo et al., 2007; Lepage & Théoret, 2006; Martineau, Cochin, Magne, & Barthelemy, 2008) investigated the extent to which this motor resonance process changes during the lifespan, in conjunction with our bodily modifications. The present study aims to fill this gap, investigating to what extent motor simulation and motor resonance processes occur in children.

We addressed this issue using a visuo-motor priming paradigm, in which a hand prime was followed by a target-object. Behavioral evidence with visuomotor priming paradigms has shown that observing an effector in potential interaction with an object re-activates our perceptual and action experience with it (Borghi, Bonfiglioli, Lugli, et al., 2007; Borghi, Bonfiglioli, Ricciardelli, et al., 2007; Vainio, Symes, Ellis, Tucker, & Ottoboni, 2008): for example, Borghi and colleagues (Borghi, Bonfiglioli, Lugli, et al., 2007; Borghi, Bonfiglioli, Ricciardelli, et al., 2007; Setti, Borghi, & Tessari, 2009) have demonstrated that an action-related prime (i.e. a static grasping hand) can activate information regarding how to manipulate (e.g. using an unimanual or a bimanual grasp; a precision or a power grip) target objects or nouns referring to them. Along the same line, neuroimaging studies have shown that observing static pictures of the same objects being grasped or touched is sufficient to selectively activate the frontal mirror region (Johnson-Frey et al., 2003); further TMS evidence confirms that a grasping hand in (implied) motion affects the primary motor area (Urgesi et al., 2006). In a developmental study, Kalenine, Bonthoux, and Borghi (2009) have shown how action primes (e.g. a hand in grasping posture) can prime basic level concepts (e.g. 'saw') more effectively than superordinate concepts (e.g. 'tool') in children from the age of 7 (even if the developmental pattern is not clear).

In a previous study Setti, Liuzza, Burke, Borghi, and Newell (in preparation) investigated to what extent motor resonance increases when participants share the same age. The authors used a priming paradigm. A hand prime was followed by heavy vs. light manipulable objects; participants were required to decide whether the target-object was heavy or light. They found that both young adults and older adults responded faster to hand primes of their same gender, but overall they did not respond faster when they observed hands of actors of their same age compared to a different age. This suggests they did not resonate to others' actions. A possible reason for the absence of the motor resonance effect with people of the same age could be due to the simple fact that humans are not sensitive to the age differences. An alternative reason is that age matters and impacts motor resonance, but only when the body schema changes substantially. Given that from youth to older adulthood only partial changes in body schema occur, the difference between the younger and older hand may have been too subtle for a difference in motor resonance to be found. In addition, the lifting actions alluded to in Setti et al. (in preparation) study may be too simple to be susceptible to a different motor simulation between younger and older (see also Poliakoff, Galpin, Dick, & Tipper, 2009), i.e. both older and younger adults can easily simulate lifting of the objects used as stimuli.

In the present study we used a similar paradigm to investigate the extent to which children were sensitive to the difference between children's and adults hands. Few studies have investigated if the MNS is at play since childhood. Among them Lepage and Théoret (2006), for example, have demonstrated that, in children aged between 4 and 11 years, action observation reduces the magnitude of the mu (8–13 Hz) rhythm which is considered to reflect the activation of the mirror fronto-parietal system. Martineau et al. (2008) compared EEG activity during the observation of videos showing actions or still scenes in autistic children and neurotypical children between 5 and 7 years of age (3 girls and 11 boys, aged 5 years 3 months–7 years

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11 months). The authors found similar mu suppression during observation of human actions in the group of healthy children but not in autistic children. Similarly, it has been found (Cattaneo et al., 2007) that normally developing children between 5 and 9 years old, but not autistic spectrum disorder children of the same age, show an electro-myographic activity coherent with the observed action. This indicates that there is evidence of motor simulation activity in young neurotypical children.

Here, analogously to the study from Setti et al. (in preparation), we used a priming paradigm and a weight judgment task with children aged 7–10. The prime was a hand in grasping posture (either belonging to a child or an adult actor) or a hand in no-grasping posture (fist) and targets were heavy or light objects, the task required participants to decide if the target object was heavy or light. Based on the aforementioned evidence we hypothesized that a motor simulation would be activated while observing objects, and that a motor resonance process would be activated while observing others hands in potential interaction with objects.

We formulated the following predictions:

a. If observing objects activates a motor simulation (first person perspective, canonical mirror system), then heavy objects should be processed slower than light ones, given that in real life lifting heavy objects requires more time and effort than lifting light ones.
b. If observing actions with objects activates a motor resonance (mirror neuron system), then objects preceded by hands in a grasping posture should be processed faster than objects preceded by fist hand primes.
c. Because motor resonance should be modulated by the similarity between an observer and a model performing an action, we predicted that children would be more susceptible to motor resonance when the actor has the same body schema as the viewer. Therefore, we predict that, when the prime is an action that is portrayed by a child's hand, reaction times should be faster.
d. If, as we hypothesize, a child mirror neuron system is more likely to resonate when the hand prime is similar to the subject's hand, the difference between the light and heavy objects should be more pronounced when preceded by a child hand prime than by an adult's hand prime.
e. Finally, if an interaction between action posture, age of the prime and weight of the target occurs, we aim to assess in what direction the presence of the prime modulates performance compared to a baseline without any prime. In other words, we hypothesize that, without any prime, we should observe the same pattern of results that we would observe in presence of a dissimilar prime or of a non-action prime. To this purpose, we ran a control experiment, in which no prime preceded the target stimuli.

2. Experiment 1

2.1. Participants

Sixty-one children (28 Female; mean age = 8.46 years old; range = 7–10; st. dev. = 1.09) volunteered to take part in the study with their parents informed consent conforming to the Declaration of Helsinki. They had self-reported good vision and hearing and they all reported to be right handed. None of the participants suffered from neurological illness. This age group was chosen as the study by Kalenine et al. (2009) suggests that children at this age are already susceptible to visuo-motor resonance, however this particular study did not directly compare action primes with perceptually similar no-action primes (action primes were compared with scenes). In addition a study by Mounoud, Duscherer, Moy, and Perraudin (2007) suggests that actions are part of an automatically activated conceptual knowledge of certain kinds of objects (i.e. tools) from age five. However none of these studies directly address visuo-motor resonance.

2.2. Stimuli

We used three pictures of familiar light objects (empty box of matches; block notes; mobile phone) and three pictures of familiar heavy objects (dictionary; brick; gym weight) as targets (Fig. 1A). The pictures were black and white and were edited

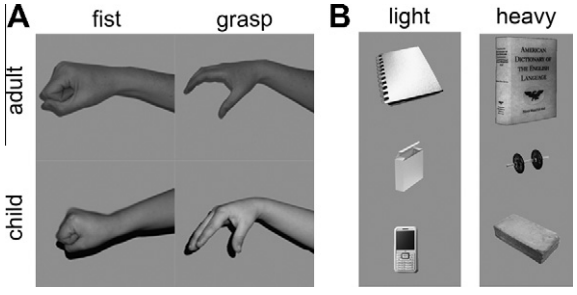

Fig. 1. (A) An example of hand primes used in the Experiment 1. (B) Target stimuli used in the Experiments 1 and 2. Subjects were asked to judge them as heavy or light.

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with Adobe Photoshop®. Their average size was 13 × 10.5° and pictures were presented to participants at a distance of 57 cm from the screen. Pictures used as primes displayed a hand in grasping or no grasping position (fist) on a neutral background. The actor portraying the grasping or no grasping action could be female or male and the hand could belong to an adult or child (Fig. 1B). Both the female and male child actors were 4 year-old and the female and male adult actors were 25 and 28 respectively.

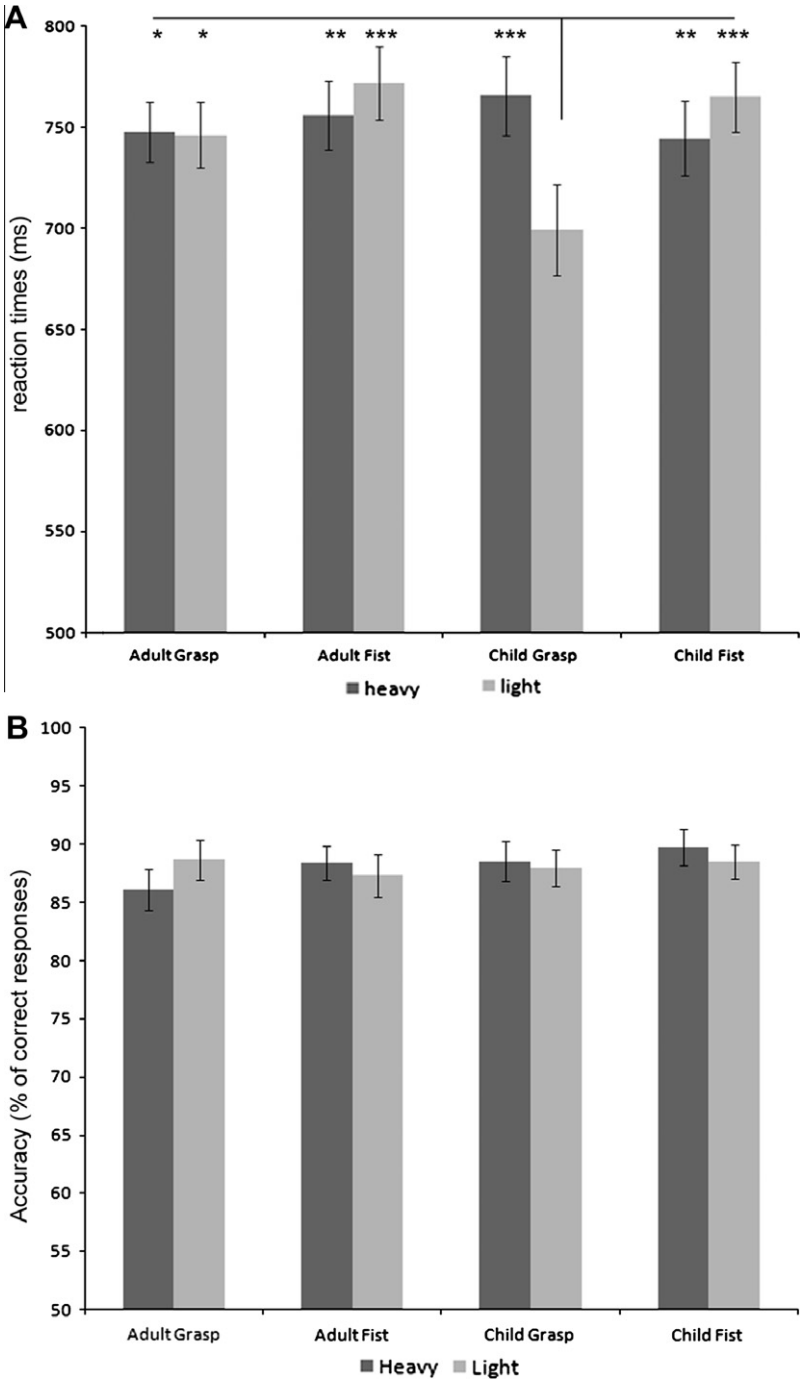

Fig. 2. (A) Experiment 1: response times (in ms) for heavy and light objects when preceded by a Child or an Adult hand in Grasp or Fist posture. Asterisks mean that the *p* Newman–Keuls post hoc is significant ($^{*}p < .05$; $^{**}p < .01$; $^{***}p < .005$). Error bars represent the standard error of the mean. (B) Experiment 1: accuracy (percentage of correct responses) for heavy and light objects when preceded by a Child or an Adult hand in Grasp or Fist posture. Error bars represent the standard error of the mean.

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2.3. Design and procedure

The gender of the prime was matched with the gender of participants. Every target stimulus was presented 16 times, and every hand prime 24 times, for a total of 96 trials.

Participants were seated at approximately 57 cm from the computer screen (DELL laptop XPS M1530, monitor 19 in.) and they were presented with a fixation cross for 500 ms, followed by a visual image of a hand (prime) for 700 ms, followed by the picture of an object that could be heavy (e.g. dictionary) or light (e.g. matches box). Their task was to respond by pressing the 'm' key with the index finger of their right hand if the object was heavy and the 'z' key with the index finger of their left hand if it was light (half of the participants responded heavy with the left hand and half with the right hand). The experiment lasted less than 10 min and it was programmed and delivered with E-Prime software.

2.4. Results

The Mean participant error rate was 12% (0.09 SD). We excluded eight participants from the correct RT analysis because their accuracy in one of the experimental conditions was less than 50%. Participants' response times (RTs) over or above two SD from the subject's RT grand mean were removed from the analysis (5.3%).

We entered the percentage of errors in a $2 \times 2 \times 2$ ANOVA with Age of the prime (child vs. adult), Kind of prime (grasp vs. no grasp) and Weight of the target (heavy vs. light) as within participant variables. We found no significant main effect. Importantly, there was no effect of the target weight, nor interactions ($F(1,60) < 1.81$, $ps > .18$, see Fig. 2B). Table 1 also reports the sensitivity (d prime) and the response bias (beta). Furthermore, mean accuracy scores and mean RTs for each subject did not positively correlate ($r = -.17$, $p > .12$). Since we could conclude that there was not speed-accuracy trade off at play, we focused our analysis on RTs.

Correct RTs were entered in a $2 \times 2 \times 2$ ANOVA with Age of the hand prime (child vs. adult), Kind of prime (grasp vs. no grasp) and Weight of the target (heavy vs. light) as within participant variables. We found a significant main effect of the Kind of prime (grasp vs. no grasp, ($F(1,52) = 5.48$, $p < .05$), participants performing faster when primed by a hand in action posture (grasp) than when the hand prime posture did not portray the grasping action (fist) (739 ms ± 98 SD vs. 759 ms ± 120 SD) respectively). We also found that the main effect of the Age of the hand approached significance ($F(1,52) = 2.98$, $p = .09$), due to the fact that participants tended to be faster when primed by a child's hand as opposed to an adult one (743 ms ± 103 SD vs. 755 ms ± 113 SD). The Kind of prime interacted significantly with the Weight of the target, ($F(1,52) = 10.1$, $p < .005$). Newman–Keuls post hoc test revealed that, within the action prime condition (i.e. when a hand in a grasp posture preceded the target), participants were faster to process light objects than heavy ones (722 ms ± 104 SD vs.

Table 1
Response bias in Experiments 1 (in each prime condition) and 2.

Experiment 1	Response "heavy"	Response "light"
Adult grasp		
Target heavy	.86	.14
Target light	.11	.89
D prime	2.29	
Beta	1.15	
Adult fist		
Target heavy	0.88	0.12
Target light	0.13	0.87
D prime	2.34	
Beta	0.94	
Child grasp		
Target heavy	0.89	0.11
Target light	0.12	0.88
D prime	2.38	
Beta	0.97	
Child fist		
Target heavy	.90	0.10
Target light	0.11	0.89
D prime	2.47	
Beta	0.92	
Experiment 2	Response "heavy"	Response "light"
Target heavy	.94	.06
Target light	.19	.81
D prime	2.45	
Beta	0.44	

The table reports the proportions of responses in each condition, the sensitivity (*D* prime) and the response bias (Beta) for each prime condition.

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757 ms ± 121 SD, $p < .02$). Furthermore, light objects were processed significantly faster ($p = .03$) when primed by an action hand posture than when primed by a fist ($ps < .03$).

Importantly, we found a significant three way interaction between Kind of prime, Age of the hand prime and Weight of the target, ($F(1,52) = 4.97$, $p = .03$, see Fig. 2A). Newman–Keuls post hoc test revealed that the interaction was due to the fact that the response to light targets primed by a child hand in an action posture was faster (699 ms ± 164 SD) than all the other conditions, $ps < .02$).

3. Experiment 2

The most important result of Experiment 1 consisted in the facilitation found when kids observed a child's hand prime. As to the target-objects, we did not find any difference in RTs between Light and Heavy Objects when they were preceded by an adult hand or by a hand prime that did not display an action (fist). Since we did not have a non-prime condition, we could not establish if the difference in RTs between Light and Heavy targets found in the Child grasp prime condition had a pattern which reflected or differed from a baseline without any prime. To clarify this point we ran a control experiment in which we presented only the target-objects without the hand prime. If observing objects activates a motor simulation (probably mediated by the canonical neurons system) even in absence of a hand prime, then we should find an advantage of light over heavy objects.

3.1. Participants

Twelve children (seven Females; mean age = 8.92 years old; range = 6–13; st. dev. = 2.23) volunteered to take part in the study with their parents informed consent conforming to the Declaration of Helsinki. They had self-reported good vision and hearing and they all reported to be right handed. None of the participants suffered from neurological illness.

3.2. Stimuli

The target-stimuli were the same as those used in Experiment 1 but the hand primes were not presented.

3.3. Design and procedure

The design was the same as that of Experiment 1, but without the prime. Every target stimulus was presented 16 times, so every condition (heavy target, light target) included 48 observations. The experiment lasted about 5 min.

3.4. Results

The Mean participant error rate was 13.11% (0.33 SD). We excluded one participant from the correct RT analysis because the accuracy in one of the experimental conditions was less than 50%. Participants' response times over or above two SD from the subject's RT grand mean were removed from the analysis (5.2%).

We compared Mean correct RTs of the Weight of the target (heavy vs. light) by a two tailed paired sample T test and we did not find any significant difference (mean light = 745 ms ± 155 SD vs. mean heavy = 702 ms ± 167 SD, $t(10) = 1.30$, $p = 0.22$, Cohen's $d = 0.27$, see Fig. 3A). This result confirms that, similarly to a baseline condition in which no prime precedes the target, the lack of a dissimilar prime (an adult hand) as well as of a similar prime which does not perform any action (a child fist) does not cause any difference in the speed of processing of heavy vs. light objects.

Even though the RTs for the heavy objects seem to be faster than in the Experiment 1, the Equal Variances Not Assumed T-Test showed no difference between the two experiments ($t(12.24) = 0.96$; $p > .3$).

In order to rule out the speed-accuracy trade off, we compared mean accuracy (percentage of correct responses on the total number of trials per condition) of the Weight of the target (heavy vs. light) by a two tailed paired sample T test and we found that participants performed worse with light (80%) than with heavy (94%) objects ($t(11) = 2.90$, $p < .05$, see Fig. 3B). This result, even if significant, is convergent with the RTs result (as is evident by looking at Fig. 3A and B) and rules out a trade off between speed and accuracy. The difference we found n accuracy seems to be due to a response bias toward "heavy", as shown in Table 1.

In order to assess whether any specific item was at the grounds of this difference, we conducted an analysis of variance with the target object as a factor. This analysis showed an effect of the stimulus ($F(5,55) = 5.48$, $p < .001$). Newman–Keuls post hoc test revealed that this was due to one single target, the notebook, which has an accuracy rate (67%) which was significantly ($ps < .05$) worse than any other stimulus percentage rate (all above 83%). The same does not apply to the first experiment, where the significant analysis of variance ($F(5, 300) = 2.50$, $p < .05$) of the single stimuli is not explained by the worst performance of a single item compared to others, but just by a worse performance with the brick compared to the gym weight (85.3% vs. 90.6%, $p < .05$).

In Experiment 2 we performed a second T-test on the accuracy scores removing the notebook stimulus. In this case, no significant difference between heavy and light targets occurred ($t(12) = 1.89$, $p = .08$).

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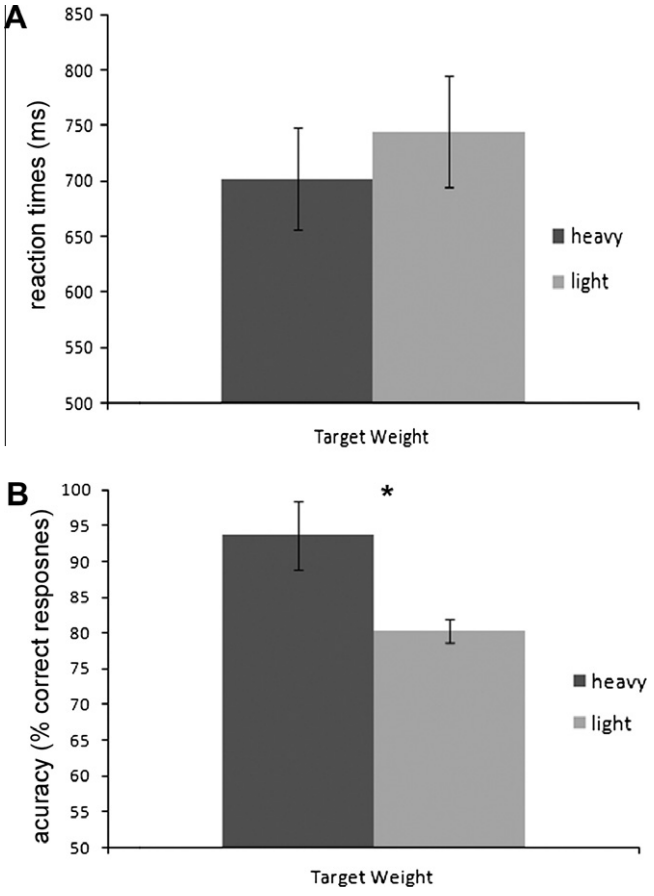

Fig. 3. (A) Mean response times of the Experiment 2. (B) Mean accuracy in the Experiment 2. ($^{*}p < .05$).

We followed the same procedure with RTs and the *T*-test confirmed that no difference between heavy and light targets was at play ($t(10) = .47$, $p = .64$).

4. Discussion

The present study investigated motor simulation and motor resonance in children from age 7 to 9. We hypothesized that motor resonance would be more pronounced when the actor was a child, because of the difference in body schema between children and adults.

4.1. Motor simulation and motor resonance in children

4.1.1. Motor simulation

Heavy and light stimuli did not differ in RTs; this suggests that no automatic motor simulation of object lifting, triggered by the simple object observation (and with the probable mediation of the canonical neurons system), was found. This difference was not observed, neither when the target objects were presented in isolation, as we showed in a control experiment (Experiment 2), nor when they were preceded by an adult hand prime or a child hand prime that did not imply an action (fist).

More importantly, Experiment 1 results showed that response times were faster when graspable objects were preceded by a visual hand prime in an action rather than in a no-action posture (fist). This indicates that observing a static hand displaying a grasping position followed by an object activates a motor simulation. Importantly, this simulation is not triggered by the generic observation of a hand, but by the observation of a hand displaying an implicit action. This confirms and extends to children results that have been previously found in adults (e.g. Borghi, 2005; Borghi, Bonfiglioli, Lugli, et al., 2007).

4.1.2. Motor resonance and motor simulation

We found that children's responses were facilitated when the hand prime was a child's hand. This effect interacted with the Kind of prime (action posture vs. no-action posture) and with the Weight of the target. Children were faster when a

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prime depicting an action portrayed by a child preceded a light object, possibly because the internal simulation of a grasping action is stronger when the actor is also a child. In addition the simulation is quicker/easier when the object is light than when it is heavy (the action of lifting a light object is less demanding than lifting a heavy object). Significantly, this difference between heavy and light target was not observed in any other condition, nor when the objects were presented without the prime (Experiment 2). This interaction allows us to determine that our results are not simply due to world knowledge; rather, they are due to motor resonance effects. Indeed, the faster RTs obtained with light objects with a child hand prime is due to the fact that participants tend put themselves in the shoes of other children. If they were due to knowledge, targets preceded by adult's hands should be processed faster than those preceded by child's hands, given that it is intuitive that, due to their bodily characteristics, adults lift objects more easily than children. Therefore our results allow us to reject a possible alternative explanation, according to which children responded by trying to assess whether the object on each trial would be light or heavy for the particular hand shown in that trial's prime. This strategy could explain the advantage of the grasping over the fist prime, but it would not explain why children responded faster when they saw a child's hand in the grasping posture than when they observed an adult's hand in the grasping posture. Therefore we can conclude that our results are due to a motor resonance effect.

We suggest that this motor resonance occurs because participants (i.e. children), shared their body schema with the child-actor portrayed in the prime. This interpretation is in line with the absence of motor resonance linked to age in Setti et al. (in preparation). The discrepancy between the present study, in which children are presented with children's and adults hands, and Setti et al. (in preparation) study, in which younger and older adults are presented with younger and older adults' hands, suggests that the changes in body schema later in life may be not as radical as from childhood to adulthood, therefore not producing an age effect in motor resonance. Alternatively the lack of a differential resonance effect between younger and older adults in our previous study may be due to the fact that both older and younger adults can easily simulate lifting the particular objects we used as stimuli. However the results of the present work favor the interpretation in terms of body schema similarities, as here a difference in motor resonance was found even if we assume that both children and adults can simulate the lifting actions.

4.2. Theoretical implications of the present study

First, our study has implications for literature on conceptual development. Since the seminal work by Piaget (1952), a variety of studies with different paradigms (property verification; feature production) have shown that children's conceptual knowledge is grounded in perception and action (Borghi & Caramelli, 2003) and that interaction with objects has a direct impact on categorization (Smith, 2005). In addition, studies with priming paradigms show that from approximately 5 years of age children automatically activate action-related information when perceiving a tool (Mounoud et al., 2007) and that a hand in a grasping posture can prime basic level concepts (e.g. 'saw'), more effectively than superordinate concepts (e.g. 'tool') from the age of 7 (even if the developmental pattern is not linear). Taken together this series of studies suggests that, when perceiving an object, children simulate the corresponding actions evoked by the object, and that, when observing a hand, a grasping action with a single object is simulated. The present study, however, is the first to provide behavioral evidence of motor simulation and motor resonance in children. Further work is needed to understand the development of the mechanisms underlying these two processes and to precisely disentangle their relationship with body schema changes during the lifespan.

Regarding the neural underpinnings of the visuo-motor simulation during development, the earliest indirect evidence available to date of an MNS in infants comes from a study by Shimada and Hiraki (2006). This study demonstrated by means of near infrared spectroscopy the presence of action execution and observation matching system in 6-month-old human infants. Lepage and Théoret (2007) recently proposed that the development of the MNS can be conceptualized as a process whereby the child learns to refrain from acting out the automatic matching mechanism that links action perception and execution. Such development could be viewed as a process leading from mandatory reenactment to a covert simulation of the observed motor acts, most likely through the maturation of prefrontal inhibiting mechanisms. In our study we found evidence of both motor simulation and motor resonance in children, from 7 years on. This suggests that in 7-year-olds an automatic matching mechanism is no longer present, given that the activation of the resonant processes is modulated by the similarity in body schema between the actor and the agent. Further studies are needed, to understand when this modulation process – which implies the recognition of the differences between our own body and others' body – starts.

Finally, our study gives us some hints on the development of the notion of self. Recent studies and theoretical proposals have explored the existing relationship between the sense of body ownership (e.g. de Vignemont, 2011) and the sense of agency, i.e. the ability to control our own actions. Tsakiris, Longo, and Haggard (2010) have shown with an fMRI study that activation of midline cortical structures was linked to the sense of sensory-driven body ownership, whereas sense of agency activated the Pre-Supplementary Motor Area. Even if there is no evidence for overlap between the neural circuits involved in body ownership and agency, being able to perform a voluntary action intuitively seems to be the precondition for developing the sense of possessing a unitary body. When we respond to external stimuli the body is perceived simply as a collection of fragmented and not integrated body parts. Once we act on objects, instead, we begin to perceive our body as a functional whole, clearly distinct from others' bodies (Tsakiris, Prabhu, & Haggard, 2006). Developing a sense of body ownership implies recognizing that this body is unique, and that it moves in a coherent and unitary way (Tsakiris et al., 2010). Crucially for the present study, an important part of the acquisition of the sense of our body concerns the ability to distinguish ourselves from

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others, and this ability is grounded in action. The fact that we found an effect of age-related motor resonance in children, whereas it was not present with younger and older adults (Setti et al., in preparation), opens some interesting scenarios. It suggests that children at this age have developed a clear social sensitivity and that this social sensitivity is truly grounded and embodied (Semin & Smith, 2008): children record and differently resonate to the differences between kinds of bodies, and in particular between their own body and the body of adults. The alternative explanation, that a child's hand could portray social identity features (Molnar-Szakacs et al., 2007) not shared by adults, i.e. that the children respond faster to members of their own in-group, is less clearly supported by the data. Namely, it would explain the advantage obtained with kids' hands compared to adults' hands, but it would not explain the pattern found in the interactions (in particular faster response times to light objects when the prime is a child hand implying action). Further studies will allow us to better understand how the process of motor resonance develops in time and during our life. This is crucial, also in light of the fact that the motor resonance process informs us about complex relationships between the sense of our own body and our social awareness, between embodiment and sociality.

4.3. Conclusions

The present study shows by means of a visuomotor priming paradigm how motor simulation occurs in 7–10 year old children. In addition, it shows that motor resonance in children is strengthened when a light target object is preceded by a child's hand in an action posture compared to an adult hand. These findings provide new insights relevant to the development of the mirror neuron system and the role of congruence between the observer and the actor's body schema in facilitating motor resonance.

Acknowledgments

The research by the EU FP7 project "Emergence of communication in RObots through Sensorimotor and Social Interaction" (ROSSI), Grant Agreement 216125 (www.rossiproject.eu).

Thanks to Kate Burke for the revision of the English text. We thank EMCO Lab (www.emcolab.it) for the support in data collection. We thank Fondazione Golinelli for the organization of Scienza in Piazza.

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OPEN ACCESS Freely available online

PLoS one

Follow My Eyes: The Gaze of Politicians Reflexively Captures the Gaze of Ingroup Voters

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Abstract

Studies in human and non-human primates indicate that basic socio-cognitive operations are inherently linked to the power of gaze in capturing reflexively the attention of an observer. Although monkey studies indicate that the automatic tendency to follow the gaze of a conspecific is modulated by the leader-follower social status, evidence for such effects in humans is meager. Here, we used a gaze following paradigm where the directional gaze of right- or left-wing Italian political characters could influence the oculomotor behavior of ingroup or outgroup voters. We show that the gaze of Berlusconi, the right-wing leader currently dominating the Italian political landscape, potentiates and inhibits gaze following behavior in ingroup and outgroup voters, respectively. Importantly, the higher the perceived similarity in personality traits between voters and Berlusconi, the stronger the gaze interference effect. Thus, higher-order social variables such as political leadership and affiliation prepotently affect reflexive shifts of attention.

Citation: Liuzza MT, Cazzato V, Vecchione M, Crostella F, Caprara GV, et al. (2011) Follow My Eyes: The Gaze of Politicians Reflexively Captures the Gaze of Ingroup Voters. PLoS ONE 6(9): e25117. doi:10.1371/journal.pone.0025117

Editor: Jan Lauwereyns, Kyushu University, Japan

Received June 7, 2011; **Accepted** August 24, 2011; **Published** September 21, 2011

Funding: This study was funded by TANGO, Istituto Italiano di Tecnologia SEED 2009 (Protocol Number 21538), and Sapienza University of Rome to S.M.A. The project Tango acknowledges the financial support of the Future and Emerging Technologies (FET) programme within the Seventh Framework Programme for Research of the European Commission, under FET-Open grant number: 249858. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing Interests: The authors have declared that no competing interests exist.

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Introduction

Possibly because of their unique morphology, human eyes are specially adept to mediate fundamental non-verbal communication skills [1]. In particular, gaze direction powerfully modulates social interactions at both explicit and implicit levels [2]. Detecting the gaze of other individuals reveals where they are attending [3,4,5], signals potential sources of reward or danger and activates basic motivational-emotional, approach-avoidance responses [6]. The reflexive shift of visuo-spatial attention is considered an early social cognitive ability leading to the later developmental ability to infer others' mental states [7,8]. Social attention may rely upon a neural network where subcortical nodes mediate crude and largely unconscious, fast orienting responses to interpersonally relevant stimuli and cortical nodes subserve slower and conscious, context-dependent appreciation responses [9].

Gaze-mediated attentional capture is a fundamentally adaptive function that may be triggered automatically and thus be comparatively impervious to the influence of higher-order socio-cognitive variables. Tellingly, however, low- social status male rhesus macaques reflexively follow the gaze of any familiar rhesus macaques, but high-status macaques selectively follow the gaze of other high-status monkeys [10].

Social attention relies on gaze following behavior, the automatic tendency to imitate the oculomotor behavior of others [11,12,13], which is at the very basis of the development of other social cognitive skills [14]. This automatic imitative behavior seems to be subserved by a neural mirroring mechanism [15] similar to the one at play in during action observation in monkeys [16]. Relevant to the present study is that, albeit automatic, the motor resonance triggered by perception of others' actions seems to be modulated by the similarity between the observer and the model [17,18].

Humans have developed large-scale political behavior, a very complex form of social behavior that requires an even more complex form of social knowledge and cognition [19]. Evidence of simpler political behavior in chimpanzees [20] and capuchins [21] suggests that we may have evolved in ways that maximize our capabilities for small-scale interactions. At least in western societies people are involved in multiple political activities, participate to elections, and join political groups. Choosing a party or a political group generically gives us a social identity [22]. Affiliation allows us to categorize rapidly and effortlessly other individuals as in-group and out-group. This act of categorization may be made consciously or unconsciously [23]. In fact, categorization of people into in-groups and out-groups has been observed after just milliseconds of mere exposure to persons or ideas about persons, with little or no effort, intention, awareness, or conscious control [24].

Beyond the mere affiliation, political ideology seems to have important social psychological functions [25]. Jost and colleagues [26], for instance, have described political conservatorism as a form of motivated social cognition which includes personality traits as authoritarianism [27] and ideological rationalizations as social dominance orientation [28]. These psychological differences between ideologies have been found to be reflected also in general neurocognitive functions [29] and in tasks where the sensitivity of

the attention to social signals as the gaze of a schematic character [30] is tested. Furthermore, research on the moral foundations of ideology [31] has shown that conservatives, compared to liberals, endorse more moral values as loyalty to authority and to their own group.

Here we expand monkey studies [10] by investigating in humans whether reflexive attention might be influenced by social identity variables. To this aim, we explored whether reflexive gaze shifts were influenced by political affiliation, a process that allows conscious or unconscious, rapid categorization of individuals as in-group or out-group [23].

We tested 28 participants who were assigned to a left-wing (N = 15) or right-wing (N = 13) group on the basis of a questionnaire assessing their political orientation and voting behavior. Participants were required to perform a saccade towards a left- or a right-sided black square (target) when a black central square turned into red or blue respectively (imperative, instruction signal). The black square was positioned between the eyes of a political character face gazing straight to the participant. 75 milliseconds before the imperative central square color change, the character made a left- or right-ward saccade, either congruent or incongruent with the direction cued by the imperative signal. The character faces used in the present study, portrayed well-known, current or former political leaders and opinion makers, in order to disentangle the possible modulating role of the actual influence on the political landscape and/or the mediatic exposure. For these reasons we chose the pictures of the following personalities: Silvio Berlusconi (the most important centre-right wing, current prime-minister, political leader), Bruno Vespa (centre-right wing, opinion maker), Antonio Di Pietro (centre-left wing, current political leader) and Romano Prodi (centre-left wing, former prime-minister, no longer active as political leader). We used the difference in the accuracy between congruent and incongruent trials as an index of the interference of the models' gaze on the onlookers' oculomotor response.

To explore whether the influence of political affiliation on reflexive gaze following is linked to dispositional factors (e.g. the perceived similarity between oneself and specific political characters), we capitalized on social psychology studies emphasizing the relationship between the voters' personality characteristics and their political affiliation [32]. We focused on a conceptual framework that highlights the similarity between personality traits of voters and of same- or different-affiliation political leaders. In particular, we predicted that higher perceived similarity with a politician induced stronger gaze following behavior in a voter. Participants rated how much each item in a list of 25 adjectives representative of each dimension of the Big Five [33,34] described themselves and four different political characters. Differences between the ratings concerning self (the voter) and others (each of four characters) provided a measure of the perceived similarity between voters and politicians.

Materials and Methods

Ethics statement

The experimental procedures were approved by the Fondazione Santa Lucia Ethics Committee (14/05/2008) and were carried out in accordance with the principles of the 1964 Declaration of Helsinki.

Participants

Twenty-eight subjects (12 males, mean age = 25.25; SD = 2.89) gave their written informed consent to participate in the study. All had normal or corrected to normal vision with no history of neurological or psychiatric disease and were naïve to the purposes of the study. On the basis of a questionnaire assessing political preference and voting behavior (see below for more details), 15 participants were assigned to the left wing (9 females) and 13 subjects to the right wing group (7 females). The two groups were matched in age ($t(26) = .03$, $p = .97$), education ($t(26) = .38$, $p = .70$) and interest in politics ($t(26) = 1.59$, $p = .12$).

Stimuli and Procedures

Eye movement recording. The study was performed in a quiet room with medium illumination (about 64 cd/m2). Subjects sat on a comfortable chair in front of an LCD monitor, positioned at about 57 cm from their eyes. Eye position and eye movements were measured monocularly in real-time by means of an infrared video-based system (ASL 504 Remote Tracker, Applied Science Laboratories, USA). The experiment was created with E-Prime software (version 1.1, Psychology Software Tools, Inc., Pittsburgh, PA) running on an IBM compatible computer. Each trial started with the appearance of a black central fixation square ($0.21^\circ \times 0.21^\circ$ in size) presented on a light gray (about 47 cd/m2) background, and of two larger black squares ($0.43^\circ \times 0.43^\circ$) presented at 10.2° of eccentricity in the left and the right visual field. The fixation square was presented on the between-eyes point of the face of a political character with straight gaze. After 575 ms, the color of the central square changed to either blue or red). This was the imperative signal for the participants to make a fast and accurate saccade toward the left (change into blue) or the right (change into orange) target square. The colored cue remained visible until the end of the trial. 75 ms before the onset of the instruction-cue (stimulus onset asynchrony, SOA) the distracting character made a left- or right-ward saccadic movement. This interval was chosen because we demonstrated that gaze following behavior is maximal at this interval [11,12,13]. The characters used as distractors where: Antonio Di Pietro; Romano Prodi; Silvio Berlusconi; Bruno Vespa. It is also important that, at the data collection time (i.e. between 24th of July, 2009 and 24th October, 2009) the index of the trust in Berlusconi, varied between 55% (August 2009) and 60% (October 2009), as emerged by the "CRESPI Ricerche" phone CATI method survey (available at http://www.sondaggipoliticoelettorali.it/) on a 1,000 people sample stratified for sex, age, geographic area and population center size.

For each character-face we prepared a RGB digital photography ($6.76^\circ \times 6.76^\circ$). The original pictures were collected by searching in internet and modified by means of the Adobe Photoshop software (Adobe Systems Incorporated). To enhance their saliency, the stimuli were animated by two frames presented in rapid sequence. The first frame (lasting 500 ms) was replaced by a second frame lasting 875 milliseconds. The first frame depicted a straight gaze. The second frame depicted a gaze that could be oriented leftward or rightward. The direction of the character gaze and that one indicated by the instruction-cue could be congruent (e.g. both leftward) or incongruent (e.g. one leftward and the other rightward). Importantly, subjects were instructed to ignore the distracting stimulus and to focus their attention on the central square color change. Subjects were tested in four separate blocks, each associated with a character face. In each block, the two instruction cues (leftward or rightward) and the two distractors (congruent or incongruent) were equally probable and were presented in a random sequence. Each of the 4 possible combinations was equally probable and was repeated 12 times. Thus, a total of 48 trials per block was run. We analyzed the participants' directional accuracy by focusing on the first horizontal saccade that followed the instruction cue and had an

amplitude larger than 2°. Saccadic RTs were also collected. Only RTs for correct trials were considered. The trials in which there was no clear evidence that a saccade occurred were excluded (725 out of 5376, 13.5%). A trial was rejected from the analysis described below if the latency was either less than 100 ms (anticipations) or greater than 500 ms (delays). The proportion of rejected trials was 3.4% of the total trials.

Measures of Voters' dispositions and personality. Participants filled out a self-report questionnaire in which the following measures were recorded: i) socio-demographic variables, as gender, age, and education level; ii) interest in politics as attested by frequency of discussion on the topic with their a) family members, b) colleagues at work, c) acquaintances, and d) friends (from 1 = "never" to 5 = "every day"). A single index of interest in politics was obtained by averaging the five ratings; iii) political orientation along a 7 point Likert like scale where 1 represents extreme left wing, 4 center, and 7 extreme right wing; iv) voting behavior in the last European political elections (June, 2009).

Participants were also shown the face of each character and asked to rate (along five-point Likert scales) the following:

1) Exposure: "please rate how much do you know the political character and his personality where 1 is "I know him very well" and 5 is "I do not know him at all";
2) Influence: "please rate how much do you think this character is influent within the Italian political landscape" where 1 is "very influent" and 5 is "not influent at all";
3) Positive emotions: "please rate how much do you think this character evokes positive emotions" where 1 is "not positive at all" and 5 is "very positive";
4) Negative emotions: "please rate how much do you think this character evokes negative emotions" where 1 is "not negative at all" and 5 is "very negative";

Assessment of personality similarity between Voters and Characters Personality. Participants rated themselves and separately each the four political characters on the Five Factors of personality (Energy/Extraversion, Agreeableness, Conscientiousness, Emotional stability, Openness [33]) using a list of 25 adjectives [34]. The list included five markers of: Energy/Extraversion (happy, determined, dynamic, energetic, active); Agreeableness (cordial, generous, loyal, sincere, unselfish); Conscientiousness (efficient, scrupulous, precise, conscientious, diligent); Emotional stability (optimistic, self-confident, solid, relaxed, calm); and Intellect/Openness to experience (sharp, creative, innovative, modern, informed). The adjectives were selected from a larger list of adjectives that have previously been identified in the Italian lexicon as being among the most frequently used to describe human personality and also the most representative of each of the dimensions of the Big Five. Each adjective was rated for how characteristic it was of each target on a 1 ("not at all") to 5 ("very much so") scale. We measured the perceived personality similarity in personality traits with each character by adopting procedure used in our previous studies [35,36]. We started computing the Euclidean distance between the ratings for the self and the four political characters for each item (e.g. the square root of the squared difference of item 1 referred to self and item 1 referred to Berlusconi). We obtained a normalized dissimilarity score by summing the Euclidean distance of all the items and divided it for the maximum value (being 4 the maximum distance for each item, and having 25 items, we divided the sum for 100). This procedure allowed us to obtain a dissimilarity score between the voter and each politician. Dissimilarity scores of 1 and 0 indicate maximal difference and absence of difference, respectively. By subtracting the dissimilarity score from 1, we obtained the perceived similarity score which ranged from 0 (no similarity) to 1 (complete similarity). This score was entered in the correlation analyses.

In addition, we assessed the similarity between the perceived personality of each participant and of the four characters as 'objectively' assessed by averaging across the whole sample the ratings on each item.

Results

Ratings

Participants classified Di Pietro and Prodi as belonging to centre-left wing coalition (ratings 3.21 and 3.00, significantly lower than 4, $ts<-3.3$, $ps<.01$) and Berlusconi and Vespa as belonging to the center-right wing coalition (ratings were 5.75 and 4.73, significantly higher than 4, $ts>3.34$, $ps<.01$).

Media exposure ratings (where 1 = I know him through the media very well and 5 = I do not know him at all) were entered in a mixed model 2×4 ANOVA with group as between-subjects and character as within-subject factors. We found a main effect of character ($F(3, 75) = 7.41$, $p<.001$), but not of group ($F(1, 25) = 1.13$, $p>.29$). The interaction between group and character was not significant ($F(3,75) = .04$, $p>.75$). Duncan post-hoc comparisons showed that Berlusconi is considered more influent than anyone else ($ps<.01$). No other comparisons were significant.

Influence ratings (where 1 = very influent and 5 = not influent at all) were entered in a mixed model 2×4 ANOVA with group as between-subjects and character as within-subject factors. We found a main effect of character ($F(3, 75) = 22.46$, $p<.001$), but not of group ($F(1, 25) = .004$, $p>.94$). The interaction between group and character was not significant ($F(3,75) = 1.07$, $p>.36$). Duncan's post-hoc comparisons showed that Berlusconi is considered more influent than anyone else (mean 1.4, $ps<.001$). Moreover, Di Pietro (mean 2.6) was judged significantly more influent than Prodi (mean 3.6, $p<.001$), but only marginally significantly more influent than Vespa (mean 3.1, $p = .05$). Reports of positive minus negative emotions were used to compute an index of emotional positivity elicited by each character in each voter. These values were entered in a mixed model 2×4 ANOVA with group as between-subjects and character as within-subject factors. We found a main effect of group ($F(1, 25) = 6.67$, $p<.05$) which was accounted for by the less positive emotions reported by left-wing (−.93) than right-wing voters (−.17). The significance of the main effect of character ($F(3, 75) = 3.84$, $p<.05$) was explained by the more positive emotions elicited by Di Pietro (.56) with respect to the other characters (Berlusconi = −.77, Prodi = −.97, Vespa = −1.03; $ps<.05$). Duncan's post-hoc comparisons suggested that the significance of the group by character interaction ($F(3, 75) = 19.37$, $p<.001$) can be explained by an emotional ingroup bias. Indeed, significantly higher positive and negative emotion ratings were given to ingroup and outgroup characters respectively (all $ps<.05$, see Table 1), with the exception of Di Pietro who did not differ from Vespa within the right wing group ($p>.5$). Importantly, within the right-wing voters, emotions toward Di Pietro and Vespa characters did not differ significantly from zero ($ps>.4$). Within the left-wing group, emotions towards Prodi did not differ from 0 ($p>.65$), but were significantly more positive than emotions toward the outgroup characters ($ps<.001$). For each character, the emotions toward him differed significantly between the two groups ($ps<.05$).

Table 1. Mean differential emotion (mean positive emotion minus mean negative emotions) ratings for each character in each group (±SD).

	Di Pietro	Prodi	Berlusconi	Vespa
Right-wing	−0.2(2.2)	−2.2(2.0)	1.5(2.0)	0.2(1.2)
Left-wing	1.4(1.9)	0.3(2.3)	−3.1(1.4)	−2.3(1.8)

Negative scores indicate that negative emotions are predominant. Thus, a clear ingroup bias can be seen in both voters' groups.
doi:10.1371/journal.pone.0025117.t001

Saccadic Reaction Times

To have an index of interference, we computed the interference index for RTs by subtracting the mean RT in incongruent trials from the mean RT in congruent trials for each distracter condition and each subject. No subject had a score above or below 3 standard deviations from the mean of the group in any condition.

We entered this interference index in a mixed ANOVA with subjects political orientation (rightwing, leftwing) as a between factor and distracter (Di Pietro, Prodi, Berlusconi and Vespa) as within factor. We did not find any main effect, nor interactions (ps>.24, partial η^2<.05). Means of the two way interactions are shown in Table 2.

Perceived similarity

We entered the subjective perceived similarity in a mixed ANOVA with subjects political orientation (rightwing, leftwing) as a between factor and distracter (Di Pietro, Prodi, Berlusconi and Vespa) as within factor. We did not find any main effect of the distractor ($F(3, 75) = .66$, $p = .58$). More importantly, we did not find any effect of the group, ($F(1, 25) = .51$, $p = .48$).

Not surprisingly, we found interaction between the participants orientation and the disctractors ($F(3, 75) = 17.60$, p<.001). Duncan's post hoc test showed that this interaction is accounted for by a more perceived similarity toward the ingroup than the outgroup characters. Indeed, left-wing voters perceived themselves more similar to Di Pietro and Prodi (mean perceived similarity: 0.77 and 0.73 respectively) than Berlusconi and Vespa (.60 and .62 respectively, ps<.01). Similarly, right-wing voters perceived themselves more similar to Berlusconi and Vespa (.74 and .72 respectively) than Di Pietro and Prodi (.61 and .56 respectively, ps<.01). Outgroup characters do not differ each other neither within the left-wing group, nor within the right-wing one (ps>.30).

Saccadic Accuracy

To have an index of interference, we subtracted the accuracy (percentage of correct responses) in incongruent trials from the accuracy in congruent trials from each condition and for each subject. We excluded a participant (left-wing, male) from the analysis because he scored above 3 standard deviations from the mean of the group in one condition. Interference index values were entered in a 2×4 mixed model ANOVA with voters group (centre-left, centre-right) as between-subjects factor and the distractor (the Di Pietro, Prodi, Vespa, Berlusconi character faces) as within-subjects factor. The ANOVA showed a trend towards a significant effect of group ($F(1,25) = 3.79$, $p = .08$), while the main effect of distractor was non significant ($F(3, 75) = 1.53$, $p = .21$). Importantly, the ANOVA showed that the crucial interaction between Distractor and Group was significant ($F(3,75) = 6.87$, p<.01, partial $\eta^2 = .18$, see Figure 1). Since interference effect on accuracy in right wing participants was not distributed normally in one condition (Di Pietro, $W = .83$; p<.05) and the variance between the two groups was different in two conditions (Berlusconi and Vespa, Levenes's $Fs(1, 25)$>4.89 ps<.05) we used a bootstrapping resampling technique [37] to test our null hypothesis. We simulated 2.000 data sets of the same length of our original sample by randomly picking up with replacement the data from our original sample. So, in each simulation, we randomly assigned each data to each condition, entered the data in the same mixed model 2×4 ANOVA, computed the F for each main effect and for the interaction in order to build an F distribution from our original data. Finally, we computed the probability of the null hypothesis using these F distributions instead of the usual central F distribution. The F distributions that emerged after bootstrapping were very similar to the usual central F distribution ones and, consequently, we obtained very similar results. In particular, the main effect of the group still approached significance ($p = .07$), the main effect of the distractor was not significant ($p = .26$) and the crucial interaction was strongly significant ($p = .001$). As shown in Figure 1, Duncan's post-hoc test within groups revealed that Right-wing participants followed Berlusconi's gaze (accurate responses in congruent minus incongruent trials: 18.3%) more than Di Pietro's (8.7%, p<.05, Cohen's $d = 0.57$) and Prodi's (4%, p<.01, Cohen's $d = 0.95$) gaze. Furthermore, right wing voters followed Vespa's gaze (17.4%) more than Di Pietro's (p<.05, Cohen's $d = 0.52$) and Prodi's (p<.01, Cohen's $d = 0.90$) gaze. The interference effects were comparable for Berlusconi and Vespa ($p = .77$, Cohen's $d = 0.05$) and for Prodi and Di Pietro ($p = .31$, Cohen's $d = 0.33$). On the other side, Left-wing characters' gaze direction did not exert any significant influence on the oculomotor responses of left-wing participants (all ps>.14). Also, a difference between the two groups was found in the Berlusconi's gaze interference effect which was greater for right-wing participants than for the left-wing (2.1%, p<.005, Cohen's $d = 1.20$). Similarly, Vespa's gaze interference effect has found to be stronger in right-wing participants than in left-wing (5.2%, p<.05, Cohen's $d = 0.91$).

Previous behavioral studies demonstrated that longer or less accurate responses to incongruent than congruent trials are robustly and reliably induced by the interferential gaze of stranger models [11,12,13]. Using a series of one-sample t-tests, we assessed the strength of this effect by comparing the index of interference of effect each political character gaze against 0 (which means absence of interference) for each group. The interference of ingroup characters' gaze was significantly different from 0 in both left-wing ($ts(13)$>3.1; ps<.05) and right-wing participants ($ts(12)$>3.59, ps<.005).

Since Di Pietro interference effect was not normally distributed in the right-wing group (Shapiro-Wilk's $W = .83$; p<.05), we bootstrapped this difference data in the 13 right-wing participants 2000 times. So, we computed the mean difference (8.3%) of these 2000 samples and its confidence interval (CI, +95% = 19.9%; −95% = 2.2%). The lower bound of the CI does not include 0. Therefore, we can conclude that right-wing participants signifi-

Table 2. Reaction times.

	Di Pietro (ms)	Prodi (ms)	Berlusconi (ms)	Vespa (ms)
Right-wing	32.9 (17.9)	18.2 (23.7)	35.9 (24.8)	32.1(30.2)
Left-wing	39.7(25.4)	34.5(20.1)	35.3(23.1)	37.1(21.8)

Mean gaze cuing (incongruent minus congruent) in ms (±SD) effect for each condition in each group.
doi:10.1371/journal.pone.0025117.t002

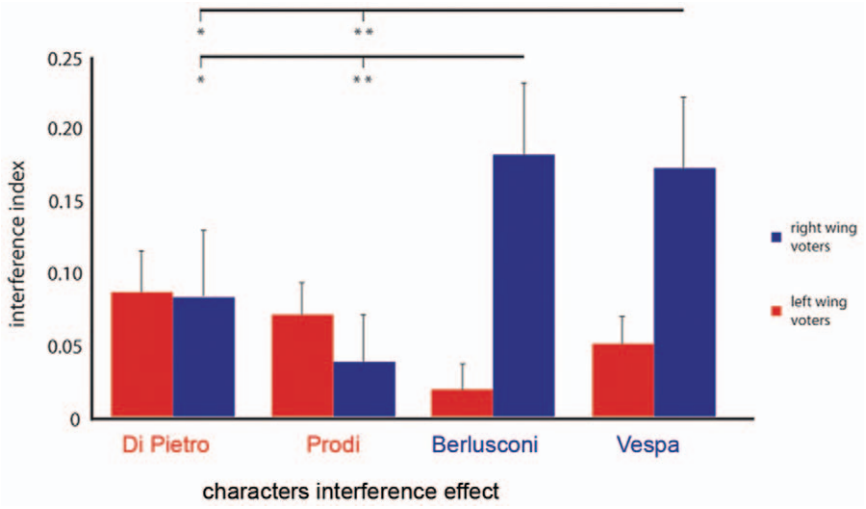

Figure 1. Interaction between participants political affiliation and characters interference effect. Influence of the political characters' gaze on the voters' oculomotor response. On the y axis is represented the interference index, deducted by the difference between the accuracy (percentage of correct responses) in congruent minus incongruent trials. Error bars represent Standard errors of mean (SEM). We reported significance (* = p <.05, ** = p<.01) only for the post-hoc comparisons between the characters' interference effect within the groups.
doi:10.1371/journal.pone.0025117.g001

cantly follow the gaze of this out-group leader. For the other stimuli, being the data normally distributed (Ws>.88, ps>.07), we performed one-sample t-tests against zero.

Interestingly, unlike what reported with stranger gaze characters where interference is quite a robust phenomenon [11,12,13], some outgroup characters's gaze did not induce significant gaze following effects in right-wing voters (p = .24, for Prodi). On the other hand a lack of significant gaze following was found for Berlusconi's gaze left-wing voters (t(13) = 1.24; p = .23).

We ran the same analysis on the interference effect on RTs. In this case, all the characters induced a significant interference effect in both groups (ts>2.76, ps<.05).

Accuracy interference index and ratings

No significant correlation between the interferential effect of characters' gaze and their reported influence or mediatic exposure was found (ps>.05).

Accuracy interference index and perceived similarity in personality

We explored whether the interference effect of each character on the participants' oculomotor behavior can be at least partially explained by the perceived personality similarity between participant and character. To this aim we correlated the interference effect scores with the scores indexing the perceived similarity between the personality of the participants and that of each of the characters.

We found a positive, significant correlation between the voters' perceived similarity with Berlusconi and the attracting influence of his gaze on their oculomotor behaviour (r = .50, p<.01; Figure 2). To be sure that the above positive correlation was not driven by outliers, we removed two subjects whose standardized residuals were above 2.5. The correlation became slightly stronger (r = .52; p<.01).

Perceived similarity in personality failed to correlate with the interference effect induced by the other characters (rs<.26, ps>.17). Because most of the correlated variables (6 out of 8) were not distributed normally (Ws<92; ps<.05), we ran the correlation analyses also on bootstrapped samples. 2000 resampled data sets were created and correlated. This procedure allowed us to check whether the confidence intervals of the Pearson's rs from the resampled data included zero. We found that the Pearson's r CI for the correlation between Berlusconi's interference effect and the perceived similarity with him did not include zero (+95% = .70, −95% = .15). Therefore, this correlation is to be considered significant. Importantly, all the other bootstrapped correlations between the character interference effect and the perceived similarity, included zero (CIs +95%<.55, −95%< −.02). Moreover, we aggregated across the whole sample the ratings concerning the perceived personality similarity and correlated this more 'objective' index with gaze interference. No correlation turned out to be significant (rs<.24, p>.22).

Discussion

Gaze following behavior has shown to be an automatic behavior, supposedly impervious to highly complex variables such as political affiliation. Studies indicate that emotional cues in the face of a model can affect gaze cuing in human onlookers ([38,39], but see [40]). Recent studies in monkeys [10] showed that social status of an individual within the group modulates gaze following of other members. However, little is known about whether this modulation can be due to dominance cues in the observed face or to social knowledge [41].

We anticipated that reflexive gaze following in humans might be influenced by highly complex cognitive and social dimensions as politic affiliation and personality dimensions linked to political ideology [25]. In this study, we investigated the interaction between the political affiliation of onlookers and distractors in an oculomotor task where the gaze direction of political characters could be spatially congruent or incongruent with the instruction to make directional saccades given to ingroup or outgroup electors. Also, since previous studies show the role of status in gaze following in monkey [10] and of familiarity on a gaze-cuing task in humans [41], we used characters who differed in terms of perceived influence in the Italian political landscape and in media exposure.

Accuracy results seem to suggest that, in each participant group, one of outgroup leaders did not exert a significant gaze following behavior. Specifically, right-wing voters seem not to be influenced by the gaze of Romano Prodi, a former centre-left Prime minister.

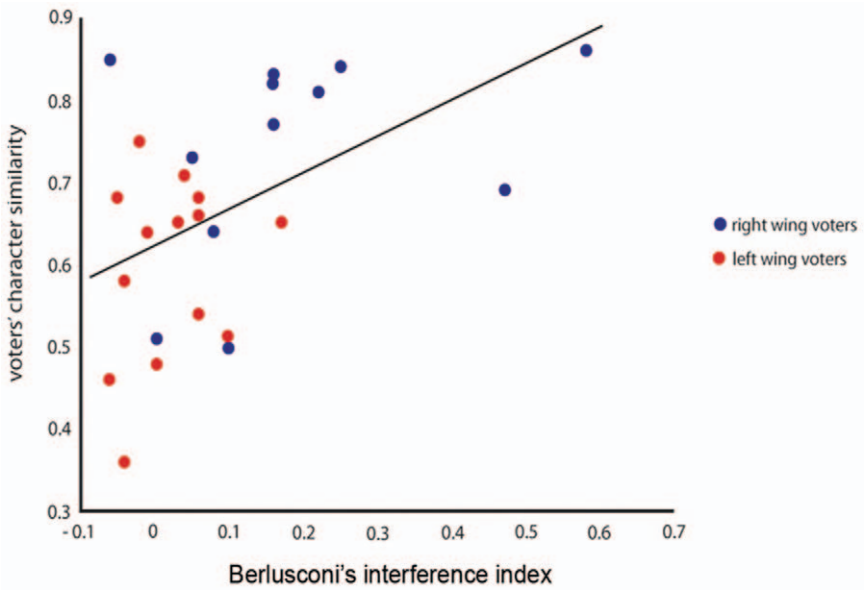

Figure 2. Correlation between participants perceived personality similarity with Berlusconi and his interference effect. On the y axis, the similarity scores, ranging from 0 (not similar at all) to 1 (completely similar) computed as described in the Methods. On the x axis, the interference index deducted by the difference between the accuracy (percentage of correct responses) in congruent minus incongruent trials.
doi:10.1371/journal.pone.0025117.g002

In a similar vein, left-wing voters seem not to be interfered by the outgroup leader and actual Prime Minister, Silvio Berlusconi. This pattern of results may suggest that an active suppression on the gaze of some outgroup leaders is implemented. However, RTs analysis shows in both left-wing and right-wing voters a significant interference effect compared to zero for all the characters. Thus, although attractive, the hypothesis of an active suppression of attracting power of ougroup leaders gaze is based on a null result and involves only accuracy. Future studies on this issue are needed.

More importantly, we found that the stronger catching power of the ingroup political character gaze on voters occurred only in the right-wing voters, who were influenced by Berlusconi and Vespa more than by Di Pietro and Prodi. Even though these two characters have been judged as having a different media exposure and power in the political landscape (not surprisingly, since Berlusconi is the leader of the centre-right coalition and Prime minister in charge at the time of the experiment), they do not differ each other in their gaze interference power, suggesting that the result might have to deal more with the group affiliation than with the status. By contrast, no significant effects of in-group political characters' gaze were found in left-wing voters.

A possible explanation of the difference between left-wing and right-wing voters may involve personality differences in ingroup loyalty [31]. Indeed, conservatives are found to be more loyal to their group. Furthermore, conservatives are thought to be more sensitive to authoritarian figures and rely more on authority acceptance [27,31]. It is thus possible that they follow the ruling group, more than simply the group they feel affiliated to. Since, at the time of data collection the centre-right group was fundamentally ruling the country, this alternative explanation cannot be disregarded. Future studies in a changed political situation or in different countries may help to better address this issue.

That left wing-voters lack of gaze-following behavior just with Berlusconi may be consistent with studies [42] showing that Italian left-wing voters detest the right-wing leader. Finally, the gaze interference effect exerted by the right wing leader was correlated to the voters' perceived similarity, in keeping with the evidence that Berlusconi is the leader that mostly capitalized on the personalization of politics strategy that has characterized several modern democracy systems in recent years [43].

Previous behavioural and neural studies of politics mainly focused on the dispositions of the participants [29,30]. It has been shown for example that conservatorism but not liberalism is associated to the number of errors in tasks where a prepotent response has to be inhibited. This better behavioural performance of liberals in response conflict monitoring paralleled an higher sensitivity to response conflicts as indexed by the amplitude of No-Go N2 and Early Related Negativity Event Related potentials [29].

Using a gaze cuing paradigm in which the distractor was a schematic face, it has also been demonstrated that liberals exhibit a very large gaze cuing effect compared to conservatives [30]. Authors interpret these data arguing that while conservative ideology relies more on individuals, liberals are more likely to attend to social cues. These studies shed light on the notion of ideology as motivated social cognition [26], and try to link cognitive styles to Political orientation. Although interesting, the above studies do not address the important issue of how fundamental social behaviours like gaze following are modulated by Political affiliation in the interaction with members of a different vs. same political group.

In conclusion, unlike studies that investigated the behavioural and neural correlates affected by political variables by focusing on the dispositions of the participants, we demonstrate that a sophisticated blend of situational and dispositional factors underlies the capture of reflexive gaze following exerted on voters by the gaze of politicians. Future studies on the plasticity of this effect may provide new insights in the fundamental aspect of the human tendency to coalesce in large groups and complex societies.

Author Contributions

Conceived and designed the experiments: MTL VC MV FC GVC SMA. Performed the experiments: MTL VC. Analyzed the data: MTL VC. Contributed reagents/materials/analysis tools: SMA MV GVC. Wrote the paper: MTL SMA MV FC VC GVC.

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Draft in preparation

A look into the ballot: gaze-following behaviour toward a candidate predicts vote intention

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INTRODUCTION

Gaze following behavior provides a window into social cognition (Shepherd, 2010): humans automatically follow others gaze (Ricciardelli et al., 2002; Crostella et al., 2009, Cazzato et al., 2010) and automatically shift their attention accordingly (Driver et al., 1999; Langton & Bruce, 1999). This automatic shift of the attention triggered by a social signal as gaze seems to be the prerequisite of developing other important social cognitive skills, from joint attention to the Theory of mind, i.e. our ability to infer others mental states (Baron-Cohen, 1995; Emery, 2000).

Gaze-following behavior has been studied also in other non human primates

(Deaner & Platt, 2003) and has found to be underpinned by a mirror-like neural mechanism (Shepherd et al., 2009). Gaze following behavior has been found to be modulated by status in monkeys (Shepherd, Deaner and Platt, 2006), by personality similarity and political affiliation in humans (Liuzza et al., submitted). In this study, we found conservative participants to be more prone to their in-group politicians gaze than the out-group.

This suggests that the gaze-following can be considered an automatic behavior which implicitly vehicles information about the attitudes toward a group and, eventually, preferences toward politicians during a political competition.

To this purpose we used an established paradigm to study the gaze-following (Ricciardelli et al., 2002; Crostella et al., 2009; Cazzato et al., 2010) using the two candidates of the most important coalitions (Centre-left, Centre-right) who ran for the governorship of the Lazio Region in Italy during the month that preceded these local elections (March 2009).

The same subjects underwent to some explicit measures as their voting intentions toward the two candidates in order to assess if their major proneness toward one of the two candidates could be predictive of the likelihood to vote for her.

In order to compare the vote intention predictiveness of gaze following with the the Implicit association test (Greenwald et al., 1998), a measure which has already shown to predict election outcomes (Arcuri et al., 2008), the same sample underwent to a IAT adapted to measure their attitude toward the two candidates.

We predicted that both these measures, independently, could predict the major likelihood of the participants to vote for one of the two candidates.

METHODS

Participants

Fifty-Four participants took part in both the gaze following paradigm and IAT (35 female, age 19 – 35 years old, mean age 24.9±3.27). All had normal or corrected to normal vision with no history of neurological or psychiatric disease and were naïve to the purposes of the study. After having received an explanation of the procedures, they provided their written informed consent to participate in the study. The study was approved by the independent Ethics Committee of the Santa Lucia Foundation (Scientific Institute for Research Hospitalization and Health Care).

Ratings

Self reported past political behaviour and voting intentions

Participants were administered a self-reported questionnaire in order to collect: a) socio-demographic variables, as gender, age, and education level; b) voting intention for the forthcoming (March 2010) regional elections. Subjects were asked to rate in a ten Likert type scale the probability to vote for each of the two most important candidates (Bonino, centre-left; Polverini, centre-right).

Post-election interview

After the elections, we were able to reach telephonically a subsample of subjects (N=20, 14 F, mean age=24.4±2.98 deviation standard) who were actually voters in the Region Lazio and asked them who they voted for and coded their response as 1 if they voted for the Centre-left candidate Bonino, -1 if they voted for the Centre-right candidate Polverini and 0 if they didn't vote fore neither of the two.

Implicit measures

An IAT (Greenwald et al., 1998) was used, in which the stimuli of the target-concept categories (*Polverini* vs. *Bonino*) were pictures of the candidates,

whereas the stimuli-words of the attribute-dimension (*pleasant* vs. *unpleasant*) were emotionally loaded attributes (e.g. *positive*, *good* vs. *negative*, *bad*)[1].

In the IAT the participants performed two types of categorization tasks, with 5 stimuli for each category. The words were presented in random order within each block of trials. As described by Greenwald et al. (1998) the entire procedure consisted of seven blocks of trials: 1 (*Polverini* vs. *Bonino*), 2 (*Pleasant* vs. *Unpleasant*) and 5 (*Bonino* vs. *Polverini*) were single categorization blocks of 20 trials whereas 3-4 and 6-7 were combined blocks (*Polverini or Pleasant* vs. *Bonino or Unpleasant*) of 20 (3-6) and 40 (4-7) trials. Subjects were requested to respond as quickly and accurately as possible to the stimuli-words that appeared on the monitor.

Following Greenwald, Nosek & Banaji (2003), data from blocks 3-4 and 6-7 were used to compute IAT difference scores, $D_{biep}=M_{IB}-M_{CB}/SD$ (D_{biep}: SE-IAT scores according to the built-in error penalty method; M_{IB} = mean latency for incompatible blocks; M_{CB} = mean latency for compatible blocks; SD = pooled standard deviation for compatible and incompatible blocks).

Positive scores indicate high implicit attitude toward Bonino and negative scores indicate high implicit attitude toward Polverini. Internal consistency was estimated by a split-half index, based on two partial scores, $D_{biep}1$ and $D_{biep}2$,, respectively computed from blocks 3 and 6 (20+20 trials), and from blocks 4 and 7 (40+40 trials).

Gaze following task

Stimuli and Procedures

[1] A complete description of the test with the full list of stimuli may be requested to the following address: francesco.dentale@libero.it .

The study was performed in a quiet room with medium illumination (about 64 cd/m2). Subjects sat on a comfortable chair in front of an LCD monitor, positioned at about 57 cm from their eyes. Eye position and eye movements were measured monocularly in real-time by means of an infrared video-based system (ASL 504 Remote Tracker, Applied Science Laboratories, USA). The experiment was created and ran with E-Prime software (version 1.1, Psychology Software Tools, Inc., Pittsburgh, PA) on an IBM compatible computer.

Saccadic eye movements were collected via a event-related protocol in a 2x2 factorial design. In each block, stimuli comprised the factorial combination of the two *Observed faces* (Bonino, Polverini) and the two *Condition* respect to the imperative cue (congruent and incongruent).

Each trial started with the appearance of a black central fixation mark (0.21° x 0.21° in size) presented on a light gray (about 47 cd/m2) background, and of two black squares (0.43° x 0.43°) presented at 10.2° of eccentricity in the left and the right visual field. After 500 milliseconds, the color of the central mark changed to either blue or orange. This was the imperative signal for making a fast and accurate saccade toward the left (change into blue) or the right (change into orange) target square. The coloured cue remained visible until the end of the trial. A distractor's gaze was presented behind the central fixation mark, at an intervals of 75 milliseconds from the onset of the instruction-cue (stimulus onset asynchrony, SOA) because we demonstrated that gaze following specifically occurs at this interval (Ricciardelli et a., 2002, Crostella et al., 2009, Cazzato et al., 2010). For each observed-face we prepared a RGB digital photography (6.76° x 6.76°). To enhance their saliency, the stimuli were animated by two frames presented in rapid sequence. The first frame (lasting 500 milliseconds) was replaced by a second frame lasting 875 milliseconds. The first frame depicted a straight gaze. The second frame

depicted a gaze which could be oriented leftward or rightward (see Figure 1). The direction of the distractor and that one indicated by the instruction-cue could be congruent (C) (for instance: both leftward) or incongruent (for instance: one leftward and the other rightward). Note that subjects were instructed to ignore the distracting stimulus and to focus their attention on the central mark colour change. The two instruction cues (leftward or rightward) and the two distractors (congruent or incongruent) were equally probable and were presented in a random sequence. Each of the 4 possible combinations was repeated 20 times, for a total of 80 trials.

We analyzed subjects' directional accuracy by focusing on the first horizontal saccade that followed the instruction cue and had an amplitude larger than 2°. Saccadic RTs were also collected. Only RTs for correct trials were considered. Trials in which signal was dirty were excluded (577 out of 4800, 13.5%). Incorrect responses were removed from RTs analysis (430 out of 4233, 10.2%). Finally, we excluded trials above or under two deviations standard from the mean (275 out of 3793, 4.6%).

Because for 6 out of 49 subjects (12.2%) we didn't collect at least 10 correct trials out of 20 (50%) in each condition, we performed the analysis on the accuracy only. In order to assess the strength of the gaze following behavior, we created a gaze following index by subtracting the accuracy in the incongruent trials from the accuracy in the congruent ones for each distracter. Secondly, to have a unique bipolar measure that could predict this implicit embodied attitude toward one or the other candidate, we subtracted the gaze following effect for Polverini from the one from Bonino. In this way, negative scores mean a stronger proneness to the center-right candidate, while positive ones were associated to a bigger proneness to center-left one. This measure doesn't significantly correlate with the mean accuracy of each subject ($r = .12$, $p = .41$).

We computed the voting intention toward each of the candidates by subtracting the probability to vote Polverini from the probability to vote Bonino. In this way we obtained a bipolar measure in which positive scores indicate high voting intention toward Bonino and negative scores indicate high voting intention toward Polverini.

RESULTS

We entered analyzed if the difference in voting intention, the IAT d score and the gaze following difference between the two candidates correlated each other. The major likelihood to vote for Bonino compared to Polverini correlated significantly with both gaze proneness to Bonino's gaze relative to Polverini's (Pearson's $r=.37$, $p<.01$) and with implicit positive attitude toward Bonino compared to Polverini (Pearson's $r=.56$, $p<.001$). Importantly, the latter two measures don't correlate each other (Pearson's $r=.24$, $p<.1$, ns).

To assess if voting intention can be predicted independently by both proneness to a candidate's gaze and implicit attitudes, we entered the difference in voting intention as the dependent variable in a multiple regression analysis in which the predictors were the gaze following difference between the two candidates and by the IAT d score. Multiple regression has been revealed to significantly predict voting intention ($F(2, 46)= 13.78$, $R^2= .37$, $p<.001$). Furthermore both IAT ($\beta= .50$, $t=4.2$, $p<.001$) and, most importantly for our purpose, proneness to the candidate's gaze ($\beta= .24$, $t=2.03$, $p<.05$) independently predicted the intention to vote one or the other of the candidates. Importantly, the two measures don't correlate each other ($r=.24$, $p<.1$, ns).

We performed the same analysis on the subsample who answered to the post election question on their actual vote. In this case we entered also the vote intention in the correlational analysis. Not surprisingly, the voting intention

strongly correlates with the actual vote (Pearson's r=.78, p<.001). gaze proneness to Bonino's gaze relative to Polverini's implicit positive attitude toward Bonino compared to Polverini correlated with the actual vote (both have Pearson's r=.44) even though both the correlations failed to reach the significance (p=.05). The multiple regression with these latter variables as predictors of the actual vote didn't reach the significance ($F(2, 17)=3.22$, p=.06). Anyway, is worth note that these analysis may have not reached the significance because, considering the smaller sample, they just lacked to reach enough statistical power.

DISCUSSION

Previous studies on Gaze following behavior showed that this behavior, even though automatic, can be modulated by the model and the onlooker social status in non human primates (Shepherd et al 2006) and by their political affiliation in humans (Liuzza et al., submitted). This last finding suggested us that gaze following behavior can be used as behavior that may implicitly embody certain attitudes toward social groups or even preferences towards candidates during political competitions. In the present study we used a well known a paradigm to study the Gaze following behavior (Ricciardelli et al. 2002; Crostella et al., 2009; Cazzato et al., 2010) in which the distractor faces were represented by the candidates of the two most important coalition during a local electoral campaign in Italy. We predicted that a bigger proneness to one candidate gaze compared to the other would predict the participants vote intentions. coherently with our predictions, we found a significant linear regression between the differential proneness to the candidate's gaze and the vote intention.

Implicit measure of attitudes toward social groups as the IAT (Greenwaldet al., 1998) have been shown to be predictive of the election outcome (Arcuri et al., 2008). Here we tested the same participants with the IAT to assess their differential implicit preference toward the two candidates. The IAT itself, coherently with previous studies, has found to be predictive of the vote intentions.

The most important result of this study is represented by the fact that an automatic behavior as the gaze-following vehicles important cues about the preference toward a group or a single politician. This result, compared with the one relative to a well known implicit measure as the IAT, is particularly striking, since the gaze-following is a behavior apparently independent by the association between the semantic representation of a group or of a single person and an emotional valence. To rule out that a significant part of the predictability of the gaze-following behavior can be explained by the strength of this semantic-affective link measured by the IAT (Fazio & Olson 2003), we entered both these measures in a multiple regression analysis. the results showed that both, independently, can predict the vote intention. Not surprisingly, the IAT has a stronger predictability (R^2=.32) since, as underlined by Fazio and Olson (2003), this measure can be only partially be considered implicit because the subjects can be aware of what is measured, even though the way in which is measured is indirect. Even though the variance explained by the gaze-following behavior toward the two candidates is smaller (R^2=.06), it represents an original contribution because, to our knowledge, this is the very first study which uses an automatic oculomotor behavior to predict the vote intention.

A possible limitation of the present study is that, because many of the participants didn't vote in the same Region the two candidates were running for as governors, we could collect the actual voting behavior of a smaller sample

(N=20). Even if this represents just a subset of the original sample, the voting intentions expressed within the month that preceded the elections and the actual voting behaviors of the participants matched significantly. More importantly, even though they didn't reach statistical significance probably because of the smaller sample size, the correlations and the multiple regression on the actual vote paralleled the results on the vote intentions, suggesting that IAT and proneness to gaze, together, may be able to predict the vote behavior.

Also, as a next step, it would be interesting to see if the gaze following can predict future explicit attitudes and voting behavior as has been shown for the IAT (Galdi et al., 2008).

Finally, since a little but strategically important part of the electorship decides a the very end without having enough information and relying mostly on cognitive heuristics as the personality traits quickly inferred just by facial features (Todorov et al., 2005, Ballew & Todorov, 2007; Olivola & Todorov, 2010), it would be interesting to test, in the future, if the proneness toward unknown faces of politicians gaze can match with their electoral outcomes.

Acknowledgments. Thanks are due to xxxxxx

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Draft in preparation

Neural Responses to In-group and Out-group Political Party predict proneness to the gaze of politicians.

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Summary: Using fMRI, we investigated whether political affiliation, political attitudes and perceived personological similarity modulate neural responses of the reflexive social attention circuit. Twenty-eight healthy subjects were assigned to the left- or the right-wing group on the basis of a questionnaire evaluating political orientation and voting behaviour. During scanning, participants were requested to detect changes of a central fixation point (FP) and to make a left- or a right-ward saccade if the FP turned into blue or red respectively. The FP was located on the face of well-known Italian right- or left-wing political leaders (Berlusconi, Bersani) or right- or left-wing perceived opinion makers (Vespa, Floris). Seventy-five msec before the colour change of the central FP, the character portrayed in the picture performed a left- or right-ward saccade which the participants were instructed to ignore. The directional instructions provided by the colour cues and the direction of the character saccade could be congruent or incongruent. After scanning, participants were asked to rate each face about political orientation, influence, exposure and emotional valence. The participants rated as more emotional positive and more

similar to them, the characters with the same political orientation. The analysis of the Incongruence-related BOLD signal (IE: Incongruent > Congruent) revealed the expected activation of frontoparietal attentional network involving Frontal Eye-Field (FEF), Intraparietal Sulcus and Superior Parietal lobe bilaterally plus several clusters in the bilateral Insula, right Supramarginal Gyrus (rSMG), right Superior Temporal Sulcus and right Superior Frontal Gyrus. In the lFEF, a significant interaction between voters's affiliation and direction of the left/right-wing characters saccades was found. Moreover, in the left-wing voters, the IE in rSMG positively correlated with in-group perceived similarity. Our results suggest that neural activity in the reflexive social attention circuit is modulated more by the gaze of in-group than out-group political leader or opinion makers.

Results

Demographics

Given that the gaze-cuing paradigm required the subject has a strong preference for a certain political coalition, we asked to participants to express their explicit preference on a scale from 1 “strongly left-wing” to 8 “strongly right-wing”, including the “apolitical” condition to assess our critical manipulation. None declared to be “apolitical”, therefore no subject of our sample was excluded for this reason. A final sample of two right- and left-wing participants groups of 14 subjects respectively was obtained. Both groups were comparable for age [$t(1,26) = .241$, n.s.], and years of education [$t(1,26) = -.192$, n.s.]. With regard to interest in politics, left-wing participants resulted to be more interested [$t(1,26) = -3.280$, $p = .003$] and informed about politics [$t(1,26) = -2.362$, $p = .026$] with respect to right-wing participants.

Self-report measures

Ratings of left and rightedness of the character faces

Participants classified Berlusconi and Vespa as belonging to centre-right wing coalition (ratings 5.57 and 5.15, significantly higher than 4, $ts < 14.52$, $ps < .001$) and Bersani and Floris as belonging to the center-left wing coalition (ratings were 2.68 and 2.50, significantly lower than 4, $ts < -14.71$, $ps < .001$).

Ratings of Familiarity, Political Influence and Emotional Valence for In- and Out-group Character.

Each Likert scale about *Exposure*, *Influence* and *Emotional valence* was investigated by means of a repeated-measures of variance with Distracter (4 levels: Berlusconi/Vespa/Bersani/Floris) as within-participant factor and Group (right- or left-wing voters) as between-group factor. Planned comparisons were Bonferroni-corrected. We displayed these results in Figure 2 A-B.

The analysis on Exposure ratings revealed a significant main effect of Distracter [$F(3,26) = 17.802$, $p < .001$]. As expected, planned comparisons revealed that Berlusconi was the most familiar character, while Vespa significantly differed with respect to Berlusconi and Bersani. Bersani instead was less familiar than right-wing character and did not differ from Floris. Finally left-wing opinion-maker Floris only significantly differed from Berlusconi. The interaction between exposure of Distracter and Group [$F(3,26) = 3.008$, $p < .05$] revealed that right-wing participants rated as familiar right- in-group faces more than left-wing out-group faces. Not surprisingly, left-wing participants rated as familiar left-wing in-group faces less than out-group right-wing faces, being Berlusconi the most familiar also for the left-wing group. (See Fig. 2A). As illustrated in Fig. 2B, a main effect of Distracter was found when we asked to participants to rate how much do they think each character is influent within the Italian political landscape [$F(3,26) = 27.943$, $p < .001$]. Both group reported that Berlusconi was the most influent with respect to the other observed-faces. Finally, no interaction between Distracter and Group was observed [$F(3,26) = .766$, n.s.].

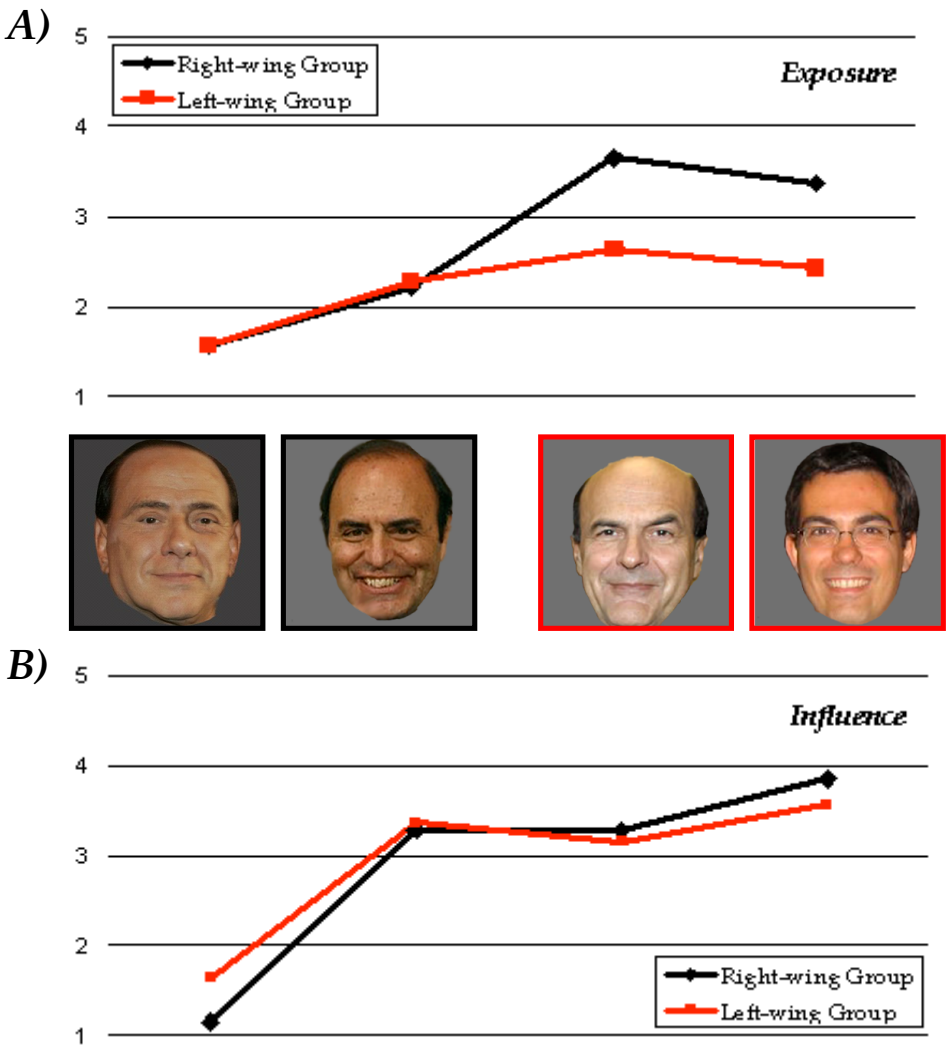

Figure 2: Ratings of Familiarity (Exposure) and Political Influence for In- and Out-group Characters. A) On the y axis, the Exposure scores, ranging from 1 ("I know him very well") to 5 ("I don't know him at all"). B) On the y axis, the Influence scores, ranging from 1 ("Very Influent") to 5 ("Not Influent at all"). On the x axis, right-wing character are depicted in a black square line (Berlusconi, Vespa) while left-wing characters are illustrated in red square line (Bersani, Floris). Scores for both Likert scales are reported for right- and left-wing participants.

The analysis of *Emotional Valence* scores revealed no main effect of Distracter [$F(3,26) = .568$, n.s.] while a significant interaction between Distracter and

Group was found [$F(3,26) = 34.299$, $p < .001$]. Planned comparison revealed that right-wing participants rated as positive in-group right- characters more than left-wing out-group faces. Exactly the opposite emotional evaluation was expressed by left-wing participants who rated left-wing in-group faces more positively than right-wing faces. This "positive in-group bias" was confirmed by the fact that right-wing faces were evaluated as positive more by right- than left-wing group, and right-wing group judged left-wing characters as negative more than left-wing group did.

Perceived Similarity Questionnaire

To measure similarity, we asked participants to evaluate whether the following traits were applicable to each face: Energy/Extraversion, Agreeableness, Conscientiousness, Emotional stability, Intellect/Openness to experience. Than we computed an overall index representing the similarity between the self and each of the four personalities. A repeated-measures of variance with Distracter (4 levels: Berlusconi/Vespa/Bersani/Floris) as within-participant factor and Group (right- or left-wing voters) as between-group factor revealed a main effect of Distracter [$F(3,27) = 3.812$, $p < .05$]. Planned comparison showed that Berlusconi had higher perceived similarity ratings than Vespa and Floris Opinion-makers. While Vespa only differed from right-wing leader as being evaluated as less similar than Berlusconi, no difference was found for Bersani with respect to the other face, while surprisingly Floris only differed from right-wing Leader being perceived more similar than Berlusconi. Importantly, a significant interaction between Observed-face and Group was found [$F(3,26) = 31.170$, $p < .0001$]. Planned comparison showed that right-wing voters perceived themselves as more similar to in-group faces (Berlusconi/Vespa) than

did out-group faces (Bersani/Floris); exactly the opposite pattern was found for left-wing participants showing higher mean scores of similarity with Bersani and Floris than for Berlusconi and Vespa. These results are in line with the emotional valence scores seeing that participants judged as more similar to them, the characters with the same political orientation, showing a mere preferential "in-group bias" for their political representatives.

Behavioural performance in the scanning session.

Since the analysis on Interest in politics showed that left-wing participants reported to be more interested in politics with respect to right-wing group, we cannot exclude that our critical interferential gaze-cuing effect on behavioral measures was affected by interest in politics. Therefore, aimed to control for this potential mediator effect, we carried out two separated analysis of repeated-measures fully factorial ANCOVA on saccadic RTs and Accuracy (numbers of incorrect trials) with 2 within-participant factors: Distracter (Berlusconi/Vespa/Bersani/Floris) and Congruence (congruent vs. incongruent), one between-group factor: Group (Right- vs. Left-wing Participants) and "Interest in politics" as covariate. A fully factorial ANCOVA includes all interaction terms between the covariate, within-participants factors and between-participants factors. Main effects of repeated-measures factors are independent of the between-participant covariate of interest in politics; therefore, pure repeated-measures effects are reported from an analysis that excludes the covariate, and so degrees of freedom may differ for pure repeated-measures effects and between-participant effects or interactions. In Table 1 we reported mean saccadic RTs in correct trials (in ms) and accuracy (numbers of

errors) as a function of the four O*bserved-face*: Berlusconi, Vespa, Bersani or Floris and *Congruence:* Congruent or Incongruent for Right- and Left-wing participants respectively.

Saccadic Reactions Times

A trend toward significance was found for the main effect of Distracter [$F(3,75) = 2.445$, $p = .07$]. Instead, we found a significant interaction between Distracter and Interest in Politics covariate [$F(3,75) = 2.867$, $p = .042$]. We also found an interaction between Distracter and Congruence [$F(3,75) = 2.811$, $p < .045$]. The result was replicated by means of a significant interaction among Distracter, Congruence and Interest in politics covariate [$F(3,75) = 3.326$, $p = .024$].

Finally, the crucial 3-way interaction Distracter by Congruence by Group showed a trend toward significance [$F(3,75) = 2.544$, $p = .062$]. No others main effect or interactions between factors were found.

Next, we computed an "Interference index" for RTs by subtracting the mean RT in incongruent trials from the ones in congruent in each distracter condition in each subject. We entered the gaze-cuing effect in a mixed 4x2 ANCOVA with distracter (Berlusconi, Vespa, Bersani and Floris) as within-subject factor and participant's political orientation (right-wing, left-wing) as a between-subject factor and Interest in Politics as covariate. A main effect of Distracter [$F(3,75) = 2.811$, $p < .045$, $\eta^2_p = .101$] showed that the Right-wing leader (Berlusconi) was the less interfering with respect to the other Distracters. The interaction between Distracter and Interest in politics resulted significant [$F(3,75) = 3.326$, $p = .024$, $\eta^2_p = .117$]. Finally, the crucial 2-way interaction Distracter by Group showed a trend toward significance [$F(3,75) = 2.544$, $p = .062$, $\eta^2_p = .606$]. No others main effect or interactions between factors were found.

The effect of covariate, was also confirmed by a significant correlation between interest in politics and the proneness to follow the gaze of Bersani Left-wing Leader only in Left-wing voters ($r = .612$, $p < .05$). In addition, the more the mediatic exposure of In-group Leaders increased the more right- and left-wing voters were prone to follow their gazes, thus reporting a significant correlation between the interference index and their relative exposure scores (Right-wing voters, Berlusconi: $r = .-553$, $p < .05$; Left-wing voters; Bersani: $r = .-600$, $p < .05$). Instead, this correlation was not found with the interference index of Opinion-makers's gaze. In the same vein, we did not find any significant correlation between the proneness to follow each Characters's gaze and their reported Influence (*ps*>.05).

Accuracy

As well as for saccadic RTs, we entered accuracy in a repeated-measures fully factorial 4x2x2 ANCOVA with 2 within-participant factors of Distracter (Berlusconi, Vespa, Bersani, Floris) and Congruence (congruent vs. incongruent), a between- group factor of Group (Right-, Left-wing voters) and "Interest in politics" as covariate. No main effects or interactions reached the statistical significance after controlling for Interest in politics covariate [all *Fs* < .877, *ps* > .358]. This probably was due to the great contribute of covariate in modulating the gaze-cuing effect seen that by rerunning the repeated-measures ANOVA (without controlling for Interest in politics covariate), we verified that we replicated the congruency effect [$F(1,26) = 38.870$, $p < .0001$].

To have an index of interference, we subtracted the accuracy in incongruent trials from the accuracy in congruent trials. Neither main effects nor interactions reached the statistical significance after controlling for Interest in

politics covariate [all *Fs* < .464, *ps* > .709]. In addition, no significant correlation between the interest in politics, exposure, influence and the numbers of erroneous gaze-following movements with respect the right- or left-wing Characters's gaze was found (*ps*>.05).

fMRI Results

To analyze the neural responses of the conflict between the directional instructions provided by the colour cues and the direction of the character saccade according to political affiliation, we used a region of interest (ROI) approach. ROIs were created extracting average BOLD signals (MarsBar 0.41, 'MARSeille Boîte À Région d'Intérêt' SPM toolbox) from voxel activity within a 10 mm radius sphere centered at coordinates defined with the following criteria: whole-brain analysis revealed five main areas within the bilateral Frontal Eye Fields (right/left FEF), left Insula, right Supramarginal Gyrus (rSMG) and right Superior Parietal Lobule (rSPL) that respond differently to the overall conflict effect (Interference Effect, IE irrespective of political affiliation of voters and observed-face), therefore ROIs centred on the peak voxel of such clusters were selected.

In addition, following the guideline for independent ROI analyses (Kriegeskorte et al., 2009) an independent fMRI study using a similar paradigm (Cazzato et al., 2011), and a meta-analysis of 59 brain-imaging experiments confirmed for eye movements, as well as for the map of saccadic eye movements, the spatial location of the frontal eye fields and parietal saccade-related regions (Grosbras et al., 2005). Accordingly, we created further ROIs centered on the reported peak voxels in the dorsal and ventral fronto-parietal network (see Table 2). Analysis regarding the interaction between Distracter (Berlusconi / Vespa/

Bersani / Floris) x Group (Right- / Left-wing Group) were carried out on the mean activation of these areas. Correlation analysis with subjective ratings was equally performed within these areas. Reported p-values were Bonferroni-corrected.

Brain responses associated with the directional conflict between gaze and instruction signals: interference effect.

To identify areas associated with greater responses to the conflict between the directional instructions provided by the colour cues and the direction of the character saccade, we compared incongruent vs. congruent condition (Interference Effect: IE), collapsed over Group and Distracter. For this comparison, the SPM threshold was set to p(FEW-corr) < 0.05 at voxel-level (cluster extent estimated a *p-uncorr* = 0.001, k = 62), considering the whole brain as the volume of interest (See Table II).

Anatomical Area	**Cluster Size**	***p-corr***	**X**	**Y**	**Z**	**z Scores**
Parietal Lobe						
R Precu	466	< .001	12	-58	58	4.84*
R SPL			18	-64	58	4.58*
R SMG	255	<.01	62	-38	38	4.06*
R STS			64	-40	24	3.85*
Frontal Lobe						
L FEF	418	<.001	-24	-2	58	4.74*
R SMA	958	<.001	18	0	62	4.63

R Mid Cingulum			8	20	36	3.98
L Insula	247	<.05	-32	20	6	3.84*
R Insula			34	22	8	4.06
L Lingual G	710	<.001	-10	-74	4	4.29

Table II. Mean MNI coordinates of activation foci associated with Incongruence Effect. Anatomical locations, peak coordinates in MNI space (Montreal Neurological Institute), and statistical values for the main effect of incongruence (incongruent > congruent trials, irrespective of Observed-face and Group). *p*-values are corrected for multiple comparisons at the cluster level, considering the whole brain as the volume of interest. R Precu= Right Precuneus; R SPL = Right Superior Parietal Lobule; R SMG = Right Supramarginal Gyrus; R STS = Right Superior Temporal Sulcus; R/L FEF= Right/Left Frontal Eye Field; R/L Insula= Right/Left Insula; R Cingulum Mid= Right Middle Cingulum; L Lingual G = left Lingual Gyrus. With the asterisk (*) we indicated the regions of interest (ROIs) within the dorsal fronto-parietal attentional network. ROIs were extracted averaging BOLD signals (see Methods) from a 10 mm sphere centred on the cluster peak.

As expected, this comparison produced mainly an extensive activation in the dorsal and ventral fronto-parietal attentional network including anterior frontal regions, namely the Frontal Eye Fields (FEF) bilaterally, and posterior parietal regions as the right Superior Parietal Lobule (SPL) and bilateral Precuneus (Corbetta and Shulman, 2002). Frontal regions also included the Superior Frontal Gyrus (SFG), the Supplementary Motor Area (SMA) extending to the middle portion of the Cingulate Cortex in the right hemisphere and left Insula. Furthermore, additional right parietal portion included Supramarginal Gyrus

(SMG) extending to temporal region as Superior Temporal Sulcus (STS). Finally, a wide cluster in bilateral occipital areas spreading bilaterally from the Calcarine Scissure to the Lingual gyri was also activated (See Figure 2). No regions were obtained from the reverse contrast ("Facilitation effect"), even at a relaxed statistical threshold of $p < .005$.

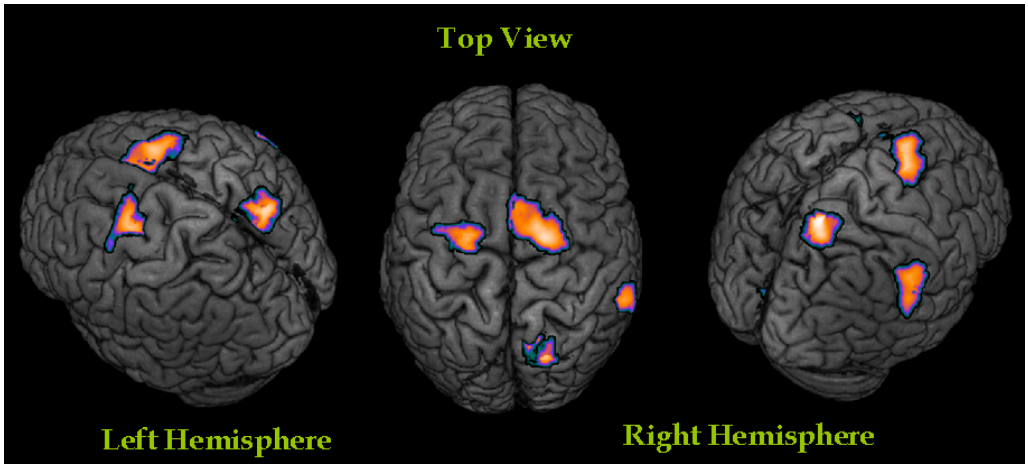

Figure 2: Brain regions activated by Interference Effect [Incongruent > Congruent trials]. Clusters showing higher activity in the incongruent than congruent condition irrespective of observed-faces and political affiliation of voters are rendered on 3-dimensional (3D) views of the SPM template. This contrast revealed the activation of dorsal and central attentional fronto-parietal networks. The regions included the Frontal Eye Fields (FEF) bilaterally, and posterior parietal regions as the right Superior Parietal Lobule (SPL) and bilateral Precuneus. Frontal regions also included the Superior Frontal Gyrus (SFG), the Supplementary Motor Area (SMA) extending to the middle portion of the Cingulate Cortex in the right hemisphere and left Insula. Furthermore, right parietal portion included Supramarginal Gyrus (SMG) extending to Superior Temporal Sulcus (STS). Finally, a wide cluster in bilateral occipital areas spreading bilaterally from the Calcarine Scissure to the Lingual gyri was also

activated. These regions were used as regions of interest to assess any differential influence of distracter/instruction signal incongruence on the brain responses (SPM thresholds are set to *p*(FWE-*corr)* = 0.05 at voxel level).

Brain responses associated with the Interference effect in Right- and Left-wing Voters

First we analyzed whether our brain regions were specifically influenced by the political affiliation of group. Thus we tested for differential IE BOLD responses in Right- and Left-wing voters, irrespective of Distracter and their belonging to the same or different political affiliation. A significant interaction IE x Group was found in left Middle Frontal Gyrus (lMFG), being the IE of Left- higher more than Right-wing Group ($t = 2.19$, $p<.05$). In the same vein, parietal ROIs as LPPC(IPS+SPL) and L Precuneus showed a significant greater IE for Left- more than Right-wing voters (L PPC: $t = 2.57$, $p<.001$; L Precu: $t = 2.29$, $p<.05$). Finally, the results were coherent with a significant greater IE effect again for Left- more than Right-wing voters in the R Anterior Cingulate ROI ($t = 2.04$, $p<.05$). No other ROIs resulted specifically modulated by this interaction or by the IE of Right- more than Left-wing voters.

Brain responses associated with the interference effect of Right- and Left-wing Distracters

To analyze the brain regions activated when participants performed a saccadic movements incongruently with respect to the gaze direction of Right- and Left-wing Characters, we tested for the interaction of IE x Right- or Left-wing Distracter, irrespective of In-group Leaders/Opinion-makers (Main effect of IE

of Right- and Left-wing Distracter). Only left Fusiform Gyrus (lFG) and right Cuneus (rCu) resulted specifically modulated by the IE of Right- more than Left-wing Faces (lFG: $t=1.72$, $p<.05$; rCu: $t=2.36$, $p<.05$). No other regions resulted specifically modulated by this interaction or by the reverse contrast [Left-wing Distracter > Right-wing Distracter].

Crucially, we hypothesized that our manipulations of IE would affect neural responses within the dorsal fronto-parietal attentional systems, depending on specific relationships with *Distracter* and *Political Affiliation* of voters (Group). To test this prediction, we analysed the differences in brain responses when participants performed saccadic movements incongruently with respect to the gaze direction of Leader and Opinion-makers belonging to the "Same" political party. In other words, we were interested in testing the specific IE of gazes belonging to the same political party, namely the IE for "In-group members". The unique region of interest resulting specifically modulated by the interaction IE x Observed-face x "Same" Political Affiliation of voters was left FEF (i.e. IE([Berlusconi + Vespa] > [Bersani + Floris] + [Bersani + Floris] > [Berlusconi + Vespa]); $t = 2.05$, $p = .021$). The result is illustrated in Figure 3. In addition, the IE of in-group Distracter was greater more than the IE of out-group on voters as expressed by significant t-values in Left Insula ($t = 1.76$, $p = .041$) and R Postcentral/IPL ROIs ($t = 2.19$, $p = .016$). No other ROI approached the significance for the IE of "In-group Bias" contrast.

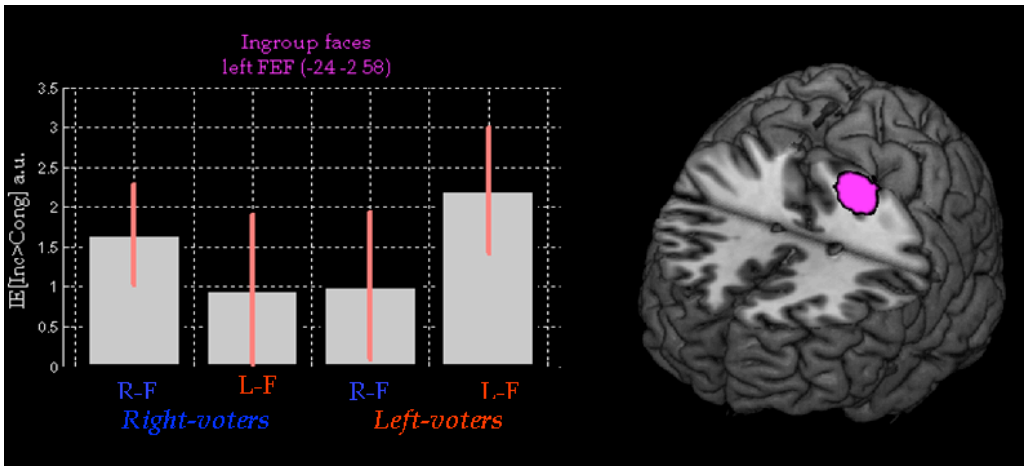

Figure 3: Brain responses in left Frontal Eye Field elicited d by the Interference Effect of In-group Left- and Right-wing characters. Right panel: 3D rendering of the canonical MNI template showing the localization of the region of interest (ROI) corresponding to the left (pink) frontal eye field [FEF] is reported in the coronal section. Left panel: the relative plot shows the mean Interference Effect [IE(inc<cong)] of the Right- and Left-wing Faces in Right- and Left-wing participants. A significant interaction was observed in this ROI: Right-wing In-group faces [R-F = Right-wing Faces] interfered on shifts of attention more than the Out-group Left-wing faces [L-F = Left-wing faces] distracter. Exactly the opposite pattern was found for Left-wing voters. The level of activation is expressed in arbitrary units (a.u., ±90% confidence interval).

Brain responses associated with the interference effect of Leader- and Opinion-makers Distracters

Next, we explored whether fronto-parietal regions are called into action when participants performed a saccadic movements incongruently with respect to the gaze direction of Leaders and Opinion-makers (irrespective to in-group political party); thus we contrasted the fMRI signal of Leaders vs. Opinion-makers (i.e.

IE[Leaders > Opinion-makers]). The interaction IE x Leaders surprisingly revealed no significant greater brain responses in the ROIs we investigated.

Instead, when we tested for the specific IE of In-group Leaders [Berl>Bers]+[Bers>Berl] in both group of voters we found a significant effect in L posteriorPC ($t = 1.80$; $p = .038$). Interestingly, the same effect of Leader was found for r MFG ($t = 1.82$; $p = .036$), being the IE of Left-wing Leader Bersani greater more than the IE of Right-wing Leader Berlusconi in Left-wing voters ($t = 2.55$; $p = .007$). The IE specifically related to Bersani Leadership in Left-wing voters was marginally significant [Bers>Floris]>[Berl>Vespa] ($t = 1.62$; $p = .054$).

Finally, the analysis testing for the effect of Berlusconi vs. Bersani in Right-wing voters revealed a significant IE for In-group more than Out-group Leader in left FG ($t = 1.90$; $p = .031$).

To the opposite, when we tested for the interaction IE of Opinion-makers vs. Leaders, several regions resulted specifically modulated. For example, the IE in left FEF was greater for Opinion-makers more than Leaders ($t = 1.85$, $p < .05$) and a trend toward significance was found specifically for In-group' Opinion-makers (irrespective of Left-wing Political Affiliation) (i.e. IE[Vespa > Floris] + [Floris > Vespa]; $t = 1.64$; $p = .053$). As well as left FEF, right SMG and right SPL showed a greater IE for In-group' Opinion Makers (right SMG: $t = 2.45$; $p = .008$; right SPL: $t = 2.19$; $p = .015$). Additional comparison, confirmed that this effect in right SMG was due to a greater IE for In-group' Opinion-maker in Left-wing Voters (i.e. IE[Floris > Vespa]; $t = 2.84$, $p = .003$]. Left Insula resulted specifically modulated only for Right-wing voters by the interaction IE x Opinion-maker x Group (i.e. IE[Vespa + Floris] > [Berlusconi > Bersani]; $t = 1.88$, $p = .038$). Additional comparison revealed that left Insula was only specifically activated for: in-group Opinion-makers (i.e. IE[Vespa > Floris] +

[Floris > Vespa]; t = 2.02; p = .023) and most important for Right-wing Opinion-maker (Bruno Vespa) in Right-wing voters (i.e. IE[Vespa > Floris]; t = 1.83, p = .035). The analysis on R Postcentral/IPL ROI, showed a significant IE of Ingroup Opinion-makers (t = 2.87, p = .003). Additional comparison confirmed that this effect was due to a greater IE of Vespa vs. Floris in right-wing voters (t = 2.03, p = .023) and to the opposite to a greater IE of Floris vs. Vespa in Left-wing voters (t = 1.76, p = .041).

Finally, in R Cuneus a higher IE was found for Opinion-makers more than Leaders in right-wing voters (t = 1.70, p = .047), this effect was partially confirmed by a trend toward significance for the IE of Vespa vs. Floris Opinion-makers in right-wing participants (t = 1.62, p = .055).

Correlations with "Perceived Similarity Scores"

To further understand the relationship between subjects' perceived similarity responses relative to in-group characters and their brain activity, we looked at how their subjective ratings of the Leaders and Opinion-makers correlated with their brain activity while performing incongruent saccadic movements with respect to in-group gazes. Surprisingly, only in Left-wing voters, activation in right SMG and left IPL (whole-brain analysis: MNI coordinates of peak voxel: -56, -24, 50, data not shown) was greater during gaze-following shifts towards left-wing in-group characters' gaze with whom participants more strongly associated themselves (with respect the out-group political members). That is, left-wing participants perceiving themselves as "similar to in-group" demonstrated greater engagement of right SMG and left IPL as a function of IE for in-group character (more than right-wing out-group characters). In Figure 4, we only depicted the positive correlation between In-group "Perceived

Similarity scores" (compared to out-group characters) and the relative IE for in-group characters in right SMG (t = 3.31; p < .001; R = 0.72; p < . 0.0039).

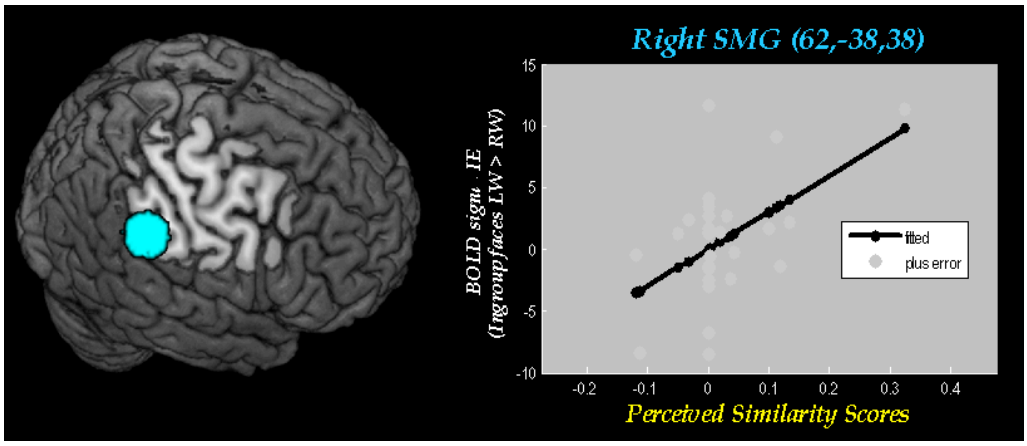

Figure 4: Scatter plot displaying the relation between BOLD responses and "Perceived Similarity Scores" in Right Supramarginal Gyrus for Left-wing Participants. The x axis displays the "Perceived Similarity score" difference calculated by subtracting the scores for in-group left-wing faces minus the scores for out-group right-wing faces for left-wing voters (higher values indicate stronger perceived similarity with respect to own in-group characters). The y axis displays the difference of the parameter estimate associated with incongruent trials minus the parameter estimate associated with congruent trials for in-group left- larger than right-wing out-group faces in left-wing voters (thus, greater values indicate grater IE for left-faces more than for right-wing faces). In right SMG, left-wing voters who perceived themselves more similar to in-group than out-group also showed larger BOLD response (Interference Effect) while performing saccadic movements incongruently with respect to the gaze direction of their political representatives (with respect to the out-group characters).

Experimental Procedure

Subjects

We recruited volunteers by placing flyers at public places and university campus (Città Universitaria at "Sapienza" University of Rome); posting information on internet political discussion group and in a virtual social network. Recruitment materials requested right-handed men and women, ages 18-36 years, who were supporting right- or left-centred wing coalition and were informed about main principal political events and the actual Italian political situation. We carried out all the screening and scanning sessions from late December 2009 until early April 2010, close to the local elections (March the 28th-29th on 2010). Potential subjects were screened by phone using a magnetic resonance imaging questionnaire (to rule out safety risks, neurological disorder and eyeglasses) and a political attitudes questionnaire using general questions to evaluate interest in politics and political orientation. We included subjects evaluating themselves as strong right- or left-wing politically orientated. In addition after scanning session, participants were asked to fill in several Likert scales assessing the interest and attitude toward politics. A rating for each face about political orientation, influence, exposure and emotional valence as well as answer to questionnaire on their personality (See Stimuli and Procedures section) was requested to them. A total of thirty healthy participants were scanned (male: 19; mean age: 23.11 years, range: 19-29, female: 11; mean age: 23.73 years, range: 18-27). The reported analysis were based on 28 normal subject (14 right-wing: male, N= 8; female, N= 6; 14 left-wing people: male, N= 10; female, N= 4), therefore two subjects were excluded because of technical problems during data acquisition. All were Italian citizens, right-handed and native Italian speakers. All subjects had normal or contact-corrected-to-normal visual acuity. After having received an explanation of the procedures, participants gave their

written consent. The study was approved by the independent Ethics Committee of the Santa Lucia Foundation (Scientific Institute for Research Hospitalization and Health Care).

Stimuli and Procedure

Self-report measures

1) Likert Scales

After scanning session, participants were administered a self-reported questionnaire in order to collect their degree of interest in politics, from 1 (not at all interested) to 5 (highly interested), and the frequency with which they discuss about politics with their family members, colleagues at work, acquaintances, and friends, from 1 (never) to 5 (every day). In addition, with the aim to be sure about their political orientation, participants were asked to: a) place themselves on seven Likert type scale, where 1 is extreme left-wing, and 7 is extreme right-wing; b) express their voting behaviour, namely in the last National political elections (April, 2008), the European political elections (June, 2009) and the intention to vote in the future local political elections (March, 2010). These measures allowed us to control that participants political attitude was coherent and strong with respect to their voting preference about past and future political coalition. None of the subjects that declared to vote for the right- or left-wing coalition had ever voted for the opponent party in the past. For each Likert scale we presented a photograph of each distracting face. Under each photograph, participants had to answer in a 1 to 5 Likert scale in order to rate:

a) *Exposure*: "please rate how much do you know, through the media, and about issues linked to his role, the personality x where 1 is "I know him very well" and 5 is "I don't know him at all";

b) *Influence*: "please rate how much do you think x is influent within the Italian political scenario" where 1 is "very influent" and 5 is "not influent at all";

c) *Emotional valence*: is an overall score computed for each face by subtracting negative emotion scores by the positive ones; we asked to participants: "please rate how much do you think x arouses positive emotions" where 1 is "not positive at all" and 5 is "very positive" and "please rate how much do you think x arouses negative emotions" where 1 is "not negative at all" and 5 is "very negative". Negative values indicated a negative emotional valence while positive values indicated a positive emotional evaluation of each Observed-face.

Most importantly, subjects had to rate which is the political orientation of the distracter, considering his ideas, in a 1 to 7 scale, where 1 is "extreme left wing", and 7 is "extreme right wing". These rating allowed us to categorize the four characters accordingly to the participants' point of view. No subjects rated as left-wing politically oriented Berlusconi or Vespa, nor Bersani or Floris were judged as belonging to right-wing coalition. Finally, subjects had to answer to the item of the following tests, presented in a computer monitor by Cogent2000 software (www.vislab.ucl.ac.uk/Cogent/). The presentation of the scales was randomized between subjects.

2) *Personality traits and Similarity Score*

Participants described themselves using a list of 25 adjectives and provided their perceptions of Berlusconi, Bersani, Vespa and Floris using the same list. The list included five markers each of: Energy/Extraversion (happy, determined, dynamic, energetic, active); Agreeableness (cordial, generous, loyal, sincere, unselfish); Conscientiousness (efficient, scrupulous, precise, conscientious, diligent); Emotional stability (optimistic, self-confident, solid, relaxed, calm); and Intellect/Openness to experience (sharp, creative,

innovative, modern, informed). The adjectives were selected from a larger list of adjectives that have previously been identified in the Italian lexicon as being among the most frequently used to describe human personality and also the most representative of each of the dimensions of the Big Five (Caprara & Perugini, 1994). Each adjective was rated for how characteristic it was of each target on a 1 (not at all) to 5 (very much so) scale. To measure similarity, an index was created that represented the similarity between the self and each of the four personalities. First, perceived dissimilarity was computed for each adjective by using the generalized Euclidean distance measure, (*d*, Cronbach & Gleser, 1953) between the personality ratings of the self and the four politicians in question. Dissimilarity was calculated at an overall level, averaging scores across all 25 adjectives. These scores were transformed into a range from 0 to 1 by using the following equation: d = d/dmax, where d is the normalized index and d is the raw index. Finally, we subtracted d from 1 by converting the distance or dissimilarity scores into similarity scores, ranging from 0 (not similar at all) to 1 (completely similar). These scores were entered in the correlation analyses.

Experimental Paradigm: Gaze-cuing task

Participants were positioned in the scanner, in a dimly lit environment. The experimental visual stimuli were presented via a mirror mounted on the MRI headcoil (total display size 19.5° x 14.6° degrees of visual angle, 1.024 × 768 screen resolution, 60 Hz refresh rate). The visual stimuli were back-projected on a screen behind the magnet. Stimulus presentation was controlled with

Cogent2000 (www.vislab.ucl.ac.uk/Cogent/). Each trial started with the appearance of a black central fixation mark (0.5° x 0.5° in size), presented centrally against a grey background, and of two black squares (1.4° x 1.4° in size), presented for 500 ms at 7.5° of eccentricity in the left and the right visual field. Twelve digital pictures, three for each face, were gathered from the news media in internet. The distracting gaze consisted of digital modified photographs of the face of well-known Italian right- or left-wing political leaders (Silvio Berlusconi, Pier Luigi Bersani) or right- or left-wing perceived opinion makers (Bruno Vespa, Giovanni Floris). It is important to note that, while Silvio Berlusconi is the actual Prime Minister and the leader of the centre-right coalition and Pier Luigi Bersani is the leader of the centre-left coalition, Bruno Vespa and Giovanni Floris are both opinion-maker journalist, and are categorized by our participants as sympathizers of the right and left-wing political coalition respectively (See Results section).

In addition, at the data collection time, the index of the trust in Berlusconi, prime minister in charge and charismatic leader of the right-wing coalition that has won local, national elections as well as the elections for sending Italian representatives to the EU parliament, varied between 61% (January 2010) and 58% (April 2010). Instead, Bersani's trust index, Leader of the Italian Democratic Party, varied between 24% and 28% in the same period, as emerged by the "CRESPI Ricerche" phone CATI method survey (available at http://www.sondaggipoliticoelettorali.it/) on a 1,000 people sample stratified for sex, age, geographic area and population center size.

The usability of each character's photograph was determined on the basis of the following criteria: a) the individual had no facial hair; b) the individual was facing the camera; c) the individual had a neutral or smiling expression (to control for emotional content, we choose for each carachter two neutral and one

smiling photographs); d) the image had an acceptable resolution; e) the photograph was taken under normal condition. For each face, the irises and pupils of the eyes were cut from the original photographs and pasted to fit on the right or left side of the eyes using Photoshop 8.0.1 (Adobe, CA). To obtain a striking attentional-capture effect, the stimuli were animated by presenting two frames in rapid sequence. The first frame depicted a straight gaze, while the second frame, which depicted a left- or rightward oriented gaze, replaced the first frame. The direction of the distracting face and the one indicated by the instruction-cue could be 50% of the time congruent or incongruent. Before starting the fMRI acquisition each participant was asked to perform outside the scanner a training task in which they had to learn with 100% accuracy on 48 consecutive trials, the association between instruction signal (red or blue) with leftward or rightward saccadic movements. In the scanner, each trial started with the presentation behind the black fixation mark of a straight gaze which lasted 500 ms. At 500 ms, a second frame, that depicted left- or rightward oriented gaze, replaced the first frame and created a strong animation effect. The directional distracters remained on until the end of the trial. 75 ms after the oriented distracter presentation, the black central fixation mark (imperative-cue) changed to either blue or red colour (Ricciardelli et al., 2002; Crostella et al., 2010; Cazzato et al., 2011). This was the instruction signal for the subjects to make a saccade movement towards the left (change into red) or the right (change into blue) target square. Thus, the direction of the distracter and that indicated by the instruction-cue could be congruent (left-red or right-blue) or incongruent (left-blue or right-red). The face remained visible until the end of the trial. In order to engage automatic processes and minimize expectations, the directional gazes were equiprobable (50% congruent) and non-predictive. It is worth noting that the subjects were instructed to ignore the distracting gaze and

to focus on the central mark colour change. Moreover, they were explicitly informed that the instruction cue was not informative on the direction of the distracters. In order to avoid subjects anticipating stimuli, a random inter-trial interval ranging from 3.5 to 4.5 s was used (See Figure 1).

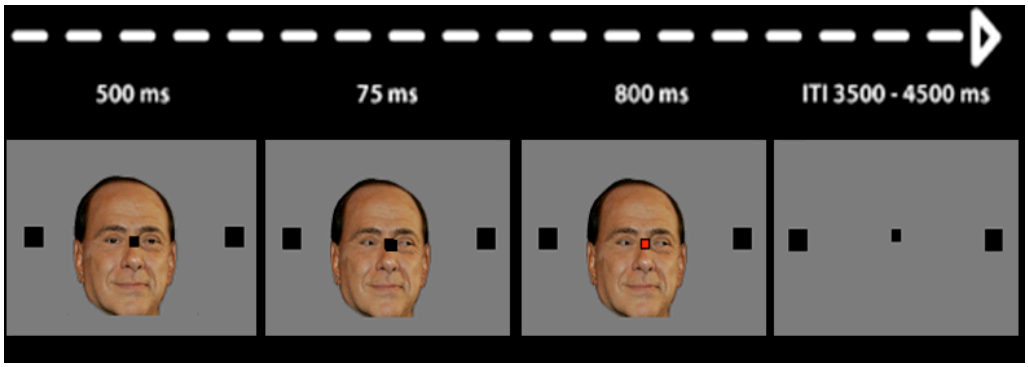

Figure 1: Trial event with a possible distracting face (incongruent condition). At the beginning of the trial, a straight gaze was presented behind a black fixation mark (500 ms). Turning the black fixation point into red was the imperative instruction signal for leftward saccades. Only incongruent condition is represented for the sake of simplicity.

Eight event types were organized in a 4 x 2 factorial design. One factor was the *Distracter: Berlusconi-Bersani-Vespa-Floris*. The second factor was the *Congruence*: *congruent-incongruent* direction between instruction signal and observed-face. Congruent and incongruent directional combinations of instruction cues and distracters were presented in unpredictable and randomized order. These factors were manipulated among the political affiliation supported by the participants, *Group: left-wing - right-wing voters*. Thus, fMRI data were acquired via a mixed, blocked (Distracter)/event related (Congruence) protocol. All participants underwent five fMRI runs. Each

participant completed a total of 720 trials, therefore each imaging session consisted of 36 repetitions for each of the four observed-faces (Berlusconi-Bersani-Vespa-Floris), respectively 18 for congruent and 18 for incongruent conditions (balanced for left/right direction and red-blue imperative-cues). Each scanning session lasted approx. 10 min for total experiment duration of about 50 min.

Eye movements recording

In the training session outside the scanner, subjects sat in front of a computer screen. In all subjects, eye position and saccadic movements were monocularly monitored using an infrared video camera (Sony EVI D31, color video camera, Sony JP). Participants were instructed to look at the location indicated by the instruction-cue and then to quickly look back at the fixation point. During the scanning session, again the participants' saccadic movements were monocularly monitored in real-time by means of an ASL eye-tracking system that was adapted for use in the scanner (Applied Science Laboratories, Bedford, MA; Model 504, sampling rate: 60 Hz). For each subject the eye-tracking system was calibrated before fMRI scanning. The calibration was repeated during the experiment whenever necessary. Eye-position traces were examined in a 2500 ms time window, beginning with the imperative cue onset until the end of the trial. Saccadic RTs were calculated from the target onset time to when a horizontal eye position exceeded 2°. Mean saccadic RTs and accuracy were calculated collapsing left and right directional target trials. We did not compute those saccadic movements performed following distracting gaze instead than instruction cues (incorrect responses), misses (no response), anticipations (RTs

< 100 ms) and retards (RTs > + 2 SD). Overall, we discarded 12.7 % of saccadic trials.

Image Acquisition and Analysis

A Siemens Allegra (Siemens Medical Systems, Erlangen, Germany) operating at 3T and equipped for echo-planar imaging (EPI) acquired functional magnetic resonance (MR) images. A quadrature volume head coil was used for radio frequency transmission and reception. Head movements were minimized by mild restraint and cushioning. Thirty-six slices of functional MR images were acquired using blood oxygenation level-dependent imaging (3.0 x 3.0 x 2.5 mm thick, 50% distance factor, TR = 2.34 s, TE = 30 ms), covering the entire cortex. We used the statistical parametric mapping package SPM5 (www.fil.ion.ucl.ac.uk) implemented in MATLAB (v 7.1, The MathWorks, Natick, MA) for data pre-processing and statistical analyses. For all participants, we acquired 1.275 fMRI volumes, 255 for each run. The first four image volumes of each run were used for stabilizing longitudinal magnetization and were discarded from the analysis. Pre-processing included rigid-body transformation (realignment) and slice timing to correct for head movement and slice acquisition delay. Residual effects of head motion were corrected for by including the six estimated motion parameters for each subject as regressors of no interest. Slice-acquisition delays were corrected using the middle slice as a reference. All images were normalized to the standard SPM5 EPI template, resampled to 2 mm isotropic voxel size, and spatially smoothed using an isotropic Gaussian kernel of 8 mm FWHM. Statistical inference was based on a random effects approach (Penny and Holmes, 2004). First, for each participant, the data were best-fitted at every voxel using a combination of effects of interest.

These were delta functions representing the onsets of the 8 conditions given by the crossing of our 4 x 2 factorial design: *Distracter* [Berlusconi / Bersani / Vespa / Floris] x *Congruence* [congruent / incongruent] convolved with the SPM5 hemodynamic response function. The onset of the hemodynamic response function was aligned with the onset of the imperative cue with duration = 0. Onsets of trials in which an erroneous response or an eye movement toward the wrong side occurred were included in the design matrix as covariates of no interest, but excluded from any further analysis. With the aim to investigate whether the reflexive joint attention mechanism is modulated by the interaction between *Distracter* and *Group,* linear contrasts were used to determine differential brain responses for incongruent minus congruent conditions (IE = Incongruence Effect) separately for the 4 Observed-faces (e.g. [Berlusconi (Incong) > Berlusconi (Cong)]).

Four contrasts images were entered in a 4×2 factorial ANOVA with *Distracter* [Berlusconi / Bersani / Vespa / Floris] and *Group* [Right- / Left-wing] separately for each analysis. Finally, linear contrasts were used to compare the IE, using between-participants variance (rather than between scans). Correction for nonsphericity (Friston et al., 2002) was used to account for possible differences in error variance across conditions and non-independent error terms for the repeated measures. The analysis aimed at determining: a) the brain regions called into action when directional cue and the observed-gaze provided conflicting directional information; and irrespective of Political Affiliation of voters, whether reflexive joint attention was differentially modulated by: b) the Social Role of each Observed-face [Political Leader > Opinion-Maker]; c) the Political Coalition of each Observed-face [e.g. (Right-wing Character) > (Left-wing Character)]. Finally, respectively to the Political Affiliation of participants, d) whether any modulation is exerted by In-group's

Political Representatives [e.g. (Right-wing Group (Berlusconi + Vespa)) > (Left-wing Group (Bersani + Floris))]; e) if reflexive joint attention resulted modulated by the social membership of In-group Political Leader with respect to Opinion-maker [e.g. (Right-wing Group (Berlusconi > Vespa))].