*Preprint of paper submitted to Trends in Cognitive Sciences*

# Altercentric cognition: how others influence our cognitive processing

**Dora Kampis & Victoria Southgate**

Affiliation: Department of Psychology, University of Copenhagen;

Øster Farimagsgade 2A, 1353 Copenhagen, Denmark

Correspondence: dk@psy.ku.dk (D. Kampis); victoria.southgate@psy.ku.dk (V. Southgate)

Keywords: altercentrism, social cognition, mirroring, perspective taking, self and other, attentional bias

## Abstract

**Humans are ultra-social, yet, theories of cognition have often been occupied with the solitary mind. Over the last decade, an increasing volume of work has revealed how individual cognition is influenced by the presence of others. Not only do we rapidly identify others in our environment, but we align our attention with their attention, which influences what we perceive, represent and remember; even when our immediate goals do not involve coordination. The present article refers to the human sensitivity to others and to the targets and content of their attention as '*altercentrism*'; and aims to bring seemingly disparate findings together, suggesting that they are all reflections of the altercentric nature of human cognition.**

## Altercentrism: alignment under joint and solitary goals

While many animals form tight social bonds and occupy complex hierarchies, humans are often described as ultra-social [1]. From early in development, human young are attuned to social cues, evidence prosociality and social learning, and are sensitive to the complexities of social relationships that form the foundation of group living [2]. Perhaps uniquely in the animal kingdom, human social cognition has evolved to meet the challenges of cooperation [1,3], including the teaching of young [4], which entails trust in the information provided by others [5].

The complexity of human social life requires us to be highly adept at perceiving, understanding, and anticipating others' behavior. Whether it is a morning commute on public transport, the planning of a political campaign, chess players trying to outsmart one another, or taking part in a ritualistic celebration, people are constantly required to think about what others are doing or thinking. This poses a nontrivial challenge for human cognition, as others often differ from us in their perceptions, dispositions, competencies, intentions, and beliefs. Acting together involves physical as well as mental coordination, and the ability to take the other's perspective. While some degree of egocentricism is apparent in communication [6,7], we are highly adept at resolving reference by considering our interlocuter's perspective [8] and when describing a scene to a partner with a different view point, speakers readily adopt a non-self-perspective depending on the other's cognitive load [9], task demand [10] and visuo-spatial abilities [11–13], and whether the spatial descriptions are relevant to the other's task [14,15]. People also track others' beliefs without instruction [16], and sometimes report the belief of another person even faster than they do reality [17], though the underlying cognitive mechanisms remain debated [18–21].

While it has long been recognized that individual behavior is influenced by the behavior of others [22] and models of group behavior have discussed the collective nature of human cognition [23,24], most theories of basic cognitive capacities, including perception, attention, action planning, and memory, have focused primarily on the individual. Even many influential theories of social cognition emphasize the individual as the reference point for access to other minds [25,26] and dominant theories of cognitive development hold that children make sense of others based on some preexisting representation of the self [27,28]. However, the primacy of the self in fundamental cognitive processes has been challenged in recent years by a wealth of data revealing that human cognition is profoundly influenced by the presence of other agents, even when our attention is ostensibly focused on our own, seemingly solitary goals and actions. Over the past decade, numerous studies have shown that people plan actions, form memories, and pay attention to aspects of their environment motivated not only by their own perspective and goals, but also by those of others around them. The current paper aims to bring together findings from various lines of research that have, to date, largely been discussed separately, but which all suggest that the way we experience the world is filtered through the lenses of others' perception (See Figure 1, Key Figure).

Coined to contrast with an 'egocentric' or self-related mode of perception, the term 'altercentric' describes other-centered perception [29,30], and the way in which the presence of others causes a shift in our general frame of reference towards the other. In the present paper the term altercentric is used to describe the effect of another agent's presence on an individual's information processing. Altercentrism may serve to align individual cognition with that of other group members, with benefits both for immediate coordination, and also for group synchronization and dynamics. While some of the effects described in the present paper have been discussed elsewhere as part of the mechanisms supporting interpersonal action coordination, the current paper brings them together with more recently documented altercentric effects, suggesting that the motivation to align with others shapes nearly every aspect of human cognition, even when people's immediate goal is individual. The ubiquity of altercentric influence can thus be seen beyond the contexts of cooperation and interaction, where they would seem most obvious, and manifest even when people are engaged in an individual task, act alone with a solitary goal, or respond to stimuli when, in principle, the other's presence is irrelevant.

**Altercentric influence on action**

One of the most well-documented indicators of altercentric influence on our own actions is the phenomenon of motor contagion, described as the unconscious and involuntary imitation of others' actions, postures, and facial expressions [31,32]. This mimicry is the presumed basis for interference effects on the observer's actions where one is less accurate [33] or slower [34] at performing a specified action if another agent is simultaneously performing a different action (see Box 1 Figure I). The dominant explanation for this effect is that observation of others' actions leads us to represent them in our own motor system, and thus concurrently producing a different action requires inhibiting the representation of the other's action. These automatic mimicry effects have been attributed various functions. For facial and postural mimicry, it is thought that they function to increase affiliation between individuals [32], whereas for spontaneous representation of others' actions, it was proposed that this could provide a means of facilitating imitation and action understanding [35] or action prediction [36,37].

While imitation is important, many of our interactions require turn-taking and coordination, and complementary rather than matching actions. Indeed, when joint action is required, we can suspend our tendency to mimic others' actions, and others' actions can prime activation of complementary actions instead [38]. Nevertheless, even when people should be focusing only on their own role, there is evidence for a spontaneous representation of the other's task. For example, when performing the so-called Simon task (a two-choice spatial task) alone (e.g., pressing a left-hand button to a blue cue and a right-hand button to a green cue), participants are slower to respond when the cue appears at the opposite spatial location to their responding hand (i.e. the green cue appears above the right hand [39]). If in such a solo set-up participants only have to respond to one kind of stimulus (e.g., only press for the green cue in a go-nogo manner) this effect disappears, and the stimulus location has no effect on reaction times [40]. Crucially, if a second person is present and responding to the other kind of stimulus (e.g. the participant has to respond only to the green cue as before, but their partner has to respond to the blue), participants again take longer to respond when the target is in the spatially incompatible location, suggesting that they incorporate the other's task into their own, effectively leading to a joint representation of their combined tasks [41]. Similar effects arise in versions of the Flanker task, where stimulus-response mappings are arbitrary, and where people are slower to respond to stimuli surrounded by distractors that are potential targets for another person who is simultaneously, but individually, performing the same task [42]. Participants even appear to represent others' successful or unsuccessful *inhibition* of action in a stop-signal task. In solo versions of such tasks, after having made a successful stop or having failed to do so, on the next trial people often show a slower and more accurate response. In a social adaptation of this task, participants have been found to show the same pattern as an after-effect of another person's prior (successful or unsuccessful) inhibition [43].

These effects likely derive from motor representations generated for others, but they also indicate that observers represent how the environment affords actions for the other. For example, people are faster to execute an instructed action if that action is congruent with an action afforded by an object reachable by someone else, suggesting that they spontaneously encode the object's affordance for the other [44]. In another study, people had to reach for a target stimulus whilst ignoring a distractor. In the solo condition, when responding to a target, distractors from the previous trial located close to the participant's own hand were strongly inhibited, resulting in slower responses. In contrast, when they took turns with another person, participants were slower to respond at locations which in the previous trial had been high salience distractors for the other person, thus showing selective inhibition based on an altercentric frame of reference [45]. These findings suggest that the way people perceive the space around them is influenced not only by the other's observable action, but by the way the other may represent the space from their perspective.

**Altercentric influence on perception and judgement**

Even when not acting together, the mere presence of another agent can lead people to spontaneously adopt the other's spatial position. For example, when asked to describe the position of objects in a scene, the presence of another person can change people's descriptions from an egocentric to an altercentric frame of reference [46,47]. In one example, participants had to answer simple questions about where an object is located (e.g., on which side of the candle is the pineapple?). When these objects were in front of a person also present in the scene (as opposed to the objects being behind the person; or a non-agentive entity instead of a person in the scene), people's left-right judgments tended to align with the other's perspective rather than their own [46].

Others' perspectives also affect how people perceive and make judgments about objects and body parts. When asked to make hand laterality judgements (whether a hand presented is a left or right hand), simply superimposing the hand to be judged on the image of a human silhouette interferes with the judgement of an egocentrically positioned hand [48] suggesting that the task-irrelevant presence of an agent activates an altercentric frame of reference. Convergently, hands that are inverted for the respondent are judged more easily in the presence of another person who sees the hand from the opposite perspective, again indicating the adoption of an altercentric frame of reference and perceiving the hand as upright [49]. The presence of another person can also influence people's perception of faces. Typically, when we are presented with upright and inverted faces, we show a larger face-sensitive N170 ERP component in response to viewing the inverted face. However, if seated opposite another person who would view that face as inverted (upright for self, inverted for other), our own N170 is again enhanced, indicating that we encode the face from the others' perspective [50]. In one of the most striking examples of the effect of others' perspective on our perception, patients with visual neglect were found to detect objects in their neglected field better when, from another person's opposite visuospatial perspective, these objects fall into the non-neglected field providing evidence that the presence of another person alters the frame of reference from which people perceive their environment [51].

Altercentric modulation manifests not only in encoding space from a point marked by the other's bodily position, but is also evident in our rapid shift of attention towards the targets of others' gaze [52], or body orientation indicating the direction of their attention [53]. The effect of such cueing often reaches further than a temporary attention shift. For example, the attention of others seems to imbue objects with properties that they do not otherwise intrinsically carry - a phenomenon termed 'intentional imposition' (for a review see [54] ). Our own perceptual decision making can be both impaired and enhanced by the apparently spontaneous encoding of another's attention. In one remarkable example of this, another person's gaze towards an object modulated participants' judgment of the angle at which an object could tilt before falling over (Figure 2a). When the object was tilted towards the gazer, the estimated angle was greater than if the object was tilted away from the gazer, as if the person's gaze could "hold" the object [55]. The presence of this other agent was irrelevant to the participant's task, yet their judgment was influenced by their encoding of the other's line of sight.

A number of studies investigated people's perceptual judgments when another person holds a conflicting visual perspective. In one of these tasks, the so-called dot-perspective taking task [56], people are asked to judge how many discs they see in a scene, in the presence of an avatar who, because of its orientation, sees either the same or a different number of discs. People are slower to judge how many discs they can see if the avatar sees a different number, suggesting that they spontaneously compute the contents of the avatar's perception and this interferes with their own decision making (see Box 2 for a discussion on the specificity of these effects for social stimuli). In another study, participants were asked to categorize words that always appeared vertically from their own perspective, but which might appear either upright or upside down for another person. Participants were slower to categorize words that appeared upside down for the confederate [57]. Similar effects arise when participants judge the magnitude of abstract numerals in the presence of another person with an opposite visual perspective. In such setups, people are slower to judge asymmetric numbers, where because of their differing orientations, one saw it as a 6 and the other as a 9; than when the numbers were symmetrical, such as 0 or 8, which look the same from both perspectives [58,59]. The effect of how the other person may perceive a stimulus on one's own perception and decision, however, seems to emerge specifically if the other person's task requires them to attend to the perspective-dependent feature (e.g. a number verification task), and not if the other is engaged in an unrelated task [59] (but see [60]).

In other cases, another person's different perspective can facilitate our judgements. A seminal study [61] showed that participants detect a magically-appearing object faster when another agent believed it to be present, even though participants themselves have seen it disappear (for further discussion see [62,63]). Strikingly, people are also more likely to detect near-threshold Gabor patterns when an avatar is also looking towards the stimulus (Figure 2d), an effect which seems to be driven by increased perceptual sensitivity to the stimulus when it is co-witnessed [64]. In spatial compatibility tasks, participants react *faster* when the stimuli are positioned in a *compatible* manner from the other's perspective, compared to a baseline where the other is passive or their view is obstructed [65,66], and even in the joint Simon task discussed earlier, people react faster to compatible than to neutral stimuli, from a joint-task-perspective [41]. In a recent study, participants' ability to judge the form of a letter which was rotated away from them was facilitated if, from another agent's perspective (who was irrelevant to the participant's task), the letter was upright (Figure 2b). This study suggests not only that we spontaneously take the other's perspective, but that the content of their perspective becomes the input to our perceptual system, such that we can perform the same kind of operations (e.g. mental rotation) that we do when this is our primary, first-person, input [67].

Finally, the implied rather than actual physical presence of others can suffice to influence our perceptual decisions. For example, people's perceptual judgements about color are modulated by others' reported judgements even when those are plainly wrong, suggesting that social influence can alter the uptake of sensory information [68]. In tasks involving stimulus-response compatibility, altercentric effects arise when people act in the presence of a real or *perceived* interactive partner [42], who is said to be performing a parallel task [65]. Even when simply listening to human speech, believing that it is coming live from another person elicits differential processing of the same input compared to when it is said to come from a recording [69], indicating that the way we process stimuli is influenced by whether we think it is in the presence of another agent.

**Altercentric effects on memory**

The influence of others' attention remains beyond the immediate attention orienting and also influences what we remember, and how we recall it. For example, gaze cueing results not just in faster detection but also in better memory for a cued than uncued target ([70] Figure 2c). Even early in life, observing a gaze shift enhances infants' memory for the gazed-at object as they later evidence greater familiarity with that object compared to a previously uncued object [71,72].

In an indication that altercentrism may function to enhance group cohesion and dynamics, the benefit of others' attention for our own memory may be especially so if we perceive the other as similar. In a series of studies [73] it was found that memory (e.g., for words) was enhanced if participants were simply given the impression that similar others were also experiencing those stimuli. Furthermore, objects that are the targets of others' actions receive enhanced encoding [74]. These data suggest that the presence of others influences our basic memory for objects and events in our environment. Moreover, the *way* in which others draw our attention towards events seems to influence the kind of information that we retain. Observing others' actions on objects outside of a communicative interaction seems to bias attention more towards encoding the spatiotemporal properties of the objects, whereas if a person communicatively draws our attention to an object (without actually telling us anything about it), people tend to preferentially encode the permanent features of those targets (e.g., [75]). Beyond enhanced memory, orienting attention towards the targets of others' attention results in increased liking for those targets [76,77], especially if multiple others are orienting towards that target [78].

Acting together also influences what we retain. In joint action scenarios, not only do we represent the other's task while performing, but we remember better stimuli that they had to attend to during their task, more so than other non-task relevant items [79]. This joint memory effect of better recall of partner-relevant items seems to be involuntary [80], and arises also when the task is of a non-motor nature [81]. However, a recent study found that the joint memory effect depends not only on the partner's visual attention, but also the task they are engaged in [82]. If their task required responding to the color rather than the semantics of presented words, people did not recall the partner's words better than they did control ones.

Taking the other's perspective in communicative scenarios also has an effect on how people later recall a scene. When people are told they will have to describe a spatial array to a partner, knowing this makes them spontaneously represent the other's viewpoint in their memory alongside their own, and use these strategically depending on their relative misalignment to the partner [83]. Similar effects have been found when people's memory was probed after the communicative episode. After having described an array to a partner, people were better at making judgments from a perspective aligned with the other person than from other non-self-perspectives, suggesting that memory representations were organized incorporating the other's perspective [84].

The social influence on memory can also be found outside of laboratory scenarios [85] in our everyday lives, from collective memory effects to eyewitness testimony. In some cases, social effects on memory can result in worse individual recall or distorted memories (e.g.,[86]), but ultimately it may serve the function of ensuring that our attention is aligned with other members of our social group. Accordingly, it has recently been proposed that episodic memory evolved for a fundamentally social purpose: rather than serving a self-referential function, it tells us when, in social engagements, we can assert epistemic authority and make claims with reference to specific events in the past [87].

**Cognitive mechanisms underlying altercentric effects**

The current paper has brought together various empirical findings under the common conceptual umbrella of altercentrism. While many processes are likely to contribute, several core candidates are worth briefly mentioning here. First, in order to receive enhanced processing, presumably we must assign value to others' choices, whether those are attentional in terms of what they choose to attend to, or motor, in terms of what they choose to interact with. Thus, it is perhaps unsurprising that awareness of others' choices leads to changes in neural mechanisms involved in assigning value to stimuli [88].

Second, that others' behavior can interfere with our own suggests that the representations we generate for others may exploit some of the same cognitive mechanisms involved in first-person representations [61]. In the motor domain, the involvement of the motor system has been shown not just in action execution but also in action observation and prediction

[89]. The other's actions, in turn, can have an effect on one's own (planned) actions, as shown by automatic motor mimicry [34]. Thus in the motor domain the common coding of self and other action [90] is proposed to be one mechanism through which other-derived motor representations can influence our own actions. In joint action, the notion of task co-representation [91] captures the idea that one's own, and the other's task are encoded as part of one integrated representation, and thus both can have an effect on one's behavior. Common neural responses elicited by the same stimuli whether experienced by self or other may also indicate shared mechanisms. For example, adults exhibit an N400, typically elicited by semantic mismatch, not only when something is incongruent for the self, but also for another ([92,93] – for similar effects in adolescents, see [94]). In addition, we show an Error Related Negativity, typically evoked by detecting our own mistakes, also when we detect a mistake made by someone else [95]. Similar common neural activity for self and other encoding has been found in infants (see Box 3), suggesting a potential developmental continuity of some of the processes involved in altercentric effects. What these common signatures imply is an important question for future research, but one possibility is that if another's perspective is indeed represented in a "quasi-perceptual" format [96], then it may be natural that the perceptual input so acquired would initially be treated as first-person input, and would thus be dealt with by the same cognitive and neural mechanisms that would deal with any first-person input. Whether and how the brain differentiates, for example, a self-relevant Error Related Negativity from an other-relevant Error Related Negativity is a further important question.

Consequently, a potential overlap between the cognitive systems that serve to represent one's own and others' perspectives raises the need for mechanisms dedicated to separating and coordinating the self and other, in order to mitigate the possible negative consequences of using shared cognitive resource, and avoid confusion between the two (see Box 1). Indeed, research suggests that stimulating brain regions involved in self-other distinction might modulate some of the altercentric effects, like motor contagion [97] and perspective interference [98], that have been touched upon in this paper.

Finally, the phenomena discussed in this paper involve cognitive processes ranging from low-level perceptual and motor phenomena, to arguably more high-level processes such as selecting a frame of reference in linguistic descriptions, or longer lasting, such as retaining information in memory. In a strict sense, what these have in common is that they are processes designated for first-person information processing while incorporating information coming from, or related to, others. The appeal to the notion of experiential alignment aims to convey that altercentric cognition will likely result in incorporating some part of others' perception of the world into how we ourselves perceive it. This, in effect, can lead to others' perspectives being more readily available in social situations. The functional role of the altercentric nature of human cognition, and the mechanisms that it entails, is potentially one of the most exciting new avenues for future investigations.

## Concluding remarks

Humans are highly attuned to the presence of potential agents, even over-attributing agency and intentions at times [99,100]. Our 'social sense' [61] leads to an attention to others even when it is seemingly unnecessary or detrimental. Altercentrism is a mode of perception that is triggered by the detection of other agents, and which highlights the targets of their attention, thus facilitating an alignment of experience. While others have described a collective mode of cognition that emerges from social interactions [24], the current paper has collected findings suggesting that collective cognition extends far beyond social interaction and coordination, perhaps representing the default state for human cognition.

While attention to the targets of others' attention is part of the notion of *Joint Attention* in which the observer understands the other's attention as *intentional* [101], the inclusion of many of the basic orienting phenomena as reflecting altercentrism may suggest that an understanding of intentionality is not necessary. Indeed, altercentric effects do not make a commitment to the richness of the observer's representations, and are compatible both with ascription of intentional states to the other person [102–104], as well as encoding the other's perspective via other, non-propositional representations [30,105,106].

The present work has amassed findings across the spectrum of information processing and suggested that these may all reflect the profoundly altercentric nature of human cognition, whereby we prioritize the attention of others, and their attentional targets may become the input to our own perception [67]. While many experimental studies have identified altercentric influence manifesting as interference, it is suggested that overall, any detriments are outweighed by the enormous advantage that is gained by being attuned to the attentional targets of others. Alignment with others likely facilitates communication and cooperation, and may benefit group coordination by ensuring that group members are align with the same input [73]. This altercentric tendency may have evolved in response to a need for mechanisms for dealing with others for human cognition [101,102], providing an effective means of overcoming differences between minds.

Social influence has long been an important area of investigation within social psychology. There, questions typically focus on the influence of majorities on individual conformity. To what extent social conformity and contagion are an extension of a core influence of others on basic information processing is an open question, but some research suggests a connection between these phenomena. For example, automatic imitation is greater when people are observing multiple actors rather than a single actor [108], suggesting that majority influence may be an exaggerated instance of a core altercentric influence triggered by the presence of other conspecifics. On the other hand, while multiple others with a shared perspective increase altercentric influence, more than one diverging perspective seems to overall suppress the influence of others, thus leaving open the subject of how multiple non-self-perspectives are integrated into one's own cognition [78].

Many questions remain for future investigation. For example, while it is suggested that the findings discussed in this paper reflect a common phenomenon, it is a further question to what degree they reflect unitary underlying cognitive mechanisms and entail common moderators. Addressing this question is challenging, in part because of the seemingly ubiquitous presence of altercentric effects across domains, age, and measures. Nevertheless, for many of the described effects, an assessment of whether the other can perceive a particular aspect of their environment seems to precede the influence of others' perspectives (see Box 2), suggesting that encoding visual perspective, or other cues indicating what the other is attending to, or acting on, may be the primary modulator of many of these effects. Furthermore, the relationship between egocentric and altercentric influence is not straightforward and remains to be clarified (see Box 4). Finally, much work has to be done to address how universal altercentrism is in humans – and what type of variability exists between individuals, and between cultures (see Outstanding Questions Box). The present paper aimed to lay the groundwork for future investigations towards a better understanding of the fundamentally social nature of human cognition.

Acknowledgment. The authors thank V. Manea, E. Yeung, I. Király, I. Konvalinka, and A. Curioni for comments on earlier versions of the manuscript, and V. Manea for their help with the figures. Both DK and VS are supported by a Consolidator Grant from the ERC (DEVOMIND 726114) to VS.

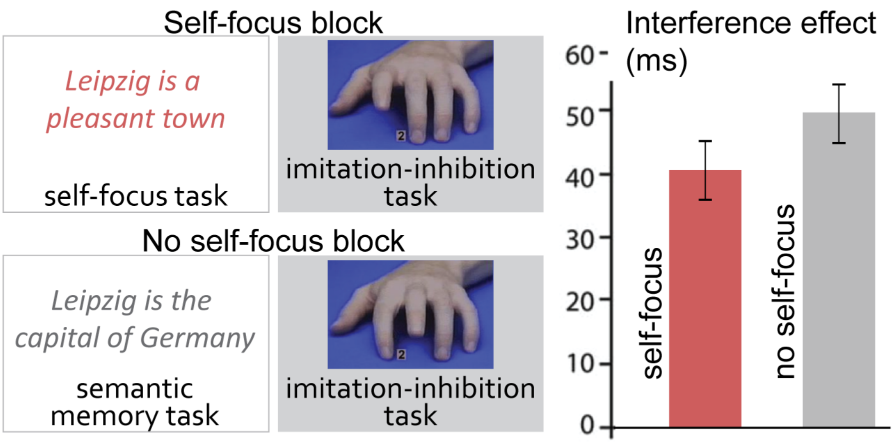
**Box 1. Coordinating the self and other's perspective**

The altercentric influence on human perception and cognition, and the proposed shared representational framework for self- and other-derived representations [90], presumably contributes to the need for mechanisms that enable the individual to differentiate between these representations, and control which will drive behavior.

In visual encoding, different cortical activation patterns seem to be related to encoding body parts from an egocentric versus an altercentric perspective [109]. In the motor domain, distinguishing self-generated from other-generated actions has been linked to the sense of agency and subjective self-consciousness [110,111]. Relatedly, in joint action, the ventral premotor cortex was found to activate when people perform their turn in a complementary task; and the orbitofrontal cortex was associated with acting in the presence of a co-actor, potentially linked to performance monitoring in turn-taking [112].

Part of the process of coordinating between multiple perspectives requires classic inhibition and control processes. Neuroimaging and patient studies suggest that, when the self and other perspective are in conflict, the inferior frontal gyrus (IFG) is involved in resolving the conflict [113–115]. However, domain-general inhibition is not the only control process involved. A body of research has identified the posterior temporoparietal junction (TPJ) as important in controlling shared representations [116] and the presence of conflicting perspectives may already be encoded in the TPJ before frontal regions are involved in perspective selection [117,118]. The posterior region of the TPJ is involved in imitation inhibition, a process that requires managing the influence of the other on the self [119]. Convergently, inhibiting TPJ via rTMS leads to impaired self-other control and a reduced ability to use self-representations [98], and less control of imitation, indicating an enhanced influence of the other [120]. Together, these studies indicate that the TPJ may play a role in shifting attention between self and other.

Contextual factors can also influence managing the self and other's perspective. The inhibition of imitation is facilitated by an increased focus on the self (Figure I), elicited, for example, by looking at oneself in the mirror [121], or presenting self-referential primes (e.g. me / mine) [122]. Imitation inhibition, in turn, improves perspective-taking - presumably via shifting attention to the self, and enhancing self-other distinction [123]. Indeed, it has been argued that the lack of perspective-taking in young children may be related to an inability to differentiate the self from others [124].



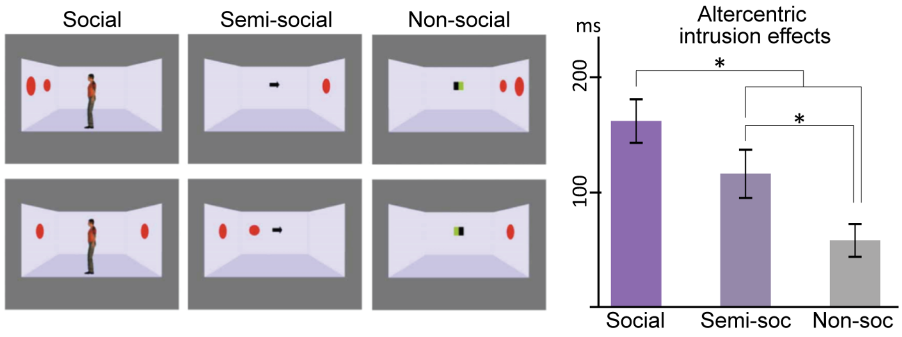

**Box 1 Figure I.** Motor compatibility effect. Participants' task is to lift their index or middle finger. They respond slower if the observed movement is incongruent with their task; but less so if they were primed with self-focus words, resulting in a smaller interference effect (measured by reaction time difference between incongruent and congruent trials).

**Box 2. Are 'altercentric' effects strictly social?**

The current paper suggests that many documented effects in human perception and cognition are attributable to the wide-reaching consequences of a tendency to attend to the focus of others' attention. However, there is debate concerning whether this tendency is elicited selectively by social stimuli, or whether it could be explained by a more domain-general orientation of attention towards any directional cue [125]. While various studies have found that altercentric effects are agent-specific and are not elicited by non-agentive entities like boxes [61], or arrows [126] ; some have found evidence of similar interference effects in seemingly non-social contexts [127]. Furthermore, while some studies have found no effect of the agent's capacity to see (e.g. [128,129], others found that factors that should impede vision influence (like goggles [130,131], blindfolds [64] or barriers [76,132] modulate altercentric interference. For example, the effect of another's gaze on participant's judgement of an object's stability [55] is removed if the person doing the gazing is wearing a blindfold.

While there are conflicting findings, there are several points that speak to the social specificity of altercentric effects. First, when directly compared, the modulation by directional cues that are not agentive, tend to be smaller than agentive influence [51,133] (Figure I); and the altercentric influence changes depending on how active role the agent plays in the scene [134]. Second, participant's own self-reported social skills correlate with altercentric interference specifically when the other is an agent and not an arrow or a block [133]. Finally, the others' task, and thus the aspect of the stimuli they attend to, influence whether he other's visual perspective or attention influences people's reaction time and recall [59,82], thus speaking against a general attention-enhancing mechanism.

Together, rather than reflecting a domain-general directional cue sensitivity, this may suggest that altercentric interference reflects a system that is specialized for orienting to social cues, but which is sometimes overextended to seemingly non-social directional cues as well. Indeed, there are other examples of dedicated social systems that are overextended to a broader category of similar stimuli [135].




**Box 2 Figure I.** Effect of other's perspective on number judgment. People's decisions about the number of disks seen from their own perspective is influenced by the presence of social cues (another's gaze) and semi-social cues (arrows) more than non-social cues (blocks).

**Box 3. Infant cognition: ultra-altercentric?**

While altercentrism seems to be characteristic of human cognition throughout the lifespan, it may have special significance early in ontogeny. The main challenge of infancy is to acquire a vast amount of information, and select what to learn about; while at the same time infants' abilities to act on the world themselves are still limited. Thus, a tendency to align attention with others may have particular adaptive value in infancy via guiding infants what information to acquire, and infancy may provide clues to the origins of altercentrism.

From early in life, infants exhibit many of the effects characteristic of altercentric perception, including gaze cueing [136,137], gaze following [138–140], enhanced memory and preference for the targets of others' attention [71,72,141,142] and action [74,143], behavioral mimicry [144], and altered expectations about the presence of objects if someone else has experienced that object's presence [61].

Like adults, there is evidence that infants rely on shared mechanisms for acting on the world themselves and for interpreting how others perceive the world: they recruit their own motor system when another person should act based on a false belief [89], and recruit similar neural mechanisms when an object is hidden from themselves and another agent [145]. They show the N400 effect, usually exhibited when we detect semantic incongruency, also when something is incongruent for someone else [146] and, while adults show this so-called social N400 when instructed to attend to the others' perspective [92] or under low cognitive load [93], infants do so spontaneously [147].

The reliance on shared mechanisms may contribute to a blurring between self and other [148], and this blurring may be particularly apparent in young infants, as self-representation is a relatively late achievement. In contrast to traditional views of cognitive development which view the Self as privileged, and egocentrism the starting point [28], only later becoming integrated with third-person information [149]; a recent account proposes that infants rather begin as altercentric [30]. Under this view, it is with the emergence of self-representation during the second year of life that infants start to distinguish their perception of the others' experience, from their own. This may, in effect, manifest in more pronounced altercentrism, in that infants prioritize the other's perspective (though may not represent it as such [30]). Altercentrism in early life may facilitate the challenge of learning, where, through the lenses of others, infants are fast-tracked to gather a shared knowledge base [150].

**Box 4: Egocentric vs. Altercentric cognition**

If altercentric influence is so widespread, why is the self-first, egocentric view of human cognition so pervasive? One contributing factor may simply be that it is difficult for us to imagine that we, as individuals, do not fully dictate our own actions [151]. Our belief that our own psychological states are direct and privileged may be an illusion, unsupported by empirical evidence which rather suggests that young children's errors in thinking about other minds extend to thinking about their own minds too [152]. Nevertheless, there is plenty of evidence for egocentricity in human perception and action. Neurons in many brain regions represent the world from an egocentric frame of reference [153,154] and it is well-documented that subjective experience is often a basis for understanding others [155].

Far from being slaves to egocentric influence, however, human cognition can be oriented towards either an egocentric or an altercentric encoding, depending on the context. One and the same situation can be perceived through an egocentric or an altercentric lens, depending on factors like whether your current attentional focus is on the self or other [121]. Another example of the shift between egocentricism and altercentrism is evident in the dot-perspective taking task where, if there exists a conflict in perspectives, participants are faster to judge the self-perspective (suggesting an egocentric bias) but if there is no conflict, participants are faster to judge the other's perspective (suggesting an altercentric bias) [56,156]. Egocentric interference, overall, tends to be more pronounced than altercentric interference but both effects appear to increase with more perceived similarity between self and other: egocentric interference is larger for in-group than for out-group members [157], and altercentric effects are reduced when the other differs in age from the respondent [158].

Finally, even within a social context, an egocentric encoding may still be useful. For example, simulation (referencing other to self) may be employed as a powerful strategy for understanding others given that others are constrained by many of the same factors that constrain our own behavior [159].

References

1 Tomasello, M. (2014) The ultra-social animal. *Eur. J. Soc. Psychol.* 44, 187–194

2 Liberman, Z. *et al.* (2017) The Origins of Social Categorization. *Trends Cogn. Sci.* 21, 556–568

3 Herrmann, E. *et al.* (2007) Humans have evolved specialized skills of social cognition: The cultural intelligence hypothesis. *Science (80-. ).* 317, 1360–1366

4 Csibra, G. and Gergely, G. (2009) Natural pedagogy. *Trends Cogn. Sci.* 13, 148–53

5 Sperber, D. *et al.* (2010) Epistemic vigilance. *Mind Lang.* 25, 359–393

6 Keysar, B. *et al.* (2003) Limits on theory of mind use in adults. *Cognition* 89, 25–41

7 Nickerson, R.S. (1999) How we know - And sometimes misjudge - What others know: Imputing one's own knowledge to others. *Psychol. Bull.* 125, 737–759

8 Hanna, J.E. *et al.* (2003) The effects of common ground and perspective on domains of referential interpretation. *J. Mem. Lang.* 49, 43–61

9 Mainwaring, S.D. *et al.* (2003) Descriptions of Simple Spatial Scenes in English and Japanese. *Spat. Cogn. Comput.* 3, 3–42

10 Duran, N.D. *et al.* (2011) Listeners invest in an assumed other's perspective despite cognitive cost. *Cognition* 121, 22–40

11 Schober, M.F. (1993) Spatial perspective-taking in conversation. *Cognition* 47, 1–24

12 Schober, M.F. (1995) Speakers, addressees, and frames of reference: Whose effort is minimized in conversations about locations? *Discourse Process.* 20, 219–247

13 Schober, M.F. (2009) Spatial dialogue between partners with mismatched abilities. In *Spatial language and dialogue* (K. R. Conventry, T. Tenbrink, & J. A. B., ed), pp. 23–39, Oxford University Press

14 Roche, J. *et al.* Proceedings of the Annual Meeting of the Cognitive Science behaviour. , *Proceedings of the Annual Meeting of the Cognitive Science behaviour*. (2010) , Cognitive Science Society, 206–211

15 Yoon, S.O. *et al.* (2012) Influence of perspective and goals on reference production in

conversation. *Psychon. Bull. Rev.* 19, 699–707

16 Schneider, D. *et al.* (2012) Eye movements reveal sustained implicit processing of others' mental states. *J. Exp. Psychol. Gen.* 141, 433–8

17 Cohen, A.S. and German, T.C. (2009) Encoding of others' beliefs without overt instruction. *Cognition* 111, 356–363

18 Schneider, D. *et al.* (2012) Cognitive Load Disrupts Implicit Theory-of-Mind Processing. *Psychol. Sci.* 23, 842–847

19 Apperly, I.A. *et al.* (2006) Is belief reasoning automatic? *Psychol. Sci.* 17, 841–844

20 Schneider, D. *et al.* (2017) Current evidence for automatic Theory of Mind processing in adults. *Cognition* 162, 27–31

21 Edwards, K. and Low, J. (2019) Level 2 perspective-taking distinguishes automatic and non-automatic belief-tracking. *Cognition* 193, 104017

22 Cialdini, R.B. and Goldstein, N.J. (2004) Social Influence: Compliance and Conformity. *Annu. Rev. Psychol.* 55, 591–621

23 Goldstone, R.L. and Janssen, M.A. (2005) Computational models of collective behavior. *Trends Cogn. Sci.* 9, 424–430

24 Gallotti, M. and Frith, C.D. (2013) Social cognition in the we-mode. *Trends Cogn. Sci.* 17, 160–165

25 Gallese, V. and Goldman, A. (1998) Mirror neurons and the simulation theory of mindreading. *Trends Cogn. Sci. Cogn. Sci.* 2, 493–501

26 Stich, S. and Nichols, S. (1992) Folk Psychology: Simulation or Tacit Theory? *Mind Lang.* 7, 35–71

27 Meltzoff, A.N. (2007) "Like me": A foundation for social cognition. *Dev. Sci.* 10, 126–134

28 Piaget, J. (1926) *The language and thought of the children*, Turbner and Co., Ltd.

29 Bråten, S. (2007) Altercentric infants and adults: On the origins and manifestations of participant perception of others' acts and utterances. In *On Being Moved: From mirror neurons to empathy* (Bråten, S., ed), pp. 111–137, John Benjamins Publishing

Company

30 Southgate, V. (2020) Are Infants Altercentric? The Other and the Self in Early Social Cognition. *Psychol. Rev.* 127, 505

31 Dimberg, U. *et al.* (2000) Unconscious facial reactions to emotional facial expressions. *Psychol. Sci.* 11, 86–89

32 Chartrand, T.L. and Bargh, J.A. (1999) The chameleon effect: the perception–behavior link and social interaction. *J. Pers. Soc. Psychol.* 76, 893–910

33 Kilner, J.M. *et al.* (2003) An Interference Effect of Observed Biological Movement on Action. *Curr. Biol.* 13, 654–658

34 Brass, M. *et al.* (2001) Movement observation affects movement execution in a simple response task. *Acta Psychol. (Amst).* 106, 3–22

35 Rizzolatti, G. *et al.* (2001) Neurophysiological mechanisms underlying the understanding and imitation of action. *Nat. Rev. Neurosci.* 2, 661–70

36 Csibra, G. (2007) Action mirroring and action understanding : an alternative account. In *Attention and Perfomnace XXII: Sensorimotor Foundations of Higher Cognition* (Haggard, P. et al., eds), pp. 435–459, Oxford University Press

37 Southgate, V. (2013) Do infants provide evidence that the mirror system is involved in action understanding? *Conscious. Cogn.* 22, 1114–1121

38 van Schie, H.T. *et al.* (2008) Understanding Action Beyond Imitation: Reversed Compatibility Effects of Action Observation in Imitation and Joint Action. *J. Exp. Psychol. Hum. Percept. Perform.* 34, 1493–1500

39 Simon, J.R. and Craft, J.L. (1970) Effects of an irrelevant auditory stimulus on visual choice reaction time. *J. Exp. Psychol.* 86, 272

40 Ansorge, U. and Wühr, P. (2004) A Response-Discrimination Account of the Simon Effect. *J. Exp. Psychol. Hum. Percept. Perform.* 30, 365–377

41 Sebanz, N. *et al.* (2003) Representing others' actions: just like one's own? *Cognition* 88, 11–21

42 Atmaca, S. *et al.* (2011) The joint flanker effect: Sharing tasks with real and imagined co-actors. *Exp. Brain Res.* 211, 371–385

43 Schuch, S. and Tipper, S.P. (2007) On observing another person' s actions: influences of observed inhibition and errors. *Percept. Psychophys.* 69, 828–837

44 Costantini, M. *et al.* (2011) Ready both to your and to my hands: Mapping the action space of others. *PLoS One* 6, 2–7

45 Frischen, A. *et al.* (2009) Seeing the world through another person's eyes: Simulating selective attention via action observation. *Cognition* 111, 212–218

46 Tosi, A. *et al.* (2020) Speakers' use of agency and visual context in spatial descriptions. *Cognition* 194, 104070

47 Tversky, B. and Hard, B. (2009) Embodied & disembodied cognition 2009. *Cognition* 110, 124–129

48 Conson, M. *et al.* (2012) Judging hand laterality from my or your point of view: Interactions between motor imagery and visual perspective. *Neurosci. Lett.* 530, 35–40

49 Böckler, A. *et al.* (2011) Giving a helping hand: Effects of joint attention on mental rotation of body parts. *Exp. Brain Res.* 211, 531–545

50 Böckler, A. and Zwickel, J. (2013) Influences of spontaneous perspective taking on spatial and identity processing of faces. *Soc. Cogn. Affect. Neurosci.* 8, 735–40

51 Becchio, C. *et al.* (2013) In your place: Neuropsychological evidence for altercentric remapping in embodied perspective taking. *Soc. Cogn. Affect. Neurosci.* 8, 165–170

52 Friesen, C.K. *et al.* (2004) Attentional Effects of Counterpredictive Gaze and Arrow Cues. *J. Exp. Psychol. Hum. Percept. Perform.* 30, 319–329

53 Azarian, B. *et al.* (2017) Averted body postures facilitate orienting of the eyes. *Acta Psychol. (Amst).* 175, 28–32

54 Becchio, C. *et al.* (2008) How the gaze of others influences object processing. *Trends Cogn. Sci.* 12, 254–258

55 Guterstam, A. *et al.* (2019) Implicit model of other people's visual attention as an

invisible, force-carrying beam projecting from the eyes. *Proc. Natl. Acad. Sci. U. S. A.* 116, 328–333

56 Samson, D. *et al.* (2010) Seeing it their way: Evidence for rapid and involuntary computation of what other people see. *J. Exp. Psychol. Hum. Percept. Perform.* 36, 1255–1266

57 Freundlieb, M. *et al.* (2018) Reading Your Mind While You Are Reading—Evidence for Spontaneous Visuospatial Perspective Taking During a Semantic Categorization Task. *Psychol. Sci.* 29, 614–622

58 Surtees, A. *et al.* (2016) I've got your number: Spontaneous perspective-taking in an interactive task. *Cognition* 150, 43–52

59 Elekes, F. *et al.* (2016) Evidence for spontaneous level-2 perspective taking in adults. *Conscious. Cogn.* 41, 93–103

60 Surtees, A.D.R. *et al.* (2016) I've got your number: Spontaneous perspective-taking in an interactive task. *Cognition* 150, 43–52

61 Kovács, Á.M. *et al.* (2010) The social sense: Susceptibility to others' beliefs in human infants and adults. *Science (80-. ).* 330, 1830–1834

62 Phillips, J. *et al.* (2015) A second look at automatic theory of mind: Reconsidering kovács, téglás, and endress (2010). *Psychol. Sci.* 26, 1353–1367

63 El Kaddouri, R. *et al.* (2019) Measuring spontaneous mentalizing with a ball detection task: putting the attention-check hypothesis by Phillips and colleagues (2015) to the test. *Psychol. Res.* DOI: 10.1007/s00426-019-01181-7

64 Seow, T. and Fleming, S.M. (2019) Perceptual sensitivity is modulated by what others can see. *Attention, Perception, Psychophys.* 81, 1979–1990

65 Freundlieb, M. *et al.* (2016) When do humans spontaneously adopt another's visuospatial perspective? *J. Exp. Psychol. Hum. Percept. Perform.* 42, 401–412

66 Freundlieb, M. *et al.* (2017) Out of your sight, out of my mind: Knowledge about another person's visual access modulates spontaneous visuospatial perspective-taking. *J. Exp.*

*Psychol. Hum. Percept. Perform.* 43, 1065–1072
67 Ward, E. *et al.* (2019) Spontaneous Vicarious Perception of the Content of Another's Visual Perspective. *Curr. Biol.* 29, 874-880.e4
68 Germar, M. *et al.* (2014) Social Influence and Perceptual Decision Making: A Diffusion Model Analysis. *Personal. Soc. Psychol. Bull.* 40, 217–231
69 Rice, K. and Redcay, E. (2016) Interaction matters: A perceived social partner alters the neural processing of human speech. *Neuroimage* 129, 480–488
70 Gregory, S.E.A. and Jackson, M.C. (2018) Barriers block the effect of joint attention on working memory: Perspective taking matters. *J. Exp. Psychol. Learn. Mem. Cogn.* 45, 795–806
71 Reid, V.M. *et al.* (2004) Eye gaze cueing facillitates neural processing of objects in 4-month-old infants. *Neuroreport* 15, 2553–2555
72 Reid, V.M. and Striano, T. (2005) Adult gaze influences infant attention and object processing: Implications for cognitive neuroscience. *Eur. J. Neurosci.* 21, 1763–1766
73 Shteynberg, G. (2010) A Silent Emergence of Culture: The Social Tuning Effect. *J. Pers. Soc. Psychol.* 99, 683–689
74 Howard, L.H. and Woodward, A.L. (2019) Human Actions Support Infant Memory. *J. Cogn. Dev.* 20, 772–789
75 Marno, H. *et al.* (2014) Nonverbal communicative signals modulate attention to object properties. *J. Exp. Psychol. Hum. Percept. Perform.* 40, 752–762
76 Manera, V. *et al.* (2014) When seeing is more than looking: Intentional gaze modulates object desirability. *Emotion* 14, 824–832
77 Bayliss, A.P. *et al.* (2006) Gaze cuing and affective judgments of objects: I like what you look at. *Psychon. Bull. Rev.* 13, 1061–1066
78 Capozzi, F. *et al.* (2014) Altercentric intrusions from multiple perspectives: Beyond dyads. *PLoS One* 9, 1–14
79 He, X. *et al.* (2011) Interpersonal memory-based guidance of attention is reduced for

ingroup members. *Exp. Brain Res.* 211, 429–438

80 Eskenazi, T. *et al.* (2013) Your words are my words: Effects of acting together on encoding. *Q. J. Exp. Psychol.* 66, 1026–1034

81 Elekes, F. *et al.* (2016) Enhanced encoding of the co-actor's target stimuli during a shared non-motor task. *Q. J. Exp. Psychol.* 69, 2376–2389

82 Elekes, F. and Sebanz, N. (2020) Effects of a partner's task on memory for content and source. *Cognition* 198, 104221

83 Galati, A. *et al.* (2013) The conversational partner's perspective affects spatial memory and descriptions. *J. Mem. Lang.* 68, 140–159

84 Shelton, A.L. and McNamara, T.P. (2004) Spatial memory and perspective taking. *Mem. Cogn.* 32, 416–426

85 Echterhoff, G. and Hirst, W. (2009) Social influence on memory. *Soc. Psychol. (Gott).* 40, 106–110

86 Barber, S.J. *et al.* (2010) When two is too many: Collaborative encoding impairs memory. *Mem. Cogn.* 38, 255–264

87 Mahr, J. and Csibra, G. (2017) Why do we remember? The communicative function of episodic memory. *Behav. Brain Sci.* DOI: 10.1017/S0140525X17000012

88 Zaki, J. *et al.* (2011) Social influence modulates the neural computation of value. *Psychol. Sci.* 22, 894–900

89 Southgate, V. and Vernetti, A. (2014) Belief-based action prediction in preverbal infants. *Cognition* 130, 1–10

90 Decety, J. and Sommerville, J.A. (2003) Shared representations between self and other: A social cognitive neuroscience view. *Trends Cogn. Sci.* 7, 527–533

91 Sebanz, N. *et al.* (2005) How two share a task: Corepresenting stimulus-response mappings. *J. Exp. Psychol. Hum. Percept. Perform.* 31, 1234–1246

92 Rueschemeyer, S.A. *et al.* (2014) The Social N400 effect: how the presence of other listeners affects language comprehension. *Psychon. Bull. Rev.* 22, 128–134

93 Jouravlev, O. *et al.* (2018) Tracking Colisteners ' Knowledge States During Language Comprehension. DOI: 10.1177/0956797618807674

94 Westley, A. *et al.* (2017) "I know something you don't know": Discourse and social context effects on the N400 in adolescents. *J. Exp. Child Psychol.* 164, 45–54

95 Kang, S.K. *et al.* (2010) Your mistakes are mine: Self-other overlap predicts neural response to observed errors. *J. Exp. Soc. Psychol.* 46, 229–232

96 Ward, E. *et al.* (2019) Spontaneous Vicarious Perception of the Content of Another's Visual Perspective. *Curr. Biol.* 29, 874-880.e4

97 Sowden, S. and Catmur, C. (2015) The role of the right temporoparietal junction in the control of imitation. *Cereb. Cortex* 25, 1107–13

98 Bardi, L. *et al.* (2017) Repetitive TMS of the temporo-parietal junction disrupts participant's expectations in a spontaneous Theory of Mind task. *Soc. Cogn. Affect. Neurosci.* 12, 1775–1782

99 Heider, F. and Simmel, M. (1944) An Experimental Study of Apparent Behavior Authors. *Am. J. Psychol.* 57, 243–259

100 Burnside, K. *et al.* (2020) Infants attribute false beliefs to a toy crane. *Dev. Sci.* 23,

101 Tomasello, M. *et al.* (1993) Cultural Learning. *Behav. Brain Sci.* 16, 495–552

102 Leslie, A.M. (1987) Pretense and representation: The origins of "theory of mind." *Psychol. Rev.* 94, 412–426

103 Kovács, Á.M. (2016) Belief Files in Theory of Mind Reasoning. *Rev. Philos. Psychol.* 7, 509–527

104 Baillargeon, R. *et al.* (2010) False-belief understanding in infants. *Trends Cogn. Sci.* 14, 110–118

105 Butterfill, S.A. and Apperly, I.A. (2013) How to construct a minimal theory of mind. *Mind Lang.* 28, 606–637

106 Rakoczy, H. (2012) Do infants have a theory of mind? *Br. J. Dev. Psychol.* 30, 59–74

107 Belfer-Cohen, A. and Hovers, E. (2020) Prehistoric Perspectives on "Others" and

"Strangers." *Front. Psychol.* 10, 1–11

108 Cracco, E. and Brass, M. (2018) The role of sensorimotor processes in social group contagion. *Cogn. Psychol.* 103, 23–41

109 Saxe, R. *et al.* (2006) My body or yours? The effect of visual perspective on cortical body representations. *Cereb. Cortex* 16, 178–182

110 David, N. *et al.* (2008) The "sense of agency" and its underlying cognitive and neural mechanisms. *Conscious. Cogn.* 17, 523–34

111 Gallagher, S. (2000) Philosophical conceptions of the self: Implications for cognitive science. *Trends Cogn. Sci.* 4, 14–21

112 Sebanz, N. *et al.* (2007) sebanz et al 2007 Is it really my turn An event related fMRI study of task sharing.pdf. *Soc. Neurosci.* 2, 81–95

113 Samson, D. *et al.* (2005) Seeing it my way: A case of a selective deficit in inhibiting self-perspective. *Brain* 128, 1102–1111

114 Hartwright, C.E. *et al.* (2015) The special case of self-perspective inhibition in mental, but not non-mental, representation. *Neuropsychologia* 67, 183–192

115 Van der Meer, L. *et al.* (2011) Inhibit yourself and understand the other: Neural basis of distinct processes underlying Theory of Mind. *Neuroimage* 56, 2364–2374

116 Steinbeis, N. (2016) The role of self-other distinction in understanding others' mental and emotional states: Neurocognitive mechanisms in children and adults. *Philos. Trans. R. Soc. B Biol. Sci.* 371,

117 Qureshi, A.W. *et al.* (2010) Executive function is necessary for perspective selection, not Level-1 visual perspective calculation: Evidence from a dual-task study of adults. *Cognition* 117, 230–236

118 McCleery, J.P. *et al.* (2011) The Neural and Cognitive Time Course of Theory of Mind. *J. Neurosci.* 31, 12849–12854

119 Spengler, S. *et al.* (2009) Control of shared representations relies on key processes involved in mental state attribution. *Hum. Brain Mapp.* 30, 3704–3718

120 Sowden, S. and Catmur, C. (2015) The role of the right temporoparietal junction in the control of imitation. *Cereb. Cortex* 25, 1107–1113

121 Spengler, S. *et al.* (2010) Minimizing motor mimicry by myself: Self-focus enhances online action-control mechanisms during motor contagion. *Conscious. Cogn.* 19, 98–106

122 Van Baaren, R.B. *et al.* (2003) It Takes Two to Mimic: Behavioral Consequences of Self-Construals. *J. Pers. Soc. Psychol.* 84, 1093–1102

123 Santiesteban, I. *et al.* (2012) Training social cognition: From imitation to Theory of Mind. *Cognition* 122, 228–235

124 Bukowski, H. *et al.* (2015) From gaze cueing to perspective taking: Revisiting the claim that we automatically compute where or what other people are looking at. *Vis. cogn.* 23, 1020–1042

125 Heyes, C.M. (2014) Submentalizing: I Am Not Really Reading Your Mind. *Perspect. Psychol. Sci.* 9, 131–143

126 Gregory, S.E.A. and Jackson, M.C. (2017) Joint attention enhances visual working memory. *J. Exp. Psychol. Learn. Mem. Cogn.* 43, 237

127 Santiesteban, I. *et al.* (2013) Avatars and Arrows: Implicit Mentalizing or Domain-General Processing? *J. Exp. Psychol. Hum. Percept. Perform.* 39, 1–9

128 Conway, J.R. *et al.* (2016) Submentalizing or mentalizing in a Level 1 perspective-taking task. *J. Exp. Psychol. Hum. Percept. Perform.* 43, 454–465

129 Millett, A.C. *et al.* (2019) Attribution of vision and knowledge in ‘spontaneous perspective taking.’ *Psychol. Res.* DOI: 10.1007/s00426-019-01179-1

130 Furlanetto, T. *et al.* (2016) Altercentric interference in level 1 visual perspective taking reflects the ascription of mental states, not submentalizing. *J. Exp. Psychol. Hum. Percept. Perform.* 42, 158–163

131 Teufel, C. *et al.* (2009) Social Cognition Modulates the Sensory Coding of Observed Gaze Direction. *Curr. Biol.* 19, 1274–1277

132 Nuku, P. and Bekkering, H. (2008) Joint attention: Inferring what others perceive (and

don't perceive). *Conscious. Cogn.* 17, 339–349

133 Nielsen, M.K. *et al.* (2015) Inclined to see it your way: Do altercentric intrusion effects in visual perspective taking reflect an intrinsically social process? *Q. J. Exp. Psychol.* 68, 1931–1951

134 Zhao, X. *et al.* (2015) In Search of Triggering Conditions for Spontaneous Visual Perspective Taking. *Proc. 37th Annu. Conf. Cogn. Sci. Soc.* at <https://mindmodeling.org/cogsci2015/papers/0481/paper0481.pdf>

135 Farroni, T. *et al.* (2005) Newborns' preference for face-relevant stimuli: Effects of contrast polarity. *Proc. Natl. Acad. Sci. U. S. A.* 102, 17245–17250

136 Hood, B.M. *et al.* (1998) Adult's eyes trigger shifts of visual attention in human infants. *Psychol. Sci.* 9, 131–134

137 Farroni, T. *et al.* (2000) Infants' use of gaze direction to cue attention: The importance of perceived motion. *Vis. cogn.* 7, 705–718

138 Flom, R. *et al.* (2007) *Gaze-following: Its development and significance*, Psychology Press.

139 Del Bianco, T. *et al.* (2019) The Developmental Origins of Gaze-Following in Human Infants. *Infancy* 24, 433–454

140 Senju, A. and Csibra, G. (2008) Gaze Following in Human Infants Depends on Communicative Signals. *Curr. Biol.* 18, 668–671

141 Okumura, Y. *et al.* (2013) The power of human gaze on infant learning. *Cognition* 128, 127–133

142 Ishikawa, M. and Itakura, S. (2018) Observing others' gaze direction affects infants' preference for looking at gazing- or gazed-at faces. *Front. Psychol.* 9, 1–7

143 Hamlin, J.K. *et al.* (2008) Do as I do: 7-Month-old infants selectively reproduce others' goals. *Dev. Sci.* 11, 487–494

144 de Klerk, C.C.J.M. *et al.* (2018) Eye contact modulates facial mimicry in 4-month-old infants: An EMG and fNIRS study. *Cortex* 106, 93–103

145 Kampis, D. *et al.* (2015) Neural signatures for sustaining object representations attributed to others in preverbal human infants. *Proc. R. Soc. B Biol. Sci.* 282, 20151683-

146 Forgács, B. *et al.* (2019) Fourteen-month-old infants track the language comprehension of communicative partners. *Dev. Sci.* 22, 1–9

147 Forgács, B. *et al.* (2020) , The social N400 effect: when semantic processing enters social cognition. , in *BCCCD*

148 Steinbeis, N. The role of self-other distinction in understanding others' mental and emotional states: Neurocognitive mechanisms in children and adults. , *Philosophical Transactions of the Royal Society B: Biological Sciences*, 371. (2016)

149 Barresi, J. and Moore, C. (1996) Intentional relations and social understanding. *Behav. Brain Sci.* 19, 107–122

150 Kampis, D. *et al.* (2013) Do infants bind mental states to agents? *Cognition* 129, 232–240

151 Richardson, M.J. *et al.* (2010) Challenging the egocentric view of coordinated perceiving, acting, and knowing. *mind Context*

152 Gopnik, A. (1993) How we know our minds: The illusion of first-person knowledge of intentionality. *Behav. Brain Sci.* 16, 1–14

153 Colby, C.L. (1998) Action-oriented spatial reference frames in cortex. *Neuron* 20, 15–24

154 Sereno, M.I. and Huang, R.S. (2014) Multisensory maps in parietal cortex. *Curr. Opin. Neurobiol.* 24, 39–46

155 Kelley, C.M. and Jacoby, L.L. (1996) Adult Egocentrism: Subjective Experience versus Analytic Bases for Judgment. *J. Mem. Lang.* 35, 157–175

156 Ramsey, R. *et al.* (2013) Seeing It My Way or Your Way: Frontoparietal Brain Areas Sustain Viewpoint-independent Perspective Selection Processes. *J. Cogn. Neurosci.* 25, 670–684

157 Simpson, A.J. and Todd, A.R. (2017) Intergroup visual perspective-taking: Shared group membership impairs self-perspective inhibition but may facilitate perspective calculation.

*Cognition* 166, 371–381

158 Ferguson, H.J. *et al.* (2018) Age of avatar modulates the altercentric bias in a visual perspective-taking task: ERP and behavioral evidence. *Cogn. Affect. Behav. Neurosci.* 18, 1298–1319

159 Goldman, A.I. (2006) *Simulating minds: The philosophy, psychology, and neuroscience of mindreading*, Oxford University Press.

Figure 1.

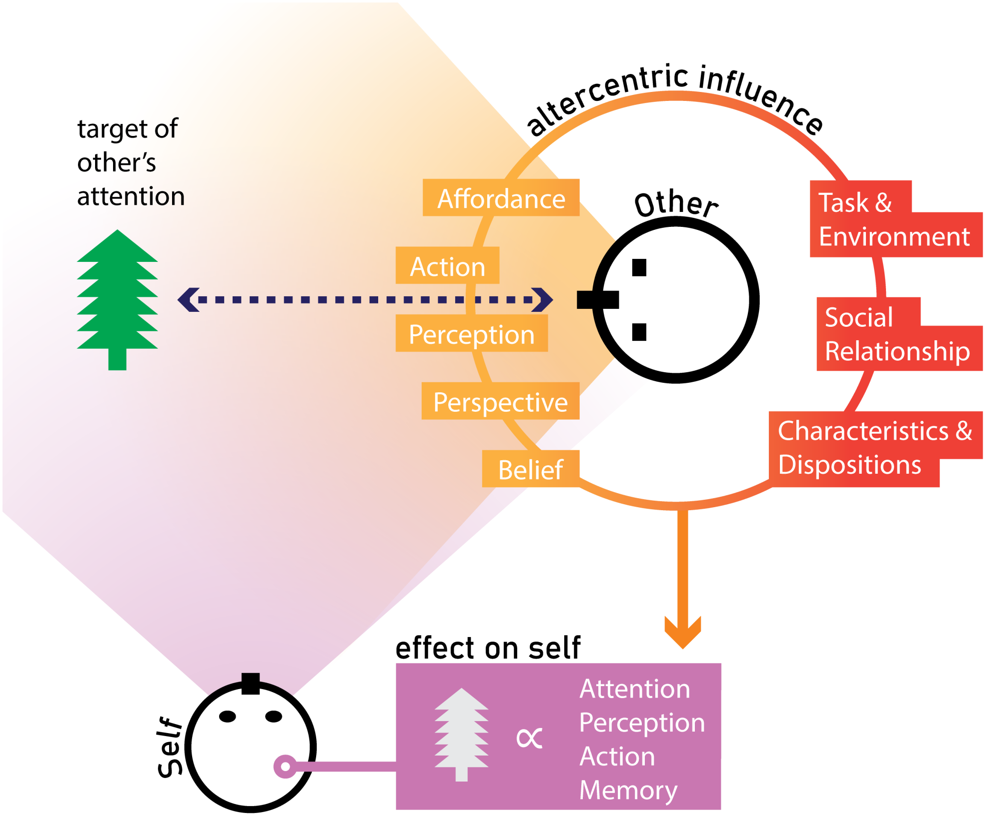



**Figure 1. The scope of altercentric influence.** Orange and purple fields indicate the perceptual range of self and other. Orange boxes indicate some of the different ways in which the other can interact with, relate to, or process, the target of their attention (indicated by the green tree). Each of these can, in turn, exert an influence on our own information processing (effects on the self, listed in the purple box), but this does not imply that the observer must represent the other as experiencing a particular state in order to be influenced by that state. For example, an infant may be influenced by the other's belief, but the infant may represent the other's relationship with the object in a non-mentalistic way. The "∝" (proportional to) symbol indicates that the representation formed by the self (grey tree) will change in relation to the processes indicated on its right side; which in turn are modulated by the altercentric influence. Red boxes depict factors that may modulate the extent of altercentric influence, including how we perceive the other's task or their relationship to us.

Figure 2.

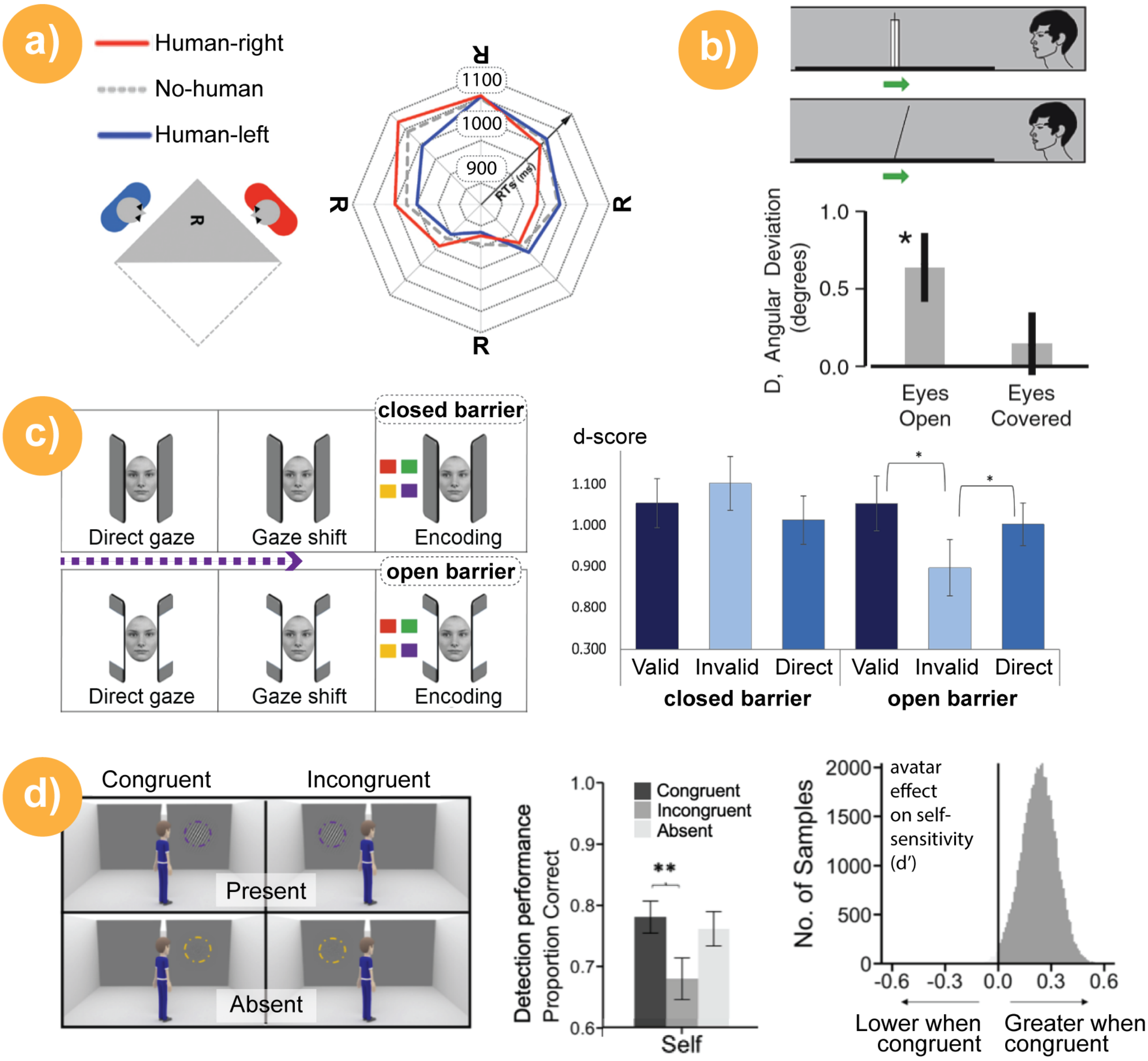



**Figure 2. Examples of studies documenting altercentric effects on action execution, perceptual judgement.** A) Effect of other's position on judgment of rotated figures. The typically-observed increased reaction times to judge the form (whether canonical or mirror-inverted) of a rotated-away alphanumeric number is ameliorated if another human in the scene would perceive this in an upright orientation. B) Effect of others' gaze on physical judgments. Participants judge an object to be able to tilt further, and thus tip over at a larger angle, if a person is gazing at this object; but not when she couldn't see because

she was blindfolded. C) Effect of gaze cueing on working memory. Items that are gaze-cued are better recalled (indicated by a higher d' score), but only if the person could see the items (open barrier condition) and not when she could not (closed barrier condition). D) Effect of others' perspective on perceptual sensitivity. Participants' sensitivity to detecting gabor patches was influenced by a bystander agent with a congruent perspective, increasing their sensitivity (d') to detect the stimuli.