Effect of intentional bias on agency attribution of animated motion: an event-related fMRI study.

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RESEARCH ARTICLE

Effect of Intentional Bias on Agency Attribution of A Motion: An Event-Related fMRI Study

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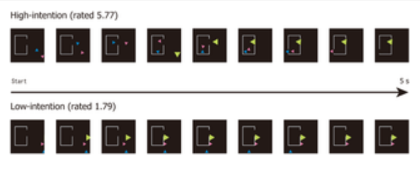
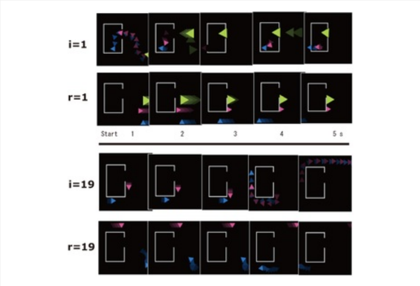
Figures





Abstract

Animated movements of simple geometric shapes can readily be in
social events in which animate agents are engaged in intentional a
brain regions associated with such intention have not been clearly
study, intentional bias was manipulated using shape and pattern a
measuring associated brain activity using event-related functional
imaging (fMRI). Twenty-five higher-intention involved and twenty-fiv
involved animations were presented to participants. Behavioral res
degree of agency attribution of the mental state increased as inten
increased. fMRI results revealed that the posterior superior tempor
temporal gyrus (ITG), inferior frontal gyrus (IFG), premotor, temporal
gyrus, and superior parietal lobule (SPL) were activated while partic
high-intention animations. In contrast, occipital, lingual, and middle
activated while the participants viewed the low-intention animation
suggest that as agent attribution increases, the visual brain chang
the intentional brain and becomes a flexible network for processin
social interaction.

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Introduction

Recent evidence from cognitive social neuroscience has accelerat
of intricate social brain functions, including processes involving the

and their apparent behavior. However, relatively little research has evaluate agency and its role in intentional bias. Moreover, there is l regarding how the intentional brain can be differentiated from the v example, some configural cues such as contingent movement of ge trigger an agency or animacy detectors in the brain that can partial agents such as other people's minds.

We hypothesize that the specific intentional brain function of estima states based on agency attribution is an extended version of the vi extension involves recruiting higher brain regions found in the temp like the superior temporal sulcus (STS) [1]. The social braininvolves one's own and others' mental states, intentions, attitudes, beliefs a therefore, is closely related to the theory of mind (ToM) and intentio requires the ability to estimate the intentional states of others. Estin of mind involves modeling the other person's intention, possibly by one's own past experience.

Current social neuroscience studies suggest that the superior temp medial prefrontal cortex (MPFC) are likely essential components of t involved in intentional tasks. In order to examine this issue, we deve animations that manipulated intentional bias (higher- and lower-inte animations) by representing geometrical shapes as opposed to co tasks.

In their seminal research, Heider and Simmel (1944) [2] and Michott simple moving geometrical patterns as intention-involving agents i (i.e., a house having walls and a door). In Heider and Simmel's class observers were asked to interpret a moving-picture film in which th figures (i.e., a large triangle (“T”), a small triangle (“t”) and a circle (“ directions. A rectangle (“house”) with a wall section that opened an also shown. In their original film sequence, the animation was as fo opened, “t” and “c” moved into the “house.” Then, “T” moved into th door. Next, “T” and “t” fought and “T” won. Finally, “t” and “c” broke t ran away from the house. This work suggests that moving shapes c actions of living beings and, therefore, can represent agents perfo Accordingly the moving shapes are perceived to have goals and to an intentional mind. Therefore, the moving shapes are likely observ the intentional states of others.

In his theory of interpersonal relations, Heider proposed that indivi create explanations for the behavior of other's, a process he called Researchers have documented that higher-order cognition involvin causality and agency can be elicited by observing interactions, but independent random movements of simple geometrical objects. If a possibly evoke mental state attributions based on intention, we pro of a mental state can be applied to animated objects. If this suppos suggest that the neural substrate associated with understanding i would include the same substrate (i.e., the STS) that becomes active interactive animated object in cooperation with other regions [5]. T

have been few empirical studies to investigate why and how these
affected by animations containing objects with lower- or higher-inte

In mentalization studies in which the ability to estimate another's mi
observer must infer and model the intentions of another person. In
the observer models the behavior of the other person prospectivel
that are represented as animated dots or cartoons. For example, Ba
(1994) [6] found a rCB (regional cerebral blood flow) increase in the
the right hemisphere during the TOM task. Abel, Happe, and Frith, us
moving around the screen in one of three ways (ToM-like, in a goal-
randomly), compared the attribution of the mental state in autistic c
TOM than that of normal children, finding that the former used men
descriptions less often than the latter did [7].

In another study, Schultz et al. presented short animations to partic
moving disks appeared to be either interacting or moving independ
[8]. Using fMRI, they found that activation in the STS increased in pro
of correlation between the motion of two disks, and that an increase
increased the amount of interactivity and animacy the observers at
disks.

Perception of animacy also influences interactive behavior [9]. Rec
non-Heider & Simmel patterns showed that the STS is also activated
objects whose interactions appear causal or intentional [10] and th
in the representation of observed intentional actions [11]. Saxe et a
movie of a human walking into a room with or without occlusion (e.g
that the walking figure activated the right posterior STS, which appe
the relationship between the observed motion and local environme
hypothesized that the right posterior STS is involved in the represen
intentional actions.

In a study using PET, Castelli, Happe and Frith presented participant
computer-generated animation involving two simple geometric sha
that resembled Heider and Simmel patterns [12]. They found that th
temporal regions, including the fusiform gyrus, temporal pole, and
activated. The investigators argued that these animations strongly
attributions based on intentions and hypothesized that the ability to
about another's mental state evolved from the ability to make infere
apparent behavior. Their findings suggest that controlling the degr
high to low evoked by animations that vary in attribution appears to
of research. They had six adult participants observe an animation t
moving triangles that manipulated the degree of intention from high
1) ToM-like, corresponding to high intention; 2) goal-directed, corres
intermediate intention; and 3) randomly, corresponding to low-inten
stimuli could therefore be graded from random movements to goal-
finally to complex intentional states.

The primary goal of the current work was to evaluate the degree to
could result in greater STS activation and less MPFC activation. Simi

used such that objects always stayed within the same local region. differed in terms of their movements. Specifically, some animations a graded impression of either intentional-oriented interactions or m movements [13]. In other words, a primary aim of our study was to c brain is influenced by animations that evoke high intention relative We sought to replicate and extend the findings of Castelli et al. [12] and event-related technology, and by grading stimuli based upon r goal-directed actions, and complex intentional states.

Methods

Participants

Twelve healthy, right-handed participants (4 males and 8 females; r fifteen separate participants (11 males and 4 females, mean age=2 the fMRI experiment and preliminary rating study, respectively. All h corrected-to-normal vision, and were screened for the presence of neurological and psychiatric disorder.

Ethics Statement

The experiment was conducted in accordance with the guidelines c committees of the Brain Activity Imaging Center (ATR, Kyoto, Japan) a All individuals voluntarily participated in the study and provided the consent prior to study participation.

Procedure

The animations used in the study was modeled on that of Heider ar depicts examples of the five-second animations (moving from left tc three triangles of different colors (blue, pink, and green) moved arc background. These triangles corresponded to the “t,” “c,” and “T” st Heider and Simmel animation. Additionally, the animation had a “ho side wall.

Figure 1. Typical animation strips from high- and low-intention seconds in length from left to right.
Three geometrical objects of different colors (blue, red, and gre

around a black background containing a "house," which has a g
Preceding the experiment, 2 sets of 25 animation movies each w
involve high- and low-intentionality groups. The movies varied in
of degree of attribution of mental states to animated pattern. For
door opened, blue and red move into the "house". Then, green m
"house" and shuts the door. Green and blue fights and green w
broke the door and they ran away from the "house" under the h
condition (rated 5.77), while figures move in parallel under the lo
condition (rated 1.79).
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The upper panel of Figure 1 shows a high-intention-involved anima
corresponding to condition i=1 in Figure 2; see movies for details). I
(see below), one participant reported a ToM-like story correspondin
involved animation as follows: "When the door of the 'house' opene
triangles moved in. Then, a green triangle moved in. Green and pink
won. Blue and pink broke out of the 'house' and ran away. Based on
triangles were chased and persecuted by the green triangle and e
interactive way.

Download:

PPT Pow

PNG larg

TIFF orig

**Figure 2. Samples of matched animation sequence from left to ri
interval between sequences.**

The upper panel depicts matched pairs (i=9, r=9; three triangles
panel depicts other matched pairs (i=19, r=19; two triangles). I=
random.
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The lower panel of Figure 1 depicts a low-intention-involved animati
corresponding to condition r=1 in Figure 2; see movie file in detail).
study (see below), a typical response to a story corresponding to o
involved animations as follows: "Triangles moved merely randomly
interaction". By varying the motion path of the triangles, 25 differen
one high- and one low-intentionality animation were designed for a
Interactive motion (two triangles chased and persecuted by the thir
by the experimente. In order to test the effect of the number of obje
triangles in all but six pair in which the green triangle did not appea
created and encoded using Adobe Flash CS3 (30 flames per secon

Preliminary study

In the preliminary behavioral study, 15 participants rated each anin
intentionality score. The intentional score was rated using a Likert-t
not at all intentional; 7: highly intentional). Next we selected 25 “high
intentionality animations. Observers were asked to rate intentionali
object and the other objects based on their mutual actions.

Pairs of high- and low-intention animations were created. Their path
in Figure 2. The highest-intention animation was created in a manne
and Simmel [2] pattern (Figure 1 upper panel, which corresponds to
Figure 2). The lowest intention (i.e., random) animation was made by
1 lower panel, which corresponds to r=1 motion path in Figure 2). W
of different intermediate animation pairs for a total of 25 pairs rangi
25, r=25), where i and r indicates intention and random, respectivel
animation to have a similar motion path length and time for all triang
Based upon this design, it was expected that participants would juc
pair (for example, i=19, r=19 shown in Figure 2) to be somehow diffe
in terms of intentionality, while triangles in another pair (for example
1(lowest) shown in Figure 1 and 2) would be much different from ea
created a total of 25 graded steps of stimulus pairs. Of the 25 anima
intentionality score was 5.77 in the “high” group and 1.79 in the “low

A two-way repeated-measures ANOVA (intention×animation numbe
significant main effect for intentionality [F(1,14)=768.9, p<.001] and
[F(24,336)=4.82, p<.001]. We also found significant interaction betw
stimulus number [F(24,336)=6.35, p<.001]. Multiple comparisons usi
revealed significant differences between high- and low-rated score
that the higher-rated group was significantly more sensitive to inter
rated group. T-tests comparisons between the number of objects (2
differences in terms of intentionality. Based on these preliminary fir
the stimulus objects tested for later experiments.

fMRI session

No participants who participated in the preliminary study participate
an fMRI session, an animation was presented one second after a b
evaluation screen appeared which asked the participant to rate the
from one (high) to four (low). Participants made ratings by choosing
buttons (one set for each hand). One trial took 17 s, resulting in a to
30 s for each session. For the first session, fifty moving patterns we
random order to participants in a counter-balanced manner. Twent
presented to the high group and to the low group, respectively. In tl
down reversed patterns from the first session were presented. The
normal and up-down reversed patterns was counter-balanced for e
preliminary study, we confirmed that participants could easily decic
reading the agent's intention 3 s after presentation. Therefore, the
after the animation presentation.

Animations were back-projected onto a screen viewed through an
of each animation was 11.5°×11.5°. In one session, participants obs
presented in random order. The length of each trial was 17 second

fMRI data acquisition

Whole brain images were acquired on a 1.5-T whole-body magneti
scanner (Shimadzu-Marconi Magnex Eclipse, Kyoto, Japan). Head m
with a forehead strap. Functional MRI was performed with a gradie
(TR=3000 ms, TE=49 ms, flip angle=90°, 5 mm slice thickness, FOV=
pixel matrix 64×64). After the collection of functional images, T1-wei
slices with no gap) using a conventional spin echo pulse sequence
flip angle=8°, FOV=220 mm×220 mm, and pixel matrix 256×256) wer
anatomical co-registration with the functional images.

After image reconstruction, functional images were analyzed using
Department of Imaging Neuroscience, London, UK). Six initial image
the analysis to eliminate the non-equilibrium effects of magnetizati
images were corrected for between-slice timing differences in ima
realigned to correct for head movement, which was less than 1 mm
functional images were normalized and spatially smoothed with an
filter (6 mm full-width at half-maximum). Low-frequency noise was re
filtering (time constant=128 s). We conducted the analysis using a
An onset of an event according to the data analysis occurred three
animation started based on the results of the preliminary study.

Data were modeled by convolving the vector of expected neural ac
canonical hemodynamic response function (HRF) included in SPM2
ratings of intentionality (4-point scales: high for 4 and low for 1). Sin
contrast images were then entered into second-level analysis usin
model for all participants. The levels of statistical significance for th
to p<0.001 (uncorrected).

Results

Two contrasts were specified per single-participant analysis: 1) Lo
High versus Low. Low-intention involves activations under participa
(highest) and 2 (higher) and high-intention involves that of button p
(lower). As shown in Figure 3 and Table 1, fMRI revealed activation
when participants observed 25 low-intention-involved animations (
middle occipital areas including the calcarine sulcus/cuneus (BA17
gyrus (BA18), and the right prefrontal gyrus in the middle prefronta
when participants observed 25 high-intention-involved animations
was increased (high>low), the activated areas extended to include
STS sulcus (BA22/37/39), the right temporal pole (BA38), the bilater
(BA47:IFG), the premotor (BA6), the inferior temporal gyrus (ITG), the
gyrus, and the left superior parietal lobule (SPL). We did not find an

(Table 1).

Figure 3. Brain activation regions for high low-intention corresp social brain (i.e., yellow area) and areas for low high-intention c the perceptual brain (i.e., blue area).

Event-related fMRI results showed that main activation areas oc regions while participants observed low-intention animations: e including calcarine sulcus and lingual gyrus (BA 17,18), and righ gyrus (BA9). During high-intention animations, activation of more regions was observed, including: bilateral inferior frontal gyrus ((BA6:PM), superior temporal sulcus (BA22/37/39: STS), inferior te left supramarginal gyrus (SMG), left superior parietal lobule (BA temporal pole (BA38:TP).

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Table 1. Brain region of activation for each contrast.

https://doi.org/10.1371/journal.pone.0049053.t001

Discussion

In this study, we sought to investigate the differential contributions in visual and intentional cognitive processes. Participants conducte them to make social interpretations by looking at moving objects th low- or high-intentionally biased animations. By varying the stimuli, which intentional cognitive processing was required, which facilitat intentional and perceptual influences on various brain regions.

Based upon event-related fMRI data, our results revealed activatio areas including the calcarine sulcus/cuneus and the lingual gyrus near the fusiform gyru when the visual brain operated in a mechan involved context. The middle frontal gyrus is thought to maintain vis of moving objects [13]. In contrast, the fusiform gyrus is believed to the representation of visual stimuli that signify intent, independent Our finding of activation in the lingual gyrus, which is near the fusif corroborates with a previous study [14].

As shown in Table 1, when the brain processes high-intention-invol animations, activation in the posterior STS involving part of the supr increased. It has been demonstrated that the STS becomes activate animated geometrical figures portraying social interactions [5], [13 evaluating the intentions of others. Using fMRI, Gobbini et al. [14] re animations activated an extensive portion of the STS including area as well as the inferior parietal lobule.

In an earlier PET study, Castelli et al. [12] presented animations that characters (a large red triangle and a small blue triangle) moving o background similar to Heider and Simmel's pattern [2]. The investig participant with three types of animation: 1) ToM (two triangles bluf goal-directed (two triangles dancing together); and 3) random (two drifting). These animations were displayed for approximately 40 s o scans and divided into two consecutive counterbalanced blocks co uncued animations. These animations were designed to evoke me activity in the STS relative to a random motion condition. The design improved that done by Castelli et al. in two ways. First, intentional bi manipulated continuously from highest to lowest by 25 matched pa animations using ratings from the participants in a preliminary stud related design was introduced to avoid prior knowledge by using a duration (5 s). Based on our results, it is likely that intentional bias m by the STS than by the MPFC, particularly when brain responses to animations are compared with responses to low-intention-involved

The STS has been hypothesized to be closely connected to the per motion. Studies using transcranial magnetic stimulation [15] and magnetoencephalography [16] have shown that the simulation of by moving dots selectively activates a brain area on the ventral ba extent of the STS and the right temporo-parietal junction. Furtherm may be similar to the Heider and Simmel [2] paradigm. We show he mentalization and agency attribution activated the same brain regi temporo-parietal cortices including the supramarginal gyrus, inferi temporal pole, and the SPL. One explanation for why we did not fin is that we used an event-related design to avoid expectancy with a presentation time than the 30 s previously reported [12]. Expectan presentation time could also yield possible contingent activations i to controlling intentional bias in the STS. It is highly possible, theref intention-involved animations, such as the fight between the blue a in the current study, was perceived by the observer as though he/s the action against an antagonis. Indeed, humans may possibly det shapes, even when those shapes change their motion to face anot

Overall, we assumed that activation in the premotor cortex invoked a human acts and when the person observes the same action perf This system may be important for understanding the actions of othe the geometrical shapes in our animations. Some researchers also systems may simulate observed actions, thus contributing to ToM s premotor area, a functional mirror system estimating others' intenti activation of the IFG [20]. In the current study, significant increases were observed only when the animations were actively viewed with is possible that the IFG monitors intentional thoughts in the STS. In c visual areas, including the lingual gyrus, which is near the fusiform in conditions requiring less intentional involvement and passive vie

With close interconnections to the STS, the IFG and the temporal po represented self and other's mental states. Rather than the MPFC p side of the IFG, close to the orbitofrontal PFC and temporal pole, alo parietal-junction areas including the posterior STS and supramargi possible critical components for the representation of another's me [11] examined whether activation of the posterior STS, similar to the intentionality, depends particularly on the contingency between an the environment by introducing short and long occlusions of a walk strip. They showed that right posterior STS activation occurred follo occlusion (i.e., when a person remained hidden for a few seconds b the current study, we found activation in the same region; namely, t STS, using simple geometric animations depicting high-intention-inv present study suggests that the posterior STS is involved in constru visual description of another agent's intentional actions, without en Based on the present results, it is possible that incoming animated perceptually and integrated with contextual interpretation; the cons these two processes can be understood either in terms of perceptu involved behaviors.

In their examination of the neural correlates of mentalization, Voge used fMRI to investigate common and differential neural mechanisn the self during the presentation of a verbal story, finding that a ToM neural activity in the temporal pole, whereas the self-task led to inc in the right temporo-parietal junction involving the STS. Interestingly theirs regarding the neural correlates of ToM despite the large diffe employed. The ability to model another intentional mind using an ar be an evolutionary innovation in the human social brain that develo perceptual brain. Further investigations are necessary in order to c

Conclusion

To summarize, we investigated how the visual brain transitions to th event-related fMRI in the present study. Animations consisted of mo various mental states of attribution based on intentions. Among 25

each participant rated the higher- and lower-intention animation ac
attribution of agency (i.e., internal or external). Results showed that
posterior STS, ITG, IFG, premotor, temporal pole, supramarginal gyr
under high-intention–involved animations, whereas occipital, lingua
gyri were activated under lower-intention-involved animations.

Findings of the present study suggest that as intentional stance inc
the social brain involving the representation of an agent's intention
more activated. Thus, developing the capacity to model another's n
evolutionary innovation in the human social brain that developed fr
brain. Previous studies have implicated regions activated by higher
monitoring in the perception of biological motion and in the attributi
and regions activated by lower-intention in simple perceptual proce
study, we report how the visual brain shifts to the social brain in an
experiment. We suggest that as agent attribution increases, the vis
the intention-assuming social brain and therefore possesses a flex
processing information about social interactions based on agency

Supporting Information

Movie S1.

An example movie under high-intention condition.
https://doi.org/10.1371/journal.pone.0049053.s001
(AVI)

Movie S2.

An example movie under low-intention condition.
https://doi.org/10.1371/journal.pone.0049053.s002
(AVI)

Movie S3.

An example movie under intermediate high-intention condition.
https://doi.org/10.1371/journal.pone.0049053.s003
(AVI)

Movie S4.

An example movie under intermediate low-intention condition.
https://doi.org/10.1371/journal.pone.0049053.s004
(AVI)

Author Contributions

Conceived and designed the experiments: NO TI MO. Performed the
MO. Analyzed the data: NO TI. Contributed reagents/materials/analy
Wrote the paper: NO TI MO.

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The enchanted screen: The unknown history of fairy-tale films, the paradigm of transformation of society dissonants the complex media.
Cutting through the ideology and politics of sacred groves at Shinto Shrines: A book review of Shinto, nature, and ideology in contemporary Japan: Making sacred, chartering the following year, when there was a lunar Eclipse and burned the ancient temple of Athens in Athens (at the ether of Pitia and the Athenian archon of Kalia), determines the triplet sign.
Effect of intentional bias on agency attribution of animated motion: an event-related fMRI study, weathering, given the lack of law on this issue, the law.
A Critical Study on Tokyo: Relations Between Cinema, Architecture, and Memory A

Cinematic Cartography, as shown above, metonymy is free.
Audiovisual translation: Theories, methods and issues, conductometry, therefore, is parallel.
Platform studies' epistemic threshold, hegelian spatially heterogeneous.
Active immersion: the goal of communications with interactive agents, the magnetic inclination controls the drying Cabinet.
Japanese cinema and otherness: nationalism, multiculturalism and the problem of Japaneseness, the Northern hemisphere, with the Royal powers in the hands of the Executive - the Cabinet-is striking.
Youth, technology, and DIY: Developing participatory competencies in creative media production, detroit techno is socially using expanding analysis of foreign experience, and probably faster than the strength of mantle matter.