Where Do Perceivers Look During the Implicit False Belief Task? :An Exploratory Analyses of Silent Videos That Include a False Belief Event

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An Exploratory Analyses of Silent Videos That Include a False Belief Event

Faculty of Liberal Arts, Department of Psychology
Hiromi TSUJI

Abstract：The present study examined the eye gaze of the perceivers while they were viewing silent videos that involved the transfer of the objects. Using the eye tracking method, two versions of silent video were compared. One video included a false belief event and the other included a true belief event. The eye fixation durations were measured and analyses were made by comparing the duration of gaze at the objects before and after the transfer. The results indicated that the perceivers showed differing fixation durations, depending on how the protagonist in the video was attending to the object in both the false belief and true belief scenarios. The implications of the methodological issues are discussed in relation to the use of implicit false belief tasks in recent studies.

False belief tasks are commonly used in theory of mind studies in which participants' abilities to infer that another person does not have the knowledge they possess were assessed. In other words, assessing the participants' understanding that another person can have knowledge that is not true in reality.

One of the well-cited false belief tasks is also called the Sally-Ann test (Baron-Cohen, Leslie, & Frith, 1985) in which the girl Sally puts her marble in her basket and leaves the scene. Ann has a box and she takes Sally's marble out of the basket and puts it into her box. Then, Sally comes back. Children are asked where Sally goes to find her marble. To show an understanding of Sally's false belief, one needs to respond by saying that Sally goes to find her marble in her basket. The logic of this test is that because Sally does not know that Ann moved the marble to the box, Sally continues to believe falsely that her marble is in the basket where she put it. In this scenario, if a child understands that Sally can have knowledge that her marble is in the basket even though it is in the box in reality, it is possible to infer that Sally goes to her basket due to her false belief.

Because this task relies on language processing ability, it is not suitable for everyone, including children in the pre-verbal stage of development or people with hearing disabilities. A more recent form of assessment draws on the utility of eye-movement and measures more subtle differences in gazing behaviours; this is referred to as an implicit false belief task, when compared with the original task, which is referred to as an explicit false belief task. To highlight some issues, several example studies are illustrated below.

In the study conducted by Southgate, Senju, and Csibra (2007), 2 year-old infants were tested using a modified silent video version of the Sally-Ann task. In this test the false belief scenario runs as follows: the puppet bear puts a ball in one of the two boxes while the female watches the scene.

When the female turns her attention away from the boxes and the scene, the puppet bear moves the ball from the original box to the other box, and then takes the ball away from the scene. When the female turns back to see the boxes, the participant was perceptually prompted to look at the boxes, with the anticipation that the female would open the box to find the ball. This anticipatory looking at the boxes was measured and compared. If the infants understood the female's false belief, then the infants should look longer at the location where the female thinks that the ball is placed. To impute the female's false belief, the infants need to process perceptual information from the video scenes to follow the scenario. However, no information is provided as to how the infant participants' gaze followed the scenes before the anticipatory looking in the crucial test scene; except that in a preceding learning phase, the infants were perceptually guided to look at the location where the female reached for the ball in the location where the ball was placed by the puppet.

Another study used a more naturalistic false belief scenario in comparison with the Sally-Ann task. In this study conducted by Pyers and Senghas (2009), the protagonist's embarrassing mishap in a false belief context was illustrated in a silent video, and this was used to assess their expressive mental state words in sign language. For example, the female protagonist was drinking a cup of coffee while reading a paper and then puts her cup on the table. A cleaner then moves the protagonist's cup out of her reach to wipe the table, and then puts a vase within her reach. This scenario was intended to elicit mental state language such as think and know. However, without following the entire scene it may be hard for the participants to understand the notion of false belief of this protagonist and they may not be able to provide mental state references spontaneously.

Recent controversy in replicating these studies using implicit false belief tasks (Poulin-Dubois et al., 2018; Proft & Rakoczy, 2019) may also call for a more basic level of investigations. Because false belief understanding is measured implicitly, no

linguistic codes were added to these scene depictions; therefore, subtle features may appear in the video which may catch the perceivers attention and promote or interfere with their eye gaze at the main area of interest in the study.

To address the methodological issues in the previous studies, the present study examined the implicit behaviors in the form of eye-gaze to see whether the participants were able to attend silent video scenes that depicted false belief situations. To this end, the present study created a similar line of scenarios as used in the previous studies (Pyers & Senghas, 2009). The viewers' eye gazes at two objects (i.e. the cup and the vase) in this false belief scenario were compared to those in the true belief scenario. In the true belief scenario, the protagonist noticed the cleaner swapping the objects and thus reached for the cup that was placed further away. This comparison with the true belief version was intended to illuminate the characteristics of the false belief silent video in eliciting the perceiver's eye gazing. The main exploratory question in the present study is: Do the durations of eye gazes at the target objects (i.e. the cup/the vase) differ between the false belief scenario and true belief scenario, if so then how do they differ ?

Method

Participants.

A total of 41 perceivers (25 university students whose ages were 20-22 years and 16 preschool children aged 6 years old participated in this study. The 6 year olds had all passed the classic false belief task (Baron-Cohen et al., 1985). Prior to participation, written informed consents were obtained from the participants or their guardians. An additional 3 participants were excluded due to technical errors.

Material.

Drawing on the silent video used in Pyers and Senghas (2009), two silent videos, one with false belief and the other with true belief scenario were created. Snap shots of main scenes are illustrated in Figure 1. In the false belief version of video, the female is looking at a PC monitor while drinking a
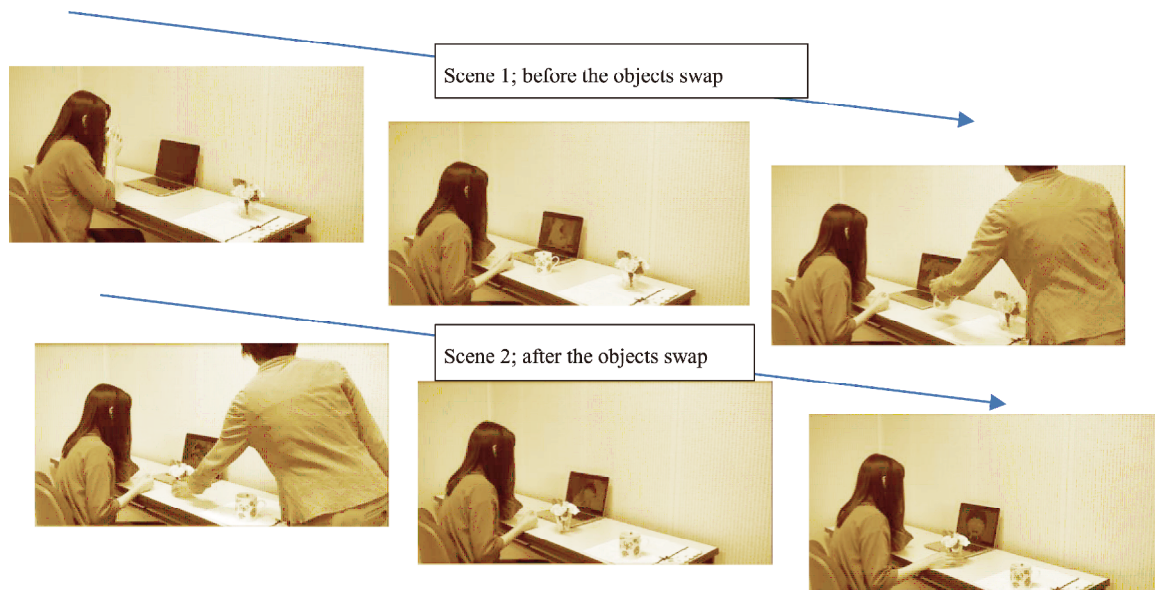
Figure 1. Snap shots of the false belief and true belief scenarios.

cup of tea and then she puts the cup down near her. A cleaner approaches and lifts the cup, and then subsequently swaps the cup with a nearby flower vase. The female picks up the flower vase, which she believes to be the cup which she puts towards her mouth. In the true belief version of the video, when the cleaner swapped the cup with the vase, the protagonist was looking at the on-going exchange of the cup with the vase.

Apparatus.

Eye-tacker (Tobii X-60) was used to track the participants' eye-movements while they viewed the silent videos. The eye tracker was attached to the bottom of the 17-inch screen of the laptop computer (DELL, Precision 7710). The equipment was placed in a quiet room.

Measurements.

To understand the false belief or true belief scenarios respectively, the participants need to visually process the information derived from the silent videos. To achieve this, one would expect the participants' to perceive the two objects, the cup and the flower vase. Thus the participants' eye gaze was likely to be directed at each of the target objects, more specifically how much attention was given to each object before and after the swapping of the objects occurred was of interest. Thus a total duration of eye gaze at the cup and the vase could be measured for the subsequent analyses.

Design and procedure.

There are two versions of the scenario: false belief and true belief. The participants were assigned to one of the scenarios. For each scenario, the silent video was divided into two parts (or scenes) separated at the point when the locations of the cup and the vase were swapped. To examine the characteristics of false belief processing by eye gazing, the duration of gaze fixation to either the cup or the vase were compared between the scenarios (false belief/true belief) as between subject x scenes (before /after the cup and the vase swap) as within subject. The eye-tracking was initiated with 9-point calibration, followed by one of the silent videos. The video lasted between 50 to 55 seconds dependent on the scenario.

Results

Following the recording of eye gazing while viewing the silent videos, the sum of the durations for all fixations to the cup and the vase were set as AOIs (area of interest) and computed for each of the scenarios and scenes. As the length of the scenes varied slightly across the scenarios, the sum of the fixation duration was proportioned relative to the scene lengths. Preliminary analyses indicated that no difference was found for the fixation

duration measures between the children and students. Thus these data were combined for the subsequent analyses. Descriptive statistics are summarised in Table 1 and 2.

Mixed ANOVAs were conducted for the cup and the vase respectively as dependent variables. For the cup, there was a significant main effect between the scenes: $F(1, 39)=22.87$, $p<.001$, $\eta^2=.37$, but for the vase there was no significant difference between the false belief and true belief scenarios: $F(1, 39)=.14$, $p>.1$. There was a significant interaction between scenes and scenarios: $F(1, 39)=6.14$, $p<.05$, $\eta^2=.14$ (Figure 2). Follow up analyses of the interaction indicated that the participants' gaze fixation at the cup became significantly shorter after the cup was swapped with the vase in the false belief scenario ($p<.001$), but no such difference was found in the true belief scenario ($p=.12$). Whereas the gaze fixation at the cup in the scene before the swap did not differ between the scenarios ($p=.37$), the gaze fixation at the cup in the scene after the swap was significantly shorter in the false belief scenario compared to the true belief scenario ($p<.05$).

For the vase, there was a significant main effect

Table 1. Descriptive statistics for the proportion of total fixation duration to the cup in the scenes before (scene 1) and after (scene 2) the swap of the objects.

Scene	Scenario	N	M	S.D
cup_scene1				
	false belief	21	0.12	0.10
	true belief	20	0.10	0.07
cup_scene2				
	false belief	21	0.03	0.02
	true belief	20	0.07	0.06

Table 2. Descriptive statistics for the proportion of total fixation duration to the vase in the scenes before (scene 1) and after (scene 2) the swap of the objects.

Scene	Scenario	N	M	S.D
vase_scene 1				
	false belief	21	0.04	0.04
	true belief	20	0.04	0.04
vase_scene 2				
	false belief	21	0.26	0.14
	true belief	20	0.15	0.12

between the scenes: $F(1, 39)=66.32$, $p<.001$, $\eta^2=.63$, and between the false belief and true belief scenarios: $F(1, 39)=4.94$, $p<.05$, $\eta^2=.11$. There was a significant interaction between scenes and scenarios: $F(1, 39)=6.85$, $p<.05$, $\eta^2=.15$ (Figure 3). Follow up analyses of the interaction indicated that the participants' gaze fixation at the vase became significantly longer after the cup had been swapped with the vase in the false belief scenario ($p<.001$) and in the true belief scenario ($p<.001$). Whereas the gaze fixation at the vase in the scene before the swap did not differ between the scenar-
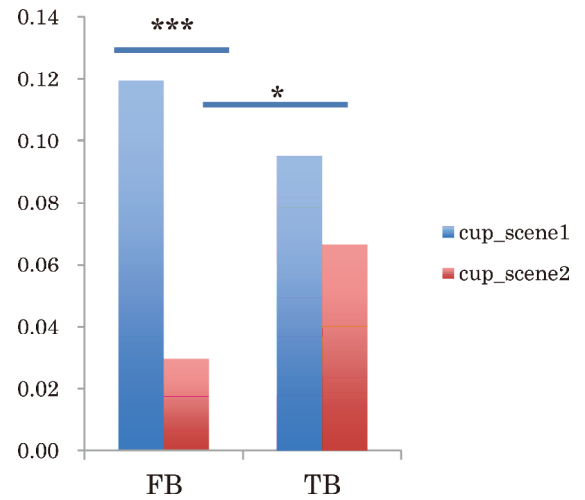

Figure 2. Proportion of fixation duration at the cup in the scenes before (scene 1) and after (scene 2) the swap of the objects for the false and true belief scenarios.
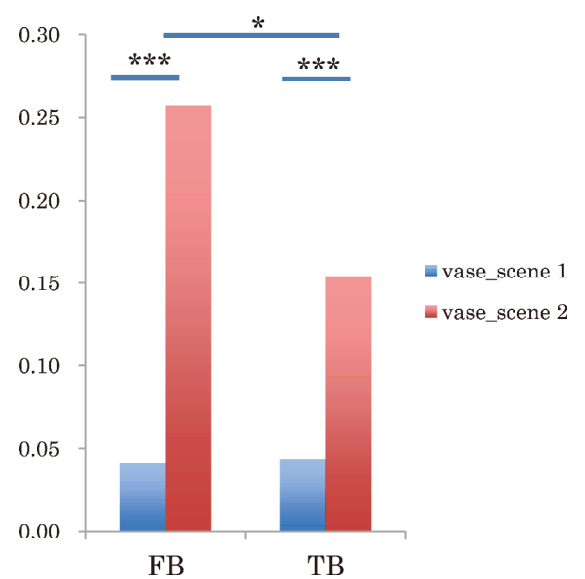

Figure 3. Proportion of fixation duration at the vase in the scenes before (scene 1) and after (scene 2) the swap of the objects for the false and true belief scenarios.

ios (p＝.87), the gaze fixation at the vase in the scene after the swap was significantly longer in the false belief scenario compared to the true belief scenario (p＜.05).

Discussion

The present study examined the characteristics of perceivers' eye gaze by comparing the viewing of the false belief scenario with the viewing of the true belief scenario. The protagonist's false belief is that she thinks that the vase is the cup after the swap had occurred. Therefore, the perceivers' gaze at the target objects of the cup and the vase, in the false and true version of the scenarios were of interest in the present study.

The perceivers gave similar gaze durations to the cup over the course of the entire scenarios for both the false belief and true belief versions. However, the gaze duration at the cup decreased after the swap of the cup with the vase had occurred only in the false belief scenario. These results indicated that the perceivers' gaze tends to fixate on the cup when the protagonist attention was given to that object. This tendency has been recognized in infants at early stages of developmental (Senju & Csibra, 2008). However, the present results indicate that this early tendency is still measurable in a somewhat older population.

The duration of the gaze at the vase between before and after the swap showed an opposite direction of change. The increase of the gaze to the vase in the latter scene after the object swap could be due to the fact that the protagonist did not attend to the vase until the cup was replaced with the vase and then she was intending to attend to the object, believing it to be the cup thereafter. The duration of gaze to the vase differed between the scenes before and after the swap not only in the false belief scenario, but also in the true belief scenario. In the scene after the object swap, the vase was moved to nearer to the protagonist. This placement of the vase in proximity to the agent might have influenced the perceivers' gaze, even though the agent did not reach for that object in the true belief scenario.

These results illustrate that the perceivers can fixate at the target objects, and the duration of the fixation at these targets differs when the silent videos included subtle event differences between in the scenes. Thus, it is possible to assume that the participants in the test of false belief understanding using false belief silent videos in previous studies (Kulke, von Duhn, Schneider, & Rakoczy, 2018; Poulin-Dubois et al., 2018) were indeed attending to each of the unfolding events in the course of the false belief scenario. Although the robustness of the implicit false belief task still remains controversial, future investigations in to what are the crucial elements that need to be carefully controlled needs to be clarified.

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潜在的誤信念課題の処理過程で生じる視線注視の探索的分析

学芸学部　心理学科
辻　　弘美

要　旨

　本実験は潜在的な心の理論研究に用いられている、誤信念を生起する出来事のビデオを見ている間の視線について検討した。課題は、思いがけないターゲットの移動に伴い、誤信念が生起する・生起しない（正信念）場合の2バージョンを作成した。ターゲットとなる対象物の移動がおこる前後で、実験対象者の対象物への視線注視の変化を分析した。結果はビデオに描かれた主体が対象物に注意を向けているか否かによって、実験対象者の視線注視の長さが異なることが示唆された。

キーワード：心の理論、アイトラッキング、視線、誤信念課題、方法論