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# Frontal and parietal lobe involvement in the processing of pretence and intention

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# Frontal and parietal lobe involvement in the processing of pretence and intention

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We assessed whether different processes might be at play during pretence understanding by examining breakdowns of performance in participants with acquired brain damage. In Experiment 1 patients with frontal or parietal lesions and neurologically intact adults were asked to categorize videos of pretend and real actions. In Experiment 2 participants saw three types of videos: real intentional actions, real accidental actions, and pretend actions. In one session they judged whether the actions they saw were intentional or accidental, and in a second session they judged whether the actions were real or pretend. Parietal patients had particular difficulties in the identification of pretend actions, and both parietal and frontal patients were more impaired than controls in understanding the intentional nature of pretence. Analyses of individual patients' performance revealed that parietal lesions, and in particular lesions to the temporo-parietal junction, impaired the ability to discriminate pretend from real actions. However, this did not necessarily affect the discrimination of intentional from unintentional actions, which instead may be independently disrupted by damage to frontal areas. Moreover, spared ability to discriminate pretend actions from real actions, and intentional actions from accidental actions, did not grant a full conceptual understanding of the intentional nature of pretence. The implications for pretence understanding are discussed.

*Keywords*: Pretence; Action understanding; Intentionality; Brain damage; Temporo-parietal junction.

Pretence has attracted the interest of developmental psychologists for decades, and a number of hypotheses have been formulated to try and explain (a) which processes contribute to the achievement of the mature concept of pretence and (b) when these processes become available to the child. Intention understanding, in particular, appears to be crucial for interpreting pretence, because it is only the intention to pretend which differentiates a pretend behaviour from a mistake.

Conversely, the understanding of pretence has scarcely been investigated in adults. One reason

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for this might be that adults rarely undertake pretend behaviours. However, adults do commonly engage in a range of related behaviours, such as fantasy and play-acting, and are clearly able to comprehend and respond to the pretend behaviours of children. Although there have been few studies to date, these suggest that when adults are required to deal with pretence, they recognize pretend interactions (German, Niehaus, Roarty, Giesbrecht, & Miller, 2004; Richert & Lillard, 2004) and reason about make-belief suppositions (Amsel, Trionfi, & Campbell, 2005) readily and apparently without effort. These studies demonstrate that pretence can be investigated in adults, but they have so far yielded only limited information about the cognitive and neural bases of different aspects of mature pretence processing.

In the current study we took the novel approach of exploring how adults' pretence processing might be disrupted as a result of brain injury. By examining the performance of adults with acquired brain injury on tasks designed to tap potentially distinct processes involved in understanding pretence and intention, we hoped to gain evidence on their relations in the mature system. In turn, knowledge on how adults process pretence and intentions will contribute to the debate about the development of these abilities by providing a model of the system that children will ultimately develop.

## Discriminating between real and pretend acts

A necessary prerequisite for the understanding of pretend acts is the identification of an action as nonreal. This process is likely to be based on the ability to recognize the behavioural cues that tend to systematically vary across real and pretend scenarios. The most common nonverbal cues used by adults to signal that a certain event needs to be interpreted as pretence are emotional expressions, looking patterns, and variations in movement and timing (Lillard & Witherington, 2004; Nishida & Lillard, 2007). A study by Richert and Lillard (2004) investigated which of these cues adults use in order to identify pretend and real acts. They selected clips of pretence arising in natural interactions (i.e., mothers and their 18-month-old children eating snacks together) based on the prevalence of each of four different features (movements, smiling, looking, sound effects), and they tried to minimize, for each type of video, the salience of all the other characteristics. The examination of the relationship between participants' and specific behavioural modifications in mothers' interactions revealed that gaze direction and movement patterns had a stronger effect than smiling and sound effects. However, the clips identified with the highest accuracy were those where all four features were present. Another result of interest of the study by Richert and Lillard is that even the clips that had been classified as "bad exemplars" of a specific cue tended nevertheless to be correctly identified as real or pretend at above chance levels. These results suggest that, when adults have to decide whether a certain action is real or pretend, they presumably rely as much on the presence of specific cues as, more generally, on the overall spatio-temporal features of the action.

At an anatomical level, it is plausible that the identification of a scenario as real or pretend might rely on the activity of the parietal lobes. Imaging and neuropsychological findings have connected the parietal lobes to the perception of real body movements (Battelli, Cavanagh, & Thornton, 2003; Bonda, Petrides, Ostry, & Evans, 1996; Grèzes, Costes, & Decety, 1998; Wicker, Michel, Henaff, & Decety, 1998), as well as to the comprehension of pantomimes (Heilman, 1973; Ohgami, Matsuo, Uchida, & Nakai, 2004; Rothi, Heilman, & Watson, 1985) and to the mental simulation of actions (Sirigu et al., 1996).

## Differentiating intentional from accidental actions

A second necessary process for the understanding of pretence is the ability to discriminate between intentional and accidental actions, which proves crucial for people not to misinterpret pretend acts as accidents. There is consistent evidence of the existence of a powerful mechanism for discerning intentions from visual motion information (Baldwin & Baird, 2001; Blakemore & Decety, 2001) and for deciding whether a given action is intentional or unintentional (Malle & Knobe, 1997). There also appears to be substantial cross-cultural agreement over intentionality judgements (Barrett, Todd, Miller, & Blythe, 2005), and whether participants are instructed with definitions of the construct has no effect on their performance (Malle & Knobe, 1997), suggesting a universally shared and relatively encapsulated underlying mechanism.

This basic intention reading skill has been mostly associated with the activity of the frontal lobes. Damage to frontal regions disrupts the ability to represent goal-directed knowledge (Zalla, Plassiart, Pillon, Grafman, & Sirigu, 2001) and to recognize and parse clusters of high-order action sequences (Zalla, Pradat-Diehl, & Sirigu, 2003). Imaging studies have further revealed increased frontal activation in response to the detection of deceitful behaviour (i.e., about the weight of a box; Grèzes, Frith, & Passingham, 2004) and to the interpretation of actions in context (Iacoboni et al., 2005). These results suggest that regions of the frontal lobe might process the intentionality of an observed action on the basis of its visual properties. Recent studies, however, have indicated that more posterior regions might play a significant role as well (Grèzes, Berthoz, & Passingham, 2006; Saxe, Xiao, Kovacs, Perrett, & Kanwisher, 2004).

## Understanding the intentional nature of pretence

It is plausible that fully grasping the logical and semantic properties of pretence might require a more complex understanding than what is needed in order to identify an act as pretend (vs. real) and to decide that a certain action has been performed purposefully (vs. unintentionally). In other words, it may be one thing to detect the behavioural features indicative of pretence, and another to interpret pretend behaviours mentalistically and to appreciate intention as a necessary condition for pretence. This distinction is well established in the developmental literature on pretence (Lillard, 1998) and parallels the differentiation found in adult studies between simply detecting intentions and recognizing their motivational, causal, and epistemic components (Moses, 2001).

The imaging literature also hints to a distinction between a "low-level" system that processes the physical properties of behaviour and their regularities and a "high-level" system that processes the psychological attributes of the same behaviours, identifying and reasoning about the unobservable mental states underlying them. In particular, a recent study by de Lange, Spronk, Willems, Toni, and Bekkering (2008) suggested that intention recognition activates a specific region of the frontal lobe (the inferior frontal area, purported to contain mirror neurons), while reflecting on the intentionality of an observed action triggers a wider set of frontal and posterior areas (medial prefrontal cortex and temporo-parietal regions). The fact that the neurological substrate of processing intentions at this higher level encompasses both frontal and temporo-parietal cortical regions of the cortex has been confirmed by a number of studies (Brunet, Sarfati, Hardy-Baylé, & Decety, 2000; Castelli, Happé, Frith, & Frith, 2000). As for pretence, two studies where adult participants were asked to watch videos of real and pretend actions found increased activation in response to pretend actions—as compared with real actions—in frontal as well as in more posterior areas (German et al., 2004; Schubotz & von Cramon, in press).

## A hypothesis on pretence processing in adults

The aim of the present study was to investigate the functional and anatomical organization of pretence understanding in adulthood by observing the performance of individuals with brain lesions localized in different areas in tasks tapping potentially distinct processes. By testing the independence of these abilities in adults we may, in turn, be able to provide data that constrain accounts of how the ability to pretend develops. We therefore generated a working hypothesis of the processes that might contribute, at different levels, to pretence understanding and of their anatomical underpinnings.

On the basis on the previously discussed literature, from a functional point of view we distinguish provisionally between: (a) processes that are sensitive to the general spatio-temporal features of behaviour and might allow pretend actions to be distinguished from real actions; (b) processes that are responsible for detecting the intentional quality of behaviour, which allow intended actions to be discriminated from accidental actions; and (c) processes that are responsible for a full conceptual understanding of the semantic and logical properties of pretence, which is required for more subtle distinctions, such as recognizing the essentially intentional nature of pretence. From an anatomical point of view, we were interested in verifying the role of the frontal and the parietal lobes in the above-mentioned processes.

In order to gain information on the functional architecture of pretence processing and on the necessary role of frontal and parietal regions in the various processes involved in understanding intention and pretence, we examined performance in patients with frontal or parietal brain lesions in two experiments. In Experiment 1 we presented closely matched videos of pretend and real actions to neurologically intact adults and patients with frontal and parietal lesions, and we asked the participants to classify the actions as being pretend or real. This tests whether the individuals are able to use behavioural cues to reliably identify pretence. In Experiment 2 we used three types of video—real intentional actions, real accidental actions, and pretend actions—and we asked participants to judge, in two separate sessions, whether the actions they saw were intentional or accidental, and whether they were real or pretend. This experiment aimed at replicating the results of Experiment 1 whilst also investigating the relationship between the processing of pretence and intention. In particular, we were interested in the presence of associations and dissociations in the performance of the two groups of patients in two types of intention processing: the discrimination between real intentional and accidental actions, and the recognition of the intentional nature of pretence.

## EXPERIMENT 1

Behavioural studies on adults have concentrated on identifying the specific behavioural cues that assist pretence interpretation, such as movement patterns, eye gaze, smiling, and sound effects (Richert & Lillard, 2004), but they have not directly compared different types of pretence. Likewise, the imaging study conducted by Schubotz and von Cramon (in press) exclusively included pretend actions where the appropriate object for the action had been substituted with an inappropriate object (e.g., writing action with scissors used as a pen). The study by German et al. (2004), however, comprised pretend items where all the objects normally used for the target action were present (pretence consisted of miming the act with the objects) and pretend items where one or more of the objects necessary to really perform the action were missing. The two conditions were not directly compared, but there appeared to be a correlation between absence of the appropriate object for the action and activity in the medial temporal lobes.

The developmental literature has also touched upon the potential relevance of distinguishing between different typologies of pretence. Tomasello, Striano, and Rochat (1999) showed that children find dealing with objects used as symbols harder when these objects have a different conventional use: for instance, 35-month-olds could understand that a small replica of a brush could stand for a real brush, but had difficulties matching a cup used as a hat with a real hat. These findings are consistent with the observation that different types of pretend play behaviours emerge at different times during development and, specifically, that pretence with conventional objects appears before pretence with substitute objects (Lezine, 1973; McCune-Nicolich, 1977) and pretence without objects (Elder & Pederson, 1978; Jackowitz & Watson, 1980). It has been proposed that these last two types of pretence develop later because they both require a symbolic competence that goes beyond the sensorimotor properties and the intentional affordances of conventional objects (McCune-Nicolich, 1981; Piaget, 1962; Tomasello, 1999).

In the present study we investigated the ability of participants with brain lesions to discriminate pretend from real actions in three different tasks, which differed in the presence and type of objects used. We filmed videos of pretend actions and of real actions, and we asked participants to decide to which category each of them belonged. Based on the literature, the videos within each category were divided into three groups: videos where the conventional object for the target action was used, videos where a substitute object was used to perform the same action, and videos where no object was present. We were interested in whether the relative difficulty of these conditions in adults would reflect the developmental progression in pretend behaviour from earlier comprehension of actions where conventional objects are used to later comprehension of actions where substitute objects or no objects are present.

## Method

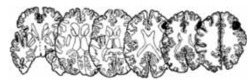
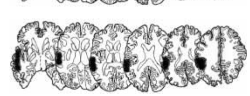
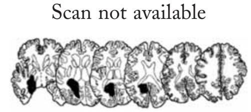
### *Participants*

A total of 7 patients with frontal lobe damage (all males; mean age 58.0 years, range 32–74 years), 10 patients with parietal lesions (1 female, 9 males; mean age 69.0 years, range 52–85 years), and 14 age-matched healthy controls (8 females, 6 males; mean age 63.2 years, range 52–79 years) took part in this study. Details for each patient can be found in Table 1. All the participants gave their informed consent prior to the inclusion in this study, which has been performed in accordance with the ethical standards of the 1964 Declaration of Helsinki.

### *Apparatus*

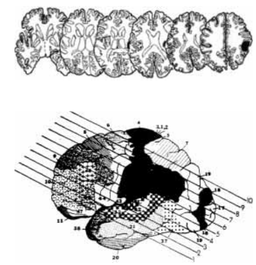
A total of 72 videos were presented to each participant: In half of them the actor performed a real action, while in the other half he performed a pretend action. Within each category, there were 12 videos where an appropriate object for the target action was used (i.e., real action—the actor used a comb to comb his hair; pretend action—the actor held a comb and pretended to comb his hair, with the comb moving in a combing fashion above his head without touching his hair); 12 videos where a substitute object was used to perform the same target action (i.e., real action—the actor used a hair brush to comb his hair; pretend action—the actor held a toothbrush and pretended to comb his hair with it, with the toothbrush moving in a combing fashion above his head without touching his hair); and 12 videos where no object was used, again to perform the same target action (i.e., real action—the actor used his own hand to comb his hair, passing his fingers through it; pretend action—the actor did not hold any object, but pretended to hold a comb and to comb his hair with it). Thus, each participant saw the same typology of action (such as hair brushing) being performed six times, comprising three real actions (with appropriate object, with substitute object, without object) and three pretend actions (with appropriate object, with substitute object, without object). See the Appendix for a list of the stimuli used. In order to minimize the differences between the videos, they were all shot in the same room, from the same visual angle and with the same actor, who always performed the action while sitting in front of a table. In addition, no language was used, and the actor was required to keep his emotional expression neutral and his movement patterns as consistent as possible across the two categories of videos, whether or not they involved objects. We hoped in this way to avoid that patients might map single cues to specific responses (i.e., if the actor overtly exaggerates his movements then it is a pretend action) and to make sure they would rely on an integrated analysis of the overall spatio-temporal features of the visual stimulus. In order to ensure that the control imposed over actors did not excessively increase the difficulty of the task, pilot studies on healthy participants were run to verify that each

**Table 1.** *Details of the patients who took part in the study*

| *Patient* | *Sex* | *Age* | | *Main lesion site* | *Etiology* | *Years Post-Onset* | *Lesion reconstruction from MRI scan* |
|---|---|---|---|---|---|---|---|
| D.S. | M | 71 | Frontal | Left inferior, middle and superior frontal gyri | Stroke | 7 |  |
| G.A. | M | 51 | | Bilateral medial and anterior temporal lobes, extending into the left medial frontal region | Herpes simplex encephalitis | 11 |  |
| P.H. | M | 32 | | Left medial and superior temporal gyri, left inferior, and middle frontal gyri | Stroke | 4 |  |
| P.W. | M | 74 | | Right inferior and middle frontal gyri, right superior temporal gyrus | Stroke | 2 |  |
| S.P. | M | 52 | | Left medial frontal region, bilateral medial and anterior temporal lobes | Herpes simplex encephalitis | 5 |  |
| T.T.[a] | M | 67 | | Right dorsolateral frontal region including the middle frontal gyrus | Stroke | 5 |  |
| W.B.A. | M | 59 | | Right inferior and middle frontal gyri, right superior temporal gyrus | Stroke | 2 |  |
| A.S.[a] | M | 70 | Parietal | Right posterior and inferior parietal cortex including the angular gyrus | Stroke | 2 |  |
| B.A. | M | 59 | | Right posterior and inferior parietal cortex including the angular gyrus | Stroke | 9 |  |
| D.B. | M | 69 | | Left angular gyrus, superior and middle temporal gyri | Stroke | 7 |  |
| F.L. | M | 68 | | Left intraparietal sulcus, bilateral occipital gyrus, lenticular nuclei | Carbon monoxide poisoning | 8 |  |
| M.H. | M | 51 | | Left angular and supramarginal gyri, lentiform nucleus | Anoxia | 8 |  |
| P.F. | F | 56 | | Left angular and supramarginal gyri, superior temporal gyrus | Stroke | 6 |  |
| R.H. | M | 71 | | Left angular and supramarginal gyri, superior temporal gyrus | Stroke | 6 |  |
| S.B. | M | 85 | | Left temporo-parietal region | Stroke | 2 | Scan not available |
| T.P.[a] | M | 84 | | Left medial occipital, posterior parietal and medial temporal regions | Stroke | 6 |  |

(*Continued overleaf*)

**Table 1.** *Continued*

| *Patient* | *Sex* | *Age* | *Main lesion site* | *Etiology* | *Years Post-Onset* | *Lesion reconstruction from MRI scan* |
|---|---|---|---|---|---|---|
| W.W. | M | 72 | Right posterior and inferior parietal lesion including the angular gyrus | Stroke | 3 |  |

*Note:* Lesions have been drawn onto standard slices from Gado, Hanaway, and Frank (1979). The bottom figure shows the 10 slices used. Only Slices 3 to 8 are depicted here. The left of each slide represents the left hemisphere. M = male. F = female. Age in years. MRI = magnetic resonance imaging.
[a]Patients who took part in Experiment 1 only.



video would be confidently identified; in all the instances where this did not happen, the video was eliminated and was replaced with a new one, and the new set of stimuli was piloted on a different group of healthy participants.

### *Procedure*

Participants sat in front of a computer screen. Each of them watched the same 72 videos: 36 real actions and 36 pretend actions; for every video, they had to decide whether the action they saw was real or pretend. The order in which the videos were presented was balanced across category (pretend, real) and task (object, substitute object, no object). Responses were manually recorded by the experimenter.

## Results

### *Group analyses*

The number of correct responses in categorizing every video was counted for each participant. An analysis of variance (ANOVA) with category (real, pretend) and task (object, substitute object, no object) as within-subjects variables and group (control, frontal, parietal) as a between-subjects variable was performed. There was a significant main effect of group, $F(2, 28) = 11.1$, $MSE = 2.3$, $p < .001$, and significant Task × Group, $F(4, 56) = 4.0$, $MSE = 1.5$, $p = .006$, Category × Task, $F(2, 56) = 8.0$, $MSE = 1.5$, $p = .001$, and Category × Task × Group, $F(4, 56) = 2.9$, $MSE = 1.5$, $p = .03$, interactions (all other $F < 0.9$, all $p$s $> .403$; Figure 1). A least significant difference (LSD) post hoc comparison revealed that, overall, the control group performed significantly better than the frontal ($p = .005$) and the parietal ($p < .001$) groups, who did not differ from each other ($p = .376$). In order to ascertain where the differences between the three groups lay, an ANOVA with category (real, pretend) as the within-subjects variable and group (control, frontal, parietal) as the between-subjects variable was performed for each task.

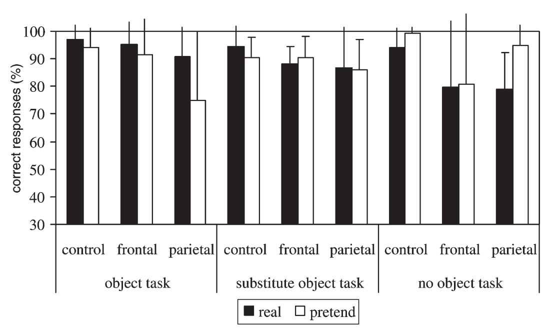



**Figure 1.** *Experiment 1: Percentage of correct responses given by each group (control, frontal, parietal) for the real and the pretend videos in the three tasks (object, substitute object, no object).*

For the object task, there was a significant main effect of category, $F(1, 28) = 5.4$, $MSE = 2.1$, $p = .028$, and of group, $F(2, 28) = 5.6$, $MSE = 2.5$, $p = .009$—the Category × Group interaction was not significant, $F(2, 28) = 1.8$, $MSE = 2.1$, $p = .179$—and a LSD post hoc comparison showed that the parietal group performed worse than the control ($p = .003$) and the frontal ($p = .03$) groups.

For the substitute object task, there was a marginally significant effect of group, $F(2, 28) = 3.2$, $MSE = 1.0$, $p = .054$ (all other $F$s $< 0.5$, all $p$s $> .617$), and a LSD post hoc comparison revealed that the parietal group performed worse than the control group ($p = .017$).

For the no object task, there was a significant effect of group, $F(2, 28) = 11.7$, $MSE = 1.7$, $p < .001$, and an almost significant effect of category, $F(1, 28) = 3.3$, $MSE = 3.4$, $p > .079$—the Category × Group interaction was not significant, $F(2, 28) = 1.1$, $MSE = 3.4$, $p = .353$—and a LSD post hoc comparison showed that the control group performed better than the parietal ($p = .005$) and the frontal ($p < .001$) groups, and that the parietal group performed marginally better than the frontal group ($p = .086$).

Because parietal patients tended to make more errors than frontal patients, especially in the object task and in the substitute object task, we compared the performance of the two groups on a number of independent measures of general cognitive ability. The Brixton test (Burgess & Shallice, 1997) requires patients to detect a changing rule in a sequence of visual patterns. The Wisconsin Card Sorting Test (WCST; Heaton, Chelune, Talley, Kay, & Curtiss, 1993) requires participants to detect arbitrary rules about how cards should be sorted and to shift between rules in response to feedback. Both tests provide measures of executive function. The forward and backward digit span procedures and the Corsi blocks, all extracted from the Wechsler Adult Intelligent Scale (WAIS; Wechsler, 1955), are measures of verbal and nonverbal working memory. The National Adult Reading Test (NART; Nelson & Willison, 1991) provides an IQ-related score.[1] There was no difference between the two patient groups on any of these measures (all $t$s $< 1.96$, all $p$s $> .5$), ensuring that the poorer performance of the parietal patients was not attributable to a greater difficulty in meeting the general cognitive task demands. Furthermore, in order to discount the possibility that parietal patients might have been more impaired than frontal patients because of an ideational apraxia deficit, which caused them difficulties in the comprehension of gestures, we administered to all our patients the 24-items test ideated by De Renzi, Motti, and Nichelli (1980). Results show that there was no difference between the two patient groups, $t(11) = 1.0$, $p = .349$.

### *Patient analyses*

We counted the number of correct responses that each patient in the frontal and parietal groups gave for each of the three tasks (object, substitute object, no object). A total of 9 out of 10 patients in the parietal group were not above chance in at least one type of real or pretend video, and 5 of those who were impaired performed at chance in more than one task. Performance in the frontal group was overall better: Even though 3 out of the 7 patients were at chance in some types of real or pretend video, for 2 of them performance was at chance in one task only.

When we looked at the co-occurrence of deficits in the three tasks, we found that all the possible combinations of error patterns were present. Within the parietal group, A.S. and D.B. were at chance only in the object task, P.F. was at chance only in the substitute object task, S.B. was at chance only in the no object task, T.P. was at chance in both the object and the substitute object tasks, F.L. and M.H. were at chance in both the object and the no object tasks, and R.H. and W.W. were at chance in both the substitute object and the no object tasks. Within the frontal group, P.W. and S.P. were at chance only

[1] Note here that 7/10 of our parietal patients had left-hemisphere lesions.

in the no object task, and G.A. was at chance in both the no object and the object tasks.

In sum, we found evidence of impaired discrimination between real and pretend actions in both patient groups, with the impairment being most apparent in the parietal patients. This difference could not be explained by general differences between the groups' abilities on tests of executive function, memory, or IQ. We found no evidence that discrimination between real and pretend actions was helped or hindered by the presence or absence of an object in the pretend action, or by the appropriateness of the object for the pretend action. In Experiment 2 we investigated the relationship between patients' ability to discriminate between pretend and real actions and their understanding of intentions.

## EXPERIMENT 2

Experiment 1 focused on the differentiation of pretend from real actions but, as we observed in the Introduction, there is more to pretence processing than the recognition that someone is pretending. In Experiment 2 we investigated two further processes that may be critical to a full understanding of pretend behaviour: discriminating intentional from unintentional actions, and recognizing that pretend acts are necessarily intentional. We filmed videos of three categories of action: normal (i.e., real, intentional) actions, accidental actions, and pretend actions. These videos were used in two different tasks. In one task participants were asked to judge whether the actions they saw were intentional or accidental (intentional–accidental task) and in the other whether the actions were real or pretend (real–pretend task).

As in Experiment 1, we were able to assess patients' discrimination between real and pretend actions by observing the accuracy with which they judged that pretend actions were pretend (not real) and that normal actions were real (not pretend). Second, patients' ability to discriminate intentional from unintentional actions was assessed by observing the accuracy with which they judged that normal actions were intentional (not accidental) and that accidental actions were accidental (not intentional). Third, patients' ability to judge pretend actions as intentional (not accidental) was the key test that they understood the intentional nature of pretence. The rationale for this was that failure to recognize the intentional nature of a pretend action (such as pretending to take a book from a shelf) would be likely to result in the pretend action being judged an accident (because the actor would in fact have failed to take a book from a shelf). Finally, patients' ability to judge accidental actions as real (not pretend) was also potentially informative about the basis for patients' judgements about pretence. If patients correctly recognized accidental actions as failed intentional actions, they should judge them to be real, not pretend. However, if patients parsed the accidental actions more superficially, for instance by seeing them as actions with an unusual outcome, they might mistakenly judge accidental actions as pretend (not real).

### Method

#### *Participants*

A total of 6 patients with frontal lobe damage (all males; mean age 56.5 years, range 32–74 years), 8 patients with parietal lesions (1 female, 7 males; mean age 66.4 years, range 51–85 years), and 9 age-matched healthy controls (3 females, 6 males; mean age 64.4 years, range 49–77 years) took part in this study. Details for each patient can be found in Table 1.

#### *Apparatus*

The same 36 target videos were presented to all the participants twice: once in the intentional–accidental task and once in the real–pretend task. There were also an additional 24 filler videos: 12 for the intentional–accidental task and 12 for the real–pretend task. The target stimuli comprised three groups of 12 videos each: normal (real intentional) actions, accidental actions, and pretend actions. For example, a normal video showed a man reaching for a book on a shelf; in the corresponding accidental video the same man dropped the book while trying to get it from the shelf; in the pretend video the man pretended to take an invisible book from the shelf. In order to avoid that the accidental videos might be interpreted as the actor "pretending" to really have accidents, a series of pilot tests was undertaken, with refilming as necessary, until we were confident that the accidents looked as natural as possible. The validity of these (as well as of all the other) videos was controlled with pilot studies on healthy participants. In all the instances where participants did not confidently interpret a video, this was eliminated and was replaced with a new one, and the new set of stimuli was piloted on a different group of healthy participants.

In a first session, each participant was administered the intentional–accidental task and was read the following instructions: "You are going to see some videos. Each video belongs to one of two categories of action: made on purpose or accidental. An action is made on purpose when everything the person does is exactly what he wanted to do. In contrast, an action is accidental when at least part of what the person does is not really what he wanted, but happens by accident. Please tell me for every video if you think the action is made on purpose or accidentally." Both the normal and the pretend videos needed to be judged as made on purpose, while the accidental videos (together with the 12 additional accidental filler videos) had to be judged as accidental.

In a second session, each participant was administered the real–pretend task and was read the following instructions: "You are going to see some videos. Each video belongs to one of two categories of action: real or pretend. If the action is real it could happen deliberately or by accident, but it is still a real action. This contrasts with actions where the person pretends to perform the action, but does not really do it. Please tell me for every video if you think it is a real or a pretend action." Both the normal and the accidental videos needed to be judged as real, while the pretend videos (together with the 12 additional pretend filler videos) had to be judged as pretend.

Thus, every participant saw the 36 target videos twice (once in the intentional–accidental task and once in the real–pretend task), and, during each task, she or he saw each of the 12 typologies of target video (e.g., removing a book from a shelf, opening a beer, etc.) being performed three times (normal action, accidental action, pretend action). In order to minimize the differences between the videos, they were all shot in the same room and with the same actor, who was not allowed to speak. The actor did not use exaggerated gestures or emotional expressions to discriminate the different conditions (normal, accidental, pretend), in order to avoid the possibility that, for instance, accidental actions could be identified solely by the disappointed look of the actor or by the fact that he could not see what he was doing. To this end, the actor was required to vary what emotional expressions he did display (neutral, positive, negative) and his looking patterns (straight to the object, away from the object) across the categories of video. In addition, in some instances—evenly distributed across the three categories of video—the actor was blindfolded. For example, consider the typology of video "take a book from a shelf" described above: In the normal and in the accidental actions the actor was looking straight to the book, while in the pretend action he was looking to the left of the same (imaginary) book; in all three cases, however, the actor's emotional expression was neutral, and he was not blindfolded. Another typology of video was "opening a beer bottle": Here the actor was always looking straight to the bottle, but while in the accidental and in the pretend actions he could clearly see the object, in the normal action he was blindfolded; in addition, while in the normal and in the pretend videos the actor was smiling, in the accidental video he displayed a disappointed emotional expression. These variations in the actor's emotional displays and looking patterns among the videos made it impossible for any category of action to be identified via such single visual cues.

### *Procedure*

Participants sat in front of a computer screen. In the first session participants undertook the intentional–accidental task. They watched the 36 target videos (plus 12 filler videos) and were asked to categorize the actions in them as intentional or accidental. In the second session participants undertook the real–pretend task. They watched the same 36 target videos (plus 12 new filler videos) and were asked to categorize the actions performed in them as either real or pretend. The intentional–accidental task's session always preceded the real–pretend task's session because we wanted the judgement on the intentional nature of pretence to be as spontaneous and immediate as possible, and we did not want participants to be influenced by previous reasoning about the real or pretend quality of the actions. However, for each task, the order in which the videos were presented was balanced across category (normal, accidental, pretend). Responses were manually recorded by the experimenter.

## Results

First of all, we looked at the errors made by the participants in all the videos in order to ascertain whether the manipulation of the actor's looking patterns (straight to the object, away from the object, blindfolded) and emotional expressions (neutral, positive, negative) affected their performance. We found that this was not the case for any group.

### *Group analyses*

The number of correct responses in categorizing every video was counted for each participant. For each task, a one-way ANOVA was used to test whether the three groups differed in the overall number of correct categorizations. In the intentional–accidental task, there was a significant difference between groups, $F(2, 20) = 28.6$, $MSE = 2.6$, $p < .001$, and a LSD post hoc comparison revealed that the control group performed significantly better than the frontal ($p < .001$) and the parietal ($p < .001$) groups. In the real–pretend task, there was again a significant effect of group, $F(2, 20) = 27.4$, $MSE = 1.9$, $p < .001$, and a LSD post hoc comparison revealed that the control group performed better than the frontal ($p = .002$) and the parietal ($p < .001$) groups, and also that the frontal group performed better than the parietal group ($p = .005$).

Subsequently, an ANOVA with task (intentional–accidental, real–pretend) and category (normal, accidental, pretend) as within-subjects variables and group (control, frontal, parietal) as a between-subjects variable was performed. There was a significant main effect of category, $F(2, 40) = 26.2$, $MSE = 3.8$, $p < .001$, and of group, $F(2, 20) = 56.1$, $MSE = 2.2$, $p < .001$, and significant Category × Group, $F(4, 40) = 4.2$, $MSE = 3.8$, $p = .006$, Task × Category, $F(2, 40) = 23.2$, $MSE = 3.7$, $p < .001$, and Task × Category × Group, $F(4, 40) = 8.3$, $MSE = 3.7$, $p < .001$, interactions (all other $F$s $< 1.1$, all $p$s $> .365$; Figure 2). For each task, an ANOVA with category (normal, accidental, pretend) as the within-subjects variable and group (control, frontal, parietal) as the between-subjects variable was performed.

In the intentional–accidental task, there was a significant main effect of category, $F(2, 40) = 15.6$, $MSE = 5.7$, $p < .001$, and of group, $F(2, 20) = 28.6$, $MSE = 2.6$, $p < .001$, and a significant Category × Group interaction, $F(4, 40) = 4.3$, $MSE = 5.7$, $p = .005$. In order to ascertain in which categories the difference between the three groups lay, a one-way ANOVA was performed for each category on the three groups (control, frontal, parietal). The effect of group was

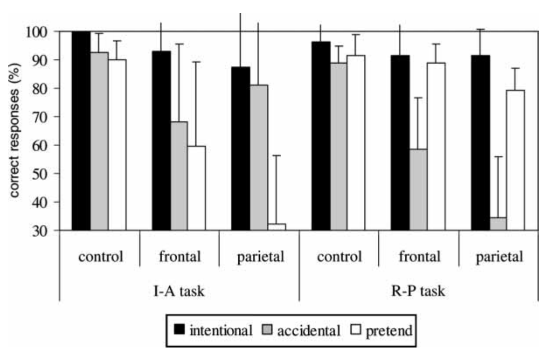



**Figure 2.** *Experiment 2: Percentage of correct responses given by each group (control, frontal, parietal) for the three categories of videos (intentional, accidental, pretend) in the intentional–accidental (I-A) task and in the real–pretend (R-P) task.*

significant for the pretend trials, $F(2, 20) = 15.9$, $p < .001$, and, marginally, for the accidental trials, $F(2, 20) = 2.9$, $p = .077$; [for the normal trials, $F(2, 20) = 2.2$, $p = .132$]. For the pretend trials a LSD post hoc comparison revealed that the control group performed better than the frontal ($p = .013$) and the parietal ($p < .001$) groups, and that the frontal group performed better than the parietal group ($p = .025$). For the accidental trials a LSD post hoc comparison revealed that the control group performed better than the frontal group ($p = .026$), but did not significantly differ from the parietal group ($p = .240$).

In the real–pretend task, there was again a significant main effect of category, $F(2, 40) = 53.2$, $MSE = 1.8$, $p < .001$, and of group, $F(2, 20) = 27.4$, $MSE = 1.9$, $p < .001$, and a significant Category × Group interaction, $F(4, 40) = 12.5$, $MSE = 1.8$, $p < .001$. In order to ascertain in which categories the difference between the three groups lay, a one-way ANOVA was performed for each category on the three groups (control, frontal, parietal). The effect of group was significant for both the accidental, $F(2, 20) = 24.4$, $p < .001$, and the pretend trials, $F(2, 20) = 6.6$, $p = .006$; [for the normal trials, $F(2, 20) = 0.8$, $p = .448$]. For the accidental trials, a LSD post hoc comparison revealed that the control group performed better than the frontal ($p = .002$) and the parietal ($p < .001$) groups, and that the frontal group performed better than the parietal group ($p = .012$). For the pretend trials, a LSD post hoc comparison revealed that the parietal group performed worse than the control ($p = .002$) and the frontal ($p = .023$) groups.

### *Patient analyses*

For an individual to score statistically above chance on a particular trial type they needed to give 10 or more out of a possible 12 correct responses (10/12 correct has a one-tailed probability of .019 by binomial test). First of all, we looked at the errors made by the patients in each group on the pretend videos, in order to verify whether they happened always on the same videos. We found that this was not the case for either group, and therefore we can exclude the possibility that the errors were due to the specific characteristics of particular videos. This is especially meaningful in relation to the parietal group's performance in the real–pretend task, given that the majority of patients made the same number of errors—that is, 9/12 (the highest score within the chance level).

To be judged successful at discriminating between real and pretend actions a patient had to classify at least 10/12 normal videos as real and at least 10/12 pretend videos as pretend. To be judged successful at discriminating between intentional and accidental actions a patient had to classify at least 10/12 normal videos as intentional and at least 10/12 accidental videos as accidental. To be judged successful at understanding the intentional nature of pretence a patient had to classify at least 10/12 pretend videos as intentional (not accidental). The same criterion was used for success at judging accidental videos to be real (not pretend).

All 9 of the control participants were above chance on all judgements, but no patient showed this normative response pattern. A total of 12 of the 14 patients were not above chance when judging pretend videos to be intentional, or accidental videos to be real actions. For the other discriminations, between pretend and real actions and between accidental and intentional actions, all the possible error patterns were observed. A total of 4 patients were impaired for both discriminations (parietal patients D.B., P.F., R.H., S.B.). While S.B. performed above chance in the pretend videos of the real–pretend task (unlike the other 3 patients), he was at chance in the normal videos of the same task, denoting a "pretend" response bias, which indicates that his ability to identify pretence was only apparently preserved. As for the discrimination between intentional and accidental actions, patients P.F. and S.B. performed above chance in the intentional videos but not in the accidental videos, and patients D.B. and R.H. performed above chance in the accidental but not in the intentional videos. It is noteworthy that these patients all had a lesion in the region of the left temporo-parietal junction (Figure 3). A second group of patients were above chance for both discriminations (frontal patients P.H. and

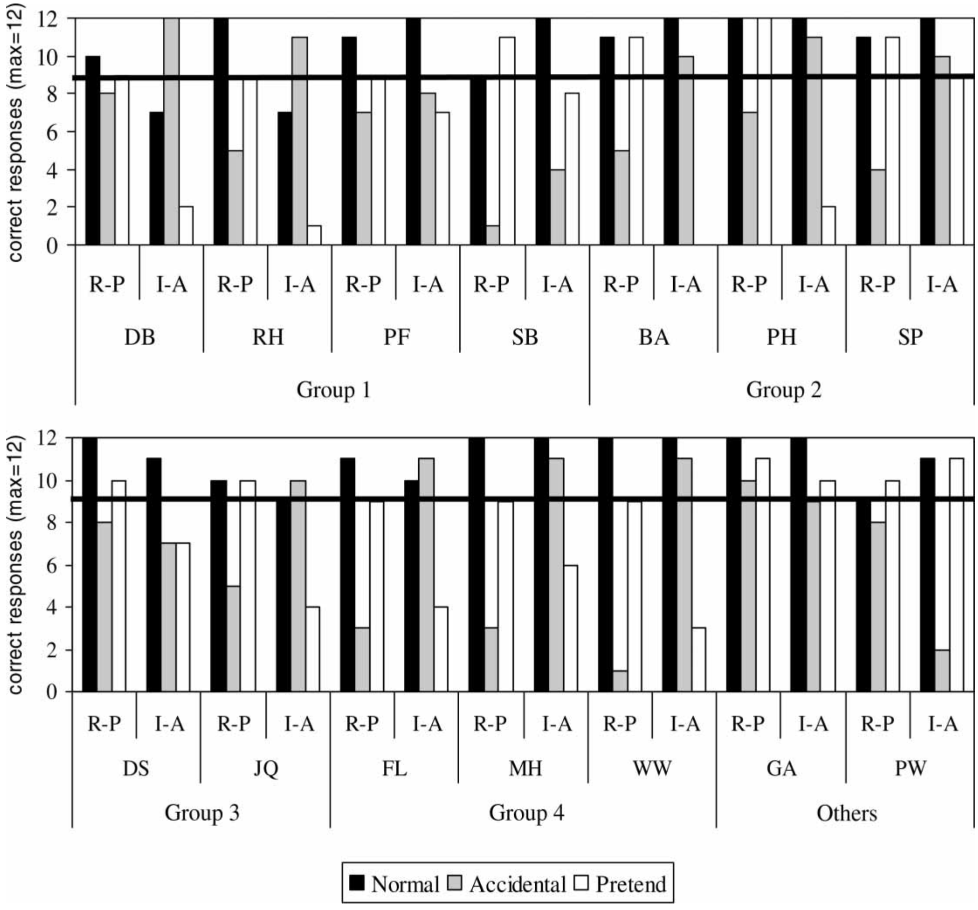



**Figure 3.** *Experiment 2: Number of correct responses given by each patient in the intentional–accidental (I-A) and in the real–pretend (R-P) tasks (the bold line indicates the chance level). Patients have been divided in groups according to their pattern of performance, as described in the Results section: Group 1 = patients impaired both in the intentional/accidental (normal and accidental videos of the intentional–accidental task) and in the real/pretend (normal and pretend videos in the real–pretend task) judgements; Group 2 = patients above chance in both judgements; Group 3 = patients impaired in the intentional/accidental judgement only; Group 4 = patients impaired in the real/pretend judgement only; Others = patients with unclear patterns of performance; see the text for details.*

S.P. and parietal patient B.A.). A third group (frontal patients W.B.A. and D.S.) successfully discriminated between real and pretend actions but failed to discriminate between intentional and accidental actions. A fourth group (parietal patients F.L., M.H., W.W.) failed to discriminate between pretend and real actions, but successfully discriminated between intentional and accidental actions.

A total of 2 patients showed different profiles of performance. Frontal patient P.W. was above chance at judging pretend videos to be intentional, while showing impairment on all other judgements. However, P.W. tended to judge almost all the videos in the intentional–accidental task as intentional (including most of the accidental videos), suggesting that P.W.'s apparently correct classification of the pretend videos as intentional was the result of a superficial response bias to judge all videos as "intentional". Frontal patient G.A. performed generally well, and had he made one fewer error judging accidental videos as accidental than would have been above chance for all parts of the task. We are reluctant to offer a strong interpretation of G.A.'s pattern of performance, and in particular his case does not seem good evidence of successful reasoning about the intentional nature of pretence despite impaired discrimination of intentional versus accidental actions.

## GENERAL DISCUSSION

To our knowledge, this is the first study in which pretence and its cognitive and neural underpinnings have been investigated in adult brain-damaged participants. In Experiment 1 patients with lesions involving either parietal or frontal cortex were asked to recognize pretend acts of different complexity (pretence with the appropriate target objects, pretence with inappropriate substitute objects, pretence without objects). Our results indicate that the parietal patients in particular were impaired relative to control individuals in the discrimination of real and pretend actions for all the three types of pretence. This seems consistent with the finding that lesions to the parietal lobe can affect the ability to interpret the low-level cues that characterize different typologies of biological behaviour (Battelli et al., 2003; Bonda et al., 1996; Grèzes et al., 1998; Wicker et al., 1998). Moreover, parietal patients were more impaired than the frontal patients, especially when the appropriate object for the target action was used in the pretend video. This is consistent with findings indicating that the parietal lobes play an important part also in the recognition and control of action (e.g., Milner & Goodale, 1995), including pantomime discrimination (Heilman, 1973; Ohgami et al., 2004; Rothi et al., 1985) and mental simulation of actions (Sirigu et al., 1996). Furthermore, the parietal patients appeared to benefit relatively little from an object being used in an action, consistent with parietal cortex being critical for programming actions with objects (Heilman, 1973).[2] In contrast to the parietal patients, the frontal patients performed similarly to the controls apart from when there was no object present. This is consistent with the frontal patients being sensitive to the perceptual realism of the action and benefiting from the extra information when the object was used. Nevertheless, the deficit shown by the frontal patients relative to the controls indicates that the grasp of pretence in these patients was not perfect. Importantly, for an individual patient, chance performance on any of the three types of pretence did not necessarily entail impairments in the other two types, suggesting that, whatever the developmental progression in the acquisition of the three behaviours may be, in adults their identification presents a similar level of difficulty. Moreover, the processes involved in interpreting the different types of action can be relatively independent—a deficit in interpreting one type of action is not necessarily critical for interpreting other actions.

Experiment 2 investigated the relationship between the recognition of pretend behaviour and the mental representation of its intentional properties by comparing (a) participants' ability to identify pretend and real actions with (b) their judgements on the intentional or accidental nature of real and (c) of pretend actions. The comparison of frontal, parietal, and control groups provided results that were consistent with Experiment 1. As a group, parietal patients were impaired in the identification of pretend actions and, perhaps unsurprisingly, were also impaired in judging pretend videos to be intentional (not accidental), and in judging accidental videos to be real (not pretend). Also similar to Experiment 1, where frontal patients were only mildly impaired, in Experiment 2 the group of frontal patients was not significantly impaired at identifying pretence. However, the frontal group did show impairment at judging pretend videos to be intentional, suggesting that successful identification of a pretend action does not entail appreciating that the action is intentional. The frontal group also showed impaired identification of videos of accidental actions.

[2] Data were not available for patient S.B. in the WCST and for patient T.P. in NART.

An analysis of the performance of individual patients helped to refine our interpretation of these patterns. First, only 1 out of 14 patients reliably classified pretend actions to be intentional (not accidental) and accidental actions to be real (not pretend), even though all 9 age-matched control participants performed above chance for these judgements. This pattern suggests that these judgements about pretence and intentionality are relatively complex and may easily be disrupted in patients, perhaps because they depend upon multiple functions and neural systems. This possibility is consistent with the relatively late development of this ability (i.e., Lillard, 1998).

It is particularly noteworthy that some patients who failed to classify pretend actions as intentional did, nonetheless, discriminate successfully between real and pretend actions (patients B.A., P.H., S.P., D.S., W.B.A.). Moreover, some of these patients could also discriminate between real intentional and accidental actions (patients B.A., P.H., S.P.). This finding is consistent with the group analyses in suggesting that successful identification of pretence does not necessarily involve representations or processes that directly afford successful judgements about the intentional nature of pretence. This pattern also seems consistent with Lillard's (1998) suggestion that young children may make reliable discriminations between real and pretend behaviour and may demonstrate quite sophisticated pretence behaviour themselves, yet lack a conceptual understanding of the intentional nature of pretence. Future research is necessary for a direct test of whether judgements about the intentional nature of pretence are functionally independent from the identification of pretend behaviours, or merely more complex. It was not possible to observe a double dissociation between these abilities in the current study because intentionality judgements were elicited using stimuli that also required pretence to be identified from observed behaviour.

The analysis of individual patients also revealed 2 frontal patients who could distinguish reliably between real and pretend actions, but not between accidental and intentional actions (patients D.S. and W.B.A.), and 3 parietal patients who showed the opposite pattern (patients F.L., M.H., W.W.). Because of the relatively small number of trials involved, this pattern must be interpreted with caution. Nonetheless, this is preliminary evidence of the possibility that a double dissociation might exist between the processes that allow the identification of pretence (impaired in the parietal patients but spared in the frontal patients) and the identification of intentional (vs. unintentional) actions (impaired in the frontal patients but spared in the parietal patients). Future investigations may investigate whether it is the case that adults (perhaps unlike children e.g., Tomasello, 1999) do not depend upon a basic understanding of intentions to differentiate pretend from real actions.

Finally, the 4 patients who could not reliably distinguish between real and pretend actions nor between intentional and accidental actions (patients D.B., R.H., P.F., S.B.) all had lesions to the left temporo-parietal junction. A total of 3 of these patients were previously reported to have a relatively specific deficit in reasoning about false beliefs (Apperly, Samson, Chiavarino, & Humphreys, 2004; Samson, Apperly, Chiavarino, & Humphreys, 2004), despite ceiling performance on control trials for memory, inhibition, and social perception demands of the false-belief task. One possibility, then, is that these patients' errors in the current study reflect a general difficulty with "theory of mind" reasoning about mental states such as beliefs, pretence, and intentions. Alternatively, as we have already noted, these patients may be impaired in interpreting both pretence and intention because they have a difficulty in processing critical perceptual cues that indicate the nature of a given behaviour—one example being biological motion, which can be disrupted after parietal damage (Battelli et al., 2003; Bonda et al., 1996; Grèzes et al., 1998; Wicker et al., 1998), and which provides the perceptual substrate for perceiving pretence and intention in action. This last speculation fits with a report from Samson et al. (2004) that 3 of the patients with temporo-parietal junction damage (P.F., D.B., and R.H.) showed difficulties judging gaze direction, another perceptual cue for social inference.

In sum, the current study provides important new support for there being distinct functional and neural processes involved in understanding pretend, intentional, and accidental actions. Consistent with many existing studies we found that parietal lesions in general, but more particularly lesions to the left temporo-parietal junction, can disrupt the discrimination of pretend actions from real actions. However, parietal damage does not necessarily impair the ability to discriminate intended from accidental actions, though this can be a difficulty after frontal lesions. Finally, a spared ability to discriminate pretend actions from real actions and intentional actions from accidental actions does not grant the ability to judge pretence to be intentional. This finding is consistent with the view that "mentalistic" judgements about the intentional nature of pretence are relatively complex and dependent upon multiple brain systems and with evidence that such judgements are an independent and relatively late development in children's understanding of pretence.

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# APPENDIX

## Description of the stimuli used in Experiment 1 and Experiment 2

Experiment 1: Real actions

| *Appropriate object* | *Substitute object* | *No object* |
|---|---|---|
| Comb one's hair with a comb. | Comb one's hair with a brush. | Comb hair with one's hand. |
| Make a call on a mobile phone. | Make a call on a home phone. | Tap fingers on the table. |
| Write on a paper with a pen. | Write on a paper with a pencil. | Make OK sign. |
| Drink from a glass. | Drink from a can. | Bite one's nails. |
| Open and read a book. | Open and read a newspaper. | Rub one's eyes. |
| Peal a potato with a peeler. | Peel a carrot with a peeler. | Clear dust from one's shirt. |
| Turn on a video recorder. | Turn on a radio. | Extend arms while yawning. |
| Put a hat on one's head. | Put sunglasses on one's head. | Scratch one's head. |
| Pour tea into a cup. | Pour tea into a glass. | Touch one's chin while thinking. |
| Steer soup with a spoon. | Stir soup with a ladle. | Massage painful wrist. |
| Wear a tie. | Wear a scarf. | Fold sleeves of one's shirt. |
| Peel a banana. | Peel a peach. | Peel an orange with one's hands. |

Experiment 1: Pretend actions

| *Appropriate object* | *Substitute object* | *No object* |
|---|---|---|
| The same objects as those in the corresponding real actions are present on the scene and/or held by the actor. However, the actor does not really perform the actions; he just pretends to execute them.<br>For example, the actor holds a potato and a peeler and makes peeling movements, but the peeler does not touch the potato. | Comb one's hair with a toothbrush (as comb).<br>Make a call with a glass (as mobile phone).<br>Write on a paper with a bottle (as pen).<br>Drink from a potato (as glass).<br>Open and read a toaster (as book).<br>Peel a mobile phone (as potato) with a peeler.<br>Turn on a box (as video recorder).<br>Put a bowl (as hat) on one's head.<br>Pour tea from teapot into a pepper (as cup).<br>Stir soup with a bottle (as spoon).<br>Wear a rope (as tie).<br>Peel a remote control (as banana). | The actor performs the very same pretend actions as those in the object condition, but this time there are no objects on the scene; thus he also pretends that the appropriate objects are present.<br>For example, the actor pretends to hold a potato and a peeler, and he pretends to use the peeler to peel the potato. |

Experiment 2

| *Normal actions* | *Accidental actions* | *Pretend actions* |
|---|---|---|
| Open a beer bottle. *(positive emotion, blindfolded)* | Fails to open the bottle. *(negative emotion, look straight)* | Appropriate object. *(positive emotion, look straight)* |
| Light a candle. *(negative emotion, look straight)* | Fails to light the candle. *(negative emotion, look straight)* | Appropriate object. *(neutral emotion, blindfolded)* |
| Put toothpaste on a toothbrush. *(neutral emotion, look away)* | Tries but the toothpaste is ended. *(positive emotion, look away)* | Appropriate object. *(neutral emotion, look straight)* |
| Write on a paper with a pen. *(positive emotion, look away)* | Tries but the ink is ended. *(neutral emotion, look straight)* | Appropriate object. *(negative emotion, look straight)* |
| Pour juice in a glass. *(positive emotion, look straight)* | Spills the juice out of the glass. *(neutral emotion, look straight)* | Substitute object. *(positive emotion, look away)* |
| Hammer a nail. *(negative emotion, look straight)* | Fails to hammer the nail. *(neutral emotion, look straight)* | Substitute object. *(neutral emotion, blindfolded)* |
| Pick up a phone. *(neutral emotion, look straight)* | Picks up a banana instead. *(neutral emotion, look away)* | Substitute object. *(negative emotion, look straight)* |
| Bite a peach. *(negative emotion, look straight)* | Bites a tennis ball instead. *(positive emotion, blindfolded)* | Substitute object. *(positive emotion, look straight)* |
| Take a book from a shelf. *(neutral emotion, look straight)* | Drops the book while taking it. *(neutral emotion, look straight)* | No object. *(neutral emotion, look away)* |
| Open a jar. *(neutral emotion, look away)* | Fails to open the jar. *(negative emotion, look straight)* | No object. *(negative emotion, look straight)* |
| Saw a piece of wood. *(neutral emotion, look straight)* | Fails to saw the wood. *(positive emotion, blindfolded)* | No object. *(neutral emotion, look straight)* |
| Open a locked box with a key. *(neutral emotion, blindfolded)* | Fails to open the box. *(neutral emotion, look straight)* | No object. *(neutral emotion, look straight)* |