Children's understanding of intentional vs. non-intentional action*

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This study investigates the development of children's understanding of others' intentions. We report 3 experiments in which three- and five-year-olds (total sample: N = 120) were tested using 15 videotaped pairs of action sequences excluding social information from the face. In each pair of videos the same action was performed with and without an intention (e.g. John *pours* water, vs. John *spills* water). Results showed that five-year-olds were more accurate in distinguishing intentional from non-intentional actions, while three-year-olds were significantly worse at understanding non-intentional actions. Three year olds tended to judge non-intentional actions as being intentional, suggesting, as Piaget proposed, they over-ascribe intentionality. This effect was found both in a verbal and non-verbal version of the task. Therefore the development of mental state explanations of actions may involve a gradual increase across preschool ages.

Keywords: intention, development, action, over-generalisation, preschool children

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Journal of Cognitive Science 8: 37 - 63, 2007.

* LC, DM and MDG were supported by the Ministero italiano dell'Istruzione e dell'Università e della Ricerca (FIRB Project, "Assessment dei disturbi della comunicazione in un'ottica riabilitativa" code n. RBAU01JEYW_001) in the development of this work. CA and SBC were supported by the MRC (UK) and NAAR during the period of this work. Correspondence should be addressed to Livia Colle, Department of Psychology, University of Turin, via Po 14, 10123 Turin, Italy.E-mail:colle@psych.unito.it

Humans are very social animals who are adept at reading the minds of others (Astington et al, 1988). This ability, also known as theory of mind (ToM), allows us to infer the mental states of others, and thus to understand and predict other people's behaviour (Premack & Woodruff, 1978). Employing a ToM is also sometimes referred to as adopting the 'intentional stance' (Dennett, 1987), or 'mind reading' (Whiten, 1991; Baron-Cohen, 1995). (Here, all these terms are used inter-changeably). A critical feature of a ToM is the idea that others' actions are driven by intentions (Woodward et al, 2001). Intentions are distinct from goals, in that goals are mental states of a desired outcome, while an intention is a mental state which describes an action plan in pursuit of a goal (Bratman, 1987; Tomasello et al, 2005). An understanding of intention is thought to serve as a building block of ToM, and one of the key questions in developmental psychology is how children come to understand the intentional behaviour of others.

Early in life infants show a basic ability to ascribe intentionality to actions (Baron-Cohen, 1995; Woodward, 1998; Tomasello, 1999). However this early capacity is limited and requires further development to fully understand intentional mental states underlying actions. As some theorists suggest, intentional understanding is a complex concept that changes from infancy to childhood, and a genuine understanding of intention depends on the emergence of meta-representational understanding (Moses, 2001; Astington, 2001; Wellman and Woolley, 1990,). For these authors, the inferential system that emerges with meta-representational ability allows humans to understand the link between actions and intentions. Therefore a meta-representational framework with inferential ability has more potential for explaining difficult and fine-grained judgments about intentionality, such as distinguishing between intentional and non-intentional actions.

Studies on children during their second year have shown they behave differently with respect to intentional compared to non-intentional actions. For example, in a study by Behne et al (2005), an adult gave a toy to infants across a table. On some trials the adult held up the toy but did not give it to the infants, because the adult was 'unwilling'. On other trials the adult did not give the toy because they were 'unable' to give it. 9 to18 month olds (but not 6 month olds) showed impatience when adults were unwilling to give the toy, but not when adults were making an effort but unable to give it. In a related study, 15 month-

old children who observed unsuccessful actions by the experimenters did not subsequently imitate the specific movements observed, but rather made attempts to reproduce the actor's intended actions (Meltzoff 1995; Bellagamba & Tomasello, 1999). Carpenter, Akhtar, and Tomasello (1998) also found that 14 to 18 month olds imitate an adult's action if it was linguistically marked as purposeful ('There!') but not if marked as accidental ('Whoops!'). These results suggest that by the second year of life, typically developing children have a basic ability to recognize intentions in the actions of others.

However, the tasks in these studies generally involved children giving a simple behavioural response, depending on whether an action was intended or not. So while 15 to 18-month-old children react differently to other's behaviour, this may simply be the result of a lower-level *implicit* intentional understanding. Children of this age might be able to detect intentions in behaviour and respond to it, but may not yet be able to demonstrate a higher-level explicit understanding that allows for more fine-grained discriminations. They may not utilise mental states to understand how agents form an intention to act (belief, desire and intention). Therefore the response of young children may not involve propositional representations of other's mental states, such as that involved in understanding 'John intended to do *x*' or 'John accidentally did *x*, but intended to do *y*'.

Primatologist suggest that to live successfully within a social group, primates must be able to anticipate the action of other animals, an ability that involves representing information about what others are trying to do (Whiten, 2001). Whilst this sounds abstract, everyday examples include the ability to distinguish between competitive and cooperative behaviour of animals during an interaction. However, while normally reared non-human primates can make such judgements about the actions of others (although evidence suggests abused or maternally neglected primates, or those reared in social isolation, cannot; Harlow and Harlow, 1965), they may make these judgements on the basis of dispositional concepts using behavioural, but do not mental state, understanding (Povinelli, 1999). In a similar way, infants and young children may detect intentions in the actions others, but may not possess an explicit propositional representation of these intentions until later in development.

Various studies suggest that development of intentional understanding occurs during the preschool years. For example, while young children seem to

confuse intention and desires, older children are able to make such fine-grained distinctions. Desires and intentions are closely related mental states, but they are not identical. One can desire an outcome, but not intend to do anything to bring it about. On the other hand, one can intend to bring about an outcome that one doesn't desire. Astington (1991) showed that preschool children infer the goal of actions based more on the outcome than other components of the action. This finding is exactly as Piaget (1932; 1954) claimed. When desire and outcome are matched, young children tend to label actions as intended. On the other hand, when desire and outcome mismatch, they often label actions as non-intended.

By 4 to 5 years of age, children now begin to differentiate desire and intention (Astington and Lee 1991; Astington 1993, 1999; Schultz, 1996; Phillips, Baron-Cohen, and Rutter, 1998). They can recognise situations such as deviant causal chains, in which an intention is unfulfilled but a desire is satisfied (Astington, 2001). In classic studies of children's understanding of intentions, children observed actions and were then asked specific questions about the goals (desires) and intentions (plans) of the actors. Results showed they could differentiate between these types of action in their explicit language by 5 years of age (Schultz, 2002). In other words, when actions do not represent the typical logical chain between desires, intentional plans, and outcome, young children find it difficult to build a propositional representation of the agent's intentions. Moses (2001) suggested that intentions are distinguished from other motivational states, like desires, because intentions must be consistent with beliefs. Therefore, children's concepts of intention can't fully emerge before the concept of belief (Moses, 2001).

The errors by young children in the more fine-grained distinctions of intentional actions have been interpreted as a difficulty in overcoming strong 'default' assumptions interpreting all actions as being goal directed (Piaget, 1932; Fodor, 1992). Since humans tend to seek causes for explaining actions, young children are biased towards adopting this intentional stance toward actions involving intentional inferences. From this perspective, an important developmental skill during preschool age involves inhibiting the default intentional attribution towards human action. In support of this, studies have shown a tendency for three and four-year olds to over-attribute mentalistic explanation to actions. For example, Smith (1978) showed videotapes of self-

initiated (voluntary) and non-self-initiated (involuntary) actions. After each action children were asked if the actor in the video wanted to do the action performed. While five-year-olds judged that only self-initiated action was based on desire, four-year-olds were more likely to judge both actions as motivated by the actor's desire. Montgomery (1996) explored different circumstances in which preschoolers use the initiation of action to infer another's desired goal. While results suggested a more sophisticated ability to read goals from action initiation in three-year-olds, it was present only under highly supportive experimental condition involving such additional social cues as eye gaze and facial expressions. Mongomery concluded that the development of detecting goal from action initiation is a gradual process, which starts around the third year and only becomes more consistent in subsequent years. Therefore the over-attribution of intention seen in young children decreases once the child better understands the person's motive, and is aware this motive does not necessarily match the outcome (Shultz and Wells, 1985; Moses 1993). This ability for improved and more fine-grained intentionality understanding with age in children likely mirrors the development of metarepresentational ability.

Although intentional understanding improves from the second to fifth years of age, evidence of this change varies according to the experimental conditions and the level of understanding required in the task (e.g. implicit or explicit responses). Importantly, the involvement of additional social cues and implicit response measures in previous studies have questioned how adept children in the 2nd year of life may be in understanding intentional actions. The present study investigated the understanding of intentional actions in children across two age groups, three and five years, using a task not involving additional social cues and requiring explicit judgments of intentional understanding. These age groups were chosen because this age range is thought to be a critical for the development of intentionality understanding (Perner, 1991). Children were shown videos of real-life actions and were asked to judge whether the actions by the actors were intentional or non-intentional. The videos were non-verbal and did not include any faces, to avoid the use of additional contextual cues like facial expressions, eye gaze, or speech, which may be involved when live actors are used. Instead, participants had to rely on perceiving the movements and non-verbal bodily cues of the actors in the videos, making the

task focused on body movements. Although the ability to discriminate intended and non-intended actions is partially present in infancy, we believe it becomes more consistent and established during childhood. This improvement in ability to discriminate between different intentions should be more evident by five years, as by this time children have developed a meta-representational ability. Therefore five year olds should be better than three year olds in discriminating intentional and non-intentional actions of others, particularly when social cues are limited to body movements.

We predicted that using a restricted set of visual social cues to detect intended and non-intended action, 3 year old children would show a typical bias to over-attribute intentions to non-intentional actions. We hypothesise that since 5 year olds possess a better developed propositional representation of intentionality, they will show better understanding of non-intentional items. We expect that when the context does not provide all possible information and the children have to judge only on the basis of motor pattern, recognizing unintended actions become particularly difficult for them. Such a finding would confirm Piaget's view, though not necessarily for the reasons given in his theory. This bias should not occur in the case of the 5 year old group.

Aims

(1) To investigate if children are more accurate in understanding intentional compared to non-intentional actions.
(2) To investigate the effect of age on the understanding of intentional and non-intentional actions.
(3) To investigate performance across verbal and non-verbal versions of the task.

Predictions

If the ability to understand intentionality from actions improves during development, then we expect 3 year-old children to perform worse at differentiating the intentional and non-intentional actions. However, since the understanding of intentional actions emerges before non-intentional understanding, we expected differences in ability to detect intentional versus non-intentional actions to be more pronounce in three-year-olds compared to five-year-olds. We predicted that intentional understanding does not depend on

the verbal demands of the task, therefore we expect to find similar results in the verbal and non-verbal experiments of the study.

Experiment 1

In Experiment 1 we tested the ability of 3 and 5 year olds to discriminate intentional vs. non-intentional actions in videos of actors performing everyday behaviours. For each action two videos were prepared with the same actor and identical context. In one condition, an agent clearly performs an action on purpose (e.g. an actor enters and with a strike of their hand, knocks some chess-pieces off a chess-board). In the other condition, the same agent performs the same action without any obvious purpose (e.g. an actor makes a movement with their hand with the intention of moving a chess-piece, and in doing so, involuntarily knocks all the pieces off the board). The child was asked if the character in the video 'meant' to do the critical action performed. The scenes were presented in a randomised order.

The advantage of using videos of real people is that it allowed experimental control in ensuring similarity between the intentional and non-intentional videos. A disadvantage with using videos is reduced ecological validity compared to real actors. However, an advantage of using videos was that we could exclude any supportive visual information providing additional social cues towards intentionality, such as the actor's facial expression, gaze information, and verbal comments. Therefore the study focuses only on children's attribution of intentions towards action patterns, without the benefit of additional information that helps to distinguish intended from non-intended actions. In the 15 pairs of videos, most actions were 'no-goal actions', which were actions executed with no specific underlying goals (such as accidentally spilling a glass of water on somebody else). Additionally, some of the actions (see appendix) have an unfulfilled goal, which we term 'mistake actions' (e.g., spilling a glass of water while grabbing a bottle).

We expected the 5 year old children would perform very well on both the intentional and non-intentional conditions, while the 3 year olds would perform better on the intentional condition. We hypothesise this is due to the over-attribution of intentionality typically seen in younger children.

Table 1. Descriptive statistics for Experiment 1.

	Group			
	Younger (3 years)		Older (5 years)	
	M	*SD*	*M*	*SD*
INT score	11.65 (77.7%)	2.28	13.60 (90.7%)	1.35
NON-INT score	3.25 (23.3%)	3.25	10.05 (67.0%)	1.90

Participants

The experimental sample consisted of two groups: (1) 20 children in the age range of 3yrs to 3yrs:6m (mean age = 3:4, sd = 1,89) who comprised the 'Younger' group, and (2) 20 children in the age range of 5yrs to 5yrs;6m (mean age = 5:4, sd = 2,19) who comprised the 'Older' group. Children were selected from two municipal nursery schools in Turin. All children spoke Italian as their first language.

Material

The material consisted of 30 video-recorded scenes (6 seconds each) involving actions performed by real actors. The scenes occurred in everyday locations (e.g. at home, in the street or in the garden). The same action was performed in an intentional and an non-intentional condition. This was to ensure that outcomes in each condition were matched. This design avoided the possibility that children might interpret action based on the desirable or undesirable outcome of the actions. The scenes were filmed without close-ups of the actors' faces, to avoid facial expression cues (e.g., disappointment/ surprise). The same actor performed the action within each pair of videos, but different actors were used to perform different pairs of videos. Each scene had the following basic framework: a starting situation (with the actor already present or entering the scene [see fig. 1-A]), an event-action (the actor performing an intentional or non-intentional action [see fig.1-B]), and a closing situation showing the result of this action (see fig. 1-C).

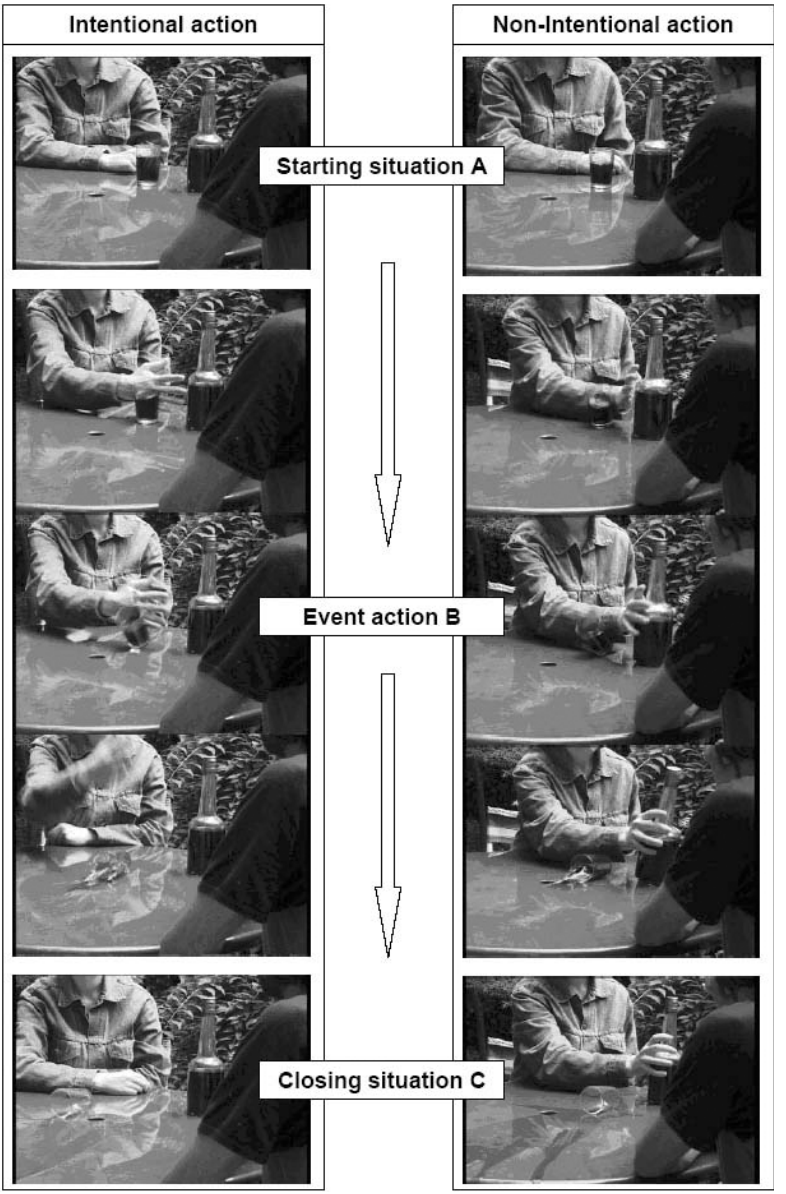

Fig. 1. Basic framework of videos: (A) Starting situation, (B) Event-action, (C) Closing situation.

Task development

The 15 pairs of scenes were selected from an initial pool of videotaped actions. The initial pool was used as a pilot test with a sample of 20 adults (aged between 20 and 60 years). From the results of this initial study, we excluded actions that appeared ambiguous. A 90% accuracy rate was chosen as a cut off to determine reliable actions. We then chose 30 clips that were randomized in order to create two versions of the task (see Appendix 1 for scene description).

Procedure

The experimental procedure involved a brief practice with three pairs of scenes (intentional vs. non-intentional), taken from the pilot testing to ensure all the participants understood the task. All of the children who participated were able to understand the procedure. In the experiment, 30 different videos were shown to the children in one of the two randomised orders. At the end of each scene the experimenter stopped the video and asked participants "*Do you think the person* [*who knocked the chess-pieces off*] *did it on purpose or not?*"). The questions were put together in such a way to draw the child°Øs attention to the specific critical action that he or she had to evaluate. The total length of the test was approximately 15 minutes. The measure of interest was the number of correct answers by the participants for each condition (range: 0-15).

Results

Descriptive statistics for the two age groups are shown in Table 1. Scores on the two subscales were analyzed with a 2-factor ANOVA with Intentionality (intentional vs. non-intentional) as the within-group factor and Age (younger group vs. older group) as the between-group factor. We found a significant main effect for Intentionality: F (1,38) = 152.54, $p < .001$, with participants performing better on the intentional items compared to the non-intentional ones. There was also a main effect of Age: F (1,38) = 145.21, $p < .001$, with the older group performing better than the younger group. Importantly, there was a significant interaction between Intentionality and Age, F (1,38) = 25.13, $p < .001$, revealing a steeper increase with age for accuracy of the non-

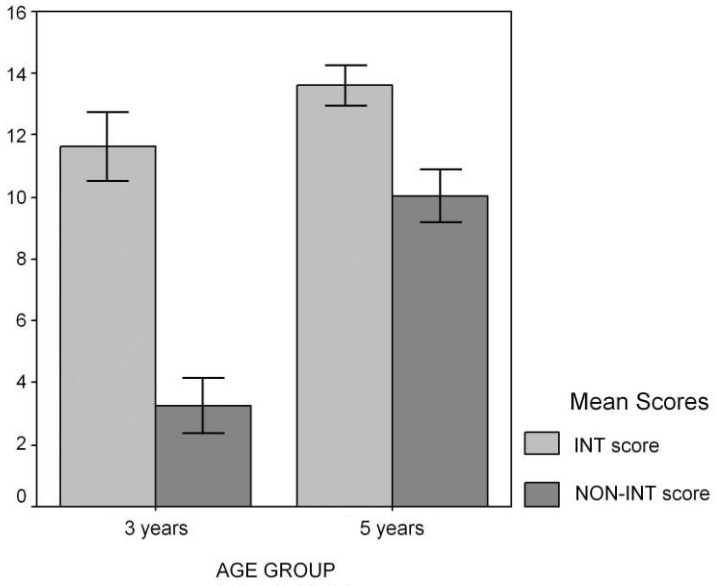

Fig. 2. Mean scores in the two age groups (experiment 1). Bars = 95% confidence intervals.

intentional items, compared to the intentional ones (see Fig. 2).

To explore possible effects related to different types of goals within the non-intentional video, we compared the percentage of correct responses for non-goal action videos to mistake-action videos. Results showed that the Younger group performed better on the mistake-actions (29% accuracy) compared with the non-goal-actions (19%), $p = .037$. The Older group showed no difference in accuracy for the mistake-actions (87%) compared to the non-goal-actions (91%), $p = .287$.

Discussion

The results from Experiment 1 showed that 3-year olds were accurate on correctly judging intentional actions. However, 3 year olds performed significantly worse when judging non-intentional items. The 5 year old group showed better performance than 3 year olds on both conditions, but interaction

effects showed they had even greater accuracy than 3 year olds on the non-intentional items. These results confirm the hypothesis that intentionality understanding about the actions of others increases during childhood, even with minimal social information available. The data also suggest that younger children attribute intentionality to actions even when the outcome is non-intended. In other words, younger children over-generalize intentionality, resulting in poorer performance on the non-intentional conditions.

In Experiment 1 participants had to say whether they thought the behaviours in the videos were intended or not. However, this does not reveal how they were doing the task. They could have been inferring mental states, or simply using a behavioural interpretation, with little or no mental state understanding. Therefore in Experiment 2 we added open-ended questions to the paradigm to investigate the explanations children give to explain non-intended actions. This would allow us to determine if they were truly over-generalizing intentions to the non-intentional items.

Experiment 2

Experiment 2 involved two different tasks. The aim of the first task was to replicate Experiment 1, and involved recognition of intentional vs. non-intentional actions. The second task used some items from Experiment 1, and asked participants to give an *explicit* description of the agent's mental states during the actions.

Participants

The sample consisted of 40 children in two age groups similar to those in Experiment 1: (1) 20 children in the age range of 3yrs to 3yrs;6m (mean age = 3:3, sd = 1.06) who formed the Younger group, and (2) 20 children in the age range of 5yrs to 5yrs;6m (mean age 5:5, sd = 0.69) who formed the Older group. All children spoke Italian as their first language. No children were excluded from the analysis during the training session, and none of the children in this experiment had participated in Experiment 1. All participants were shown the complete set of 30 scenes in a randomised order, with 6 questions to probe for an *explicit* description of the agent's mental states.

Material and Procedure

Task 1

The material consisted of the same 30 video-recorded scenes (15 pairs of intentional/non-intentional actions) presented in Experiment 1. At the end of each scene, the experimenter stopped the video and asked the child whether the action seen was performed intentionally or non-intentionally ("*Did the person you saw* [*knock the chess-pieces off the board*] *do it on purpose or not?*"). In addition to the two options included in Experiment 1 (yes or no), a third option (*don't know*) was added and restated each time. This allowed the children an additional answer if they were uncertain, in order to avoid forced-choice response artefacts. The total length of the test was approximately 15 minutes. Each subject received two scores, ranging from 0 to 15, one for the intentional items and one for the non-intentional ones. In computing the two scores, the "don't know" answers were treated as wrong; they accounted for 6.4% of the total answers (see Table 2).

Table 2. Descriptive statistics for Experiment 2

		Group			
		Younger (3 years)		Older (5 years)	
		M	*SD*	*M*	*SD*
Task 1	INT score	13.90 (92.7%)	0.97	13.10 (87.3%)	1.12
	NON-INT score	3.00 (20.0%)	1.30	11.95 (79.7%)	1.73
	Don't know (pooled)	3.00 (20.0%)	1.30	11.95 (79.7%)	1.73
Task 2 (*open questions*)	Correct Over-generalized Other	0.30 2.15 0.55	0.47 0.81 0.76	2.60 0.25 0.45	0.68 0.55 0.94

Task 2

After the first task, 6 scenes of the original protocol (3 intentional and 3 non-intentional; see Appendix 1) were presented with a different question: "*What did the person want to do?*" The question was left open to investigate the child°Øs explicit mental state attributions during the non-intentional videos. The total length of the task was about 10 minutes. Answers to the open questions about the *non-intentional* items were then coded in 3 categories:

Correct answer. The child answers the closed question correctly in Task 1, and in the open question explicitly attributes another (correct) intention to the actor. e.g.: *No, he didn't* [*knock the chess pieces off*] *on purpose; he wanted to grab the other piece.*

Over-generalization. The child gives the wrong answer to the closed question in Task 1, and in the open question explicitly attributes the wrong intention to the actor (treating the unintended outcome as an intended one). e.g.: *Yes, he did it* [*knock the chess pieces off*] *on purpose; he wanted to make them fall.*

Other. Contradictory and/or incomplete answers that didn°Øt fit the above categories.

The number of answers of each type (0-3) was counted for each subject. The three intentional items were used as distractors, and their answers were not coded.

Results

Task 1

Descriptive statistics for the two age groups are shown in Table 2. First, we tested whether the results of Experiment 1 replicated. Scores on the two subscales were analyzed with a 2-factor ANOVA with Intentionality (intentional vs. non-intentional) as the within-group factor and Age (younger vs. older group) as the between-group factor. Again, we found significant main effects for Intentionality: F (1,38) = 638.99, $p < .001$; and for Age: F (1,38) = 144.43, $p < .001$), showing that performance increases with age and that intentional items are easier than non-intentional ones Again, there was a significant interaction between Intentionality and Age, F (1,38) = 418.34, $p < .001$ (see Fig. 3). Therefore the results from Experiment 2 replicate findings

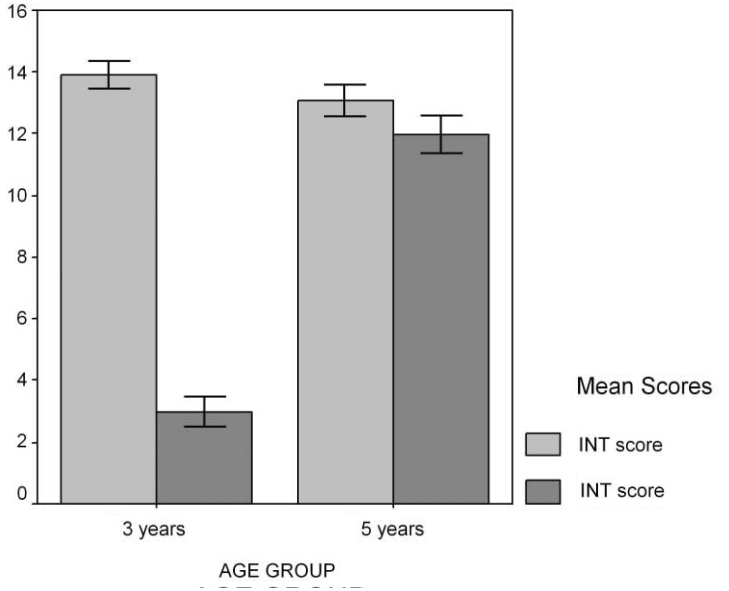

Fig. 3. Mean scores in the two age groups (experiment 2; Task 1). Bars = 95% confidence intervals.

from Experiment 1 in a different group of children.

As in Experiment 1, we also tested for difference between mistake-action videos and non-goal-videos. Results showed in the Younger group there was no difference for the mistake-action videos (27%) compared to the non-goal videos (17%), however there was a trend towards significance, p = .090. The Older group were significantly better on the mistake-action videos (91%) compared to the non-goal action videos (75%), p = .011.

Task 2

We then compared the two age groups on the answers to the open questions (Fig. 4), in terms of the proportion of correct and over-generalized answers. The older group showed significantly more correct answers t (38) = 12.43; p < .001, and less over-generalized answers, t (38) = 8.66; p < .001, compared to the younger group. On the other hand, a majority of the younger children's answers consisted of explicit over-generalizations (mean: 2.15; sd = 0.81;

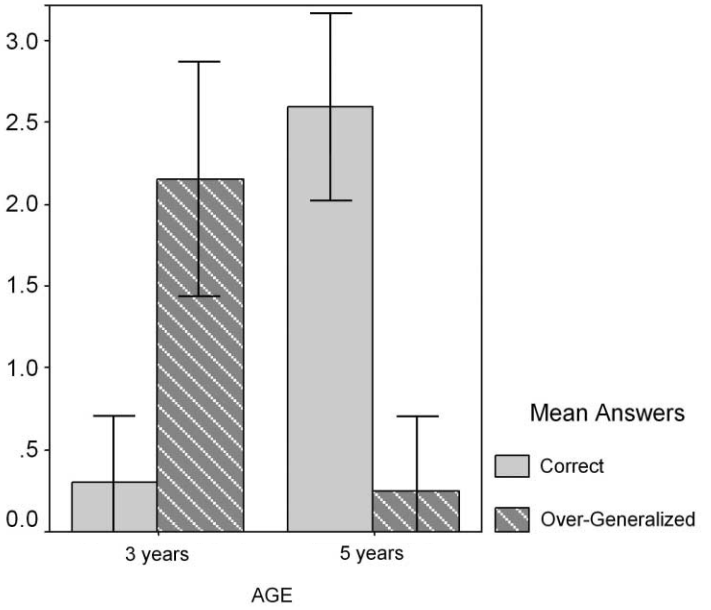

Fig. 4. Mean number of correct and over-generalized answers in the two age groups (experiment 2; Task 1). Bars = 95% confidence intervals.

correct answers out of 3), showing a reversed pattern compared to the older group (mean: 2.6; sd = 0.68; out of 3).

Discussion

Experiment 2 showed that 3-year old children were able to recognize intentional actions accurately, but they performed worse than 5-year olds when judging non-intentional ones. These findings are consistent with the results from Experiment 1, even though Experiment 2 included an "I don't know" answer for each question. Therefore we can be confident that the results are not due to forced-choice artefacts. Thus, the ability to recognize non-intentional actions shows greater improvement with age than does the recognition of intentional actions, as in Experiment 1. This is consistent with the hypothesis that interpreting actions as intentional is dominant at younger ages, extending

even to actions that are accidental in nature. Analysis of the open questions suggests that, as Piaget claimed, younger children tend to interpret all actions as intentional. Children appear biased towards explaining human behaviour in terms of purposeful action (over-generalization of intentionality) and tend to see even non-intended actions as having intentionality. Age appears to be an independent predictor of performance on the non-intentional items. However, results from Experiments 1 and 2 could be confounded by a possible response bias of the children because of the verbal nature of the instructions. We investigated this possible effect in Experiment 3.

Experiment 3

Experiment 3 involved a non-verbal version of the intentional vs. non-intentional task. The lower performance in accidental action recognition by the 3-year-olds in Experiments 1 and 2 might have been due to the verbal nature of the instructions and responses, which may not tap the true competence of children for two methodological reasons. Firstly, the question "*Did the person who* [*knocked the chess-pieces off the board*] *do it on purpose or not?*" could have produced a higher proportion of positive answers for the younger children due to the fixed order in which alternatives were presented in the question. Indeed, younger children's responses tended to be the same for both kinds of items (they tended to respond "yes" to both the intentional and non-intentional items), which could be due to a response bias. The second issue concerns linguistic knowledge of the phrase 'on purpose'. Younger children may have less understanding of this expression, and such a difference in understanding could have affected their performance. In order to rule out the influence of language abilities in understanding of the videos and to exclude the possibility of question-induced response bias, we developed a non-verbal version of the task.

Material and Procedure

Three pictures were placed in front of the participants, one representing each of the response options. The pictures were initially described and presented as support for intended, non-intended and don't know answers (see phase one and two below). In the experimental task the children pointed to one of three

pictures for their answer.

Before the task, children underwent a 15 minutes training session, which had two phases. The first phase was to ensure that children correctly understood the meaning of each category of "on purpose" and "by accident". Eight new movie clips were prepared, which depicted four intentional and four non-intentional different actions. The actions involved simple hand or foot movements (for example, a man who falls down the stairs). The experimenter played the eight clips and explained each of them. He described the actions to the child verbally in order to introduce the categories of intended ("he did x on purpose") and non-intended ("he did x by accident") action. For both categories of action he/she also introduced a picture that represented a prototypical image of each category. (The pictures were taken from the last two frames of the two videos, one intended and one unintended, that the child had just seen). A third picture with a question mark was also introduced to represent the 'I don't know' option. All the children passed this phase successfully, showing that they understood the categories of 'intentional' and 'accidental'.

The second phase trained the children how to answer. Four separate movie clips of simple intentional and non-intentional actions were presented, and the experimenter verbally defined each of them as intentional ("he did it on purpose") or non-intentional ("he did it by accident"). The child had to point to the picture corresponding to the correct category for each action. The aim of this phase was to check whether children were able to match the action categories with the corresponding picture. The matching procedure used in the training phase was the same as that used in the experiment. In the actual task the experimenter did not give a verbal description of the scene and the child had to categorize the action on his/her own. Each child had to match all 4 videos in the training phase correctly in order to participate in the actual experiment. All of the children passed the training session successfully, showing that they were able to match the action type with the corresponding response categories.

During the test stage each child received 30 trials of videos (15 pairs of intentional/non-intentional actions). These were identical to those of Experiment 1 and 2 and were presented in a randomised order. At the end of each scene, the experimenter stopped the video and asked the child to choose from the pictures in front of him/her (intentional, non-intentional, or I don't

Table 3. Descriptive statistics for Experiment 3

	Group			
	Younger (3 years)		Older (5 years)	
	M	*SD*	*M*	*SD*
INT score	10.40 (69.3%)	0.96	12.61 (84.1%)	1.32
NON-INT score	5.35 (35.7%)	1.34	10.00 (66.7%)	1.67
Don't know (pooled	0.60 (4.0%)	0.84	0.79 (5.2%)	0.78

know), which one fitted the action of the person in the video. The order of the pictures in front of the child was randomly varied each trial, in order to prevent response bias due to the picture position. The total length of the test was about 15 minutes. Each child received two scores ranging from 0 to 15, one for the intentional items and one for the non-intentional ones. In computing the two scores, the "I don't know" answers were considered wrong answers. However, these accounted for less than 4,7% of the total answer (see Table3).

Participants

The experimental sample consisted of 40 children in two age groups similar to the two previous experiments: (1) 20 children in the age ranger of 3yrs to 3yrs;6m (mean age = 3;3 years, sd = 2.15) who were the Younger group, and (2) 20 children in the age ranger of 5yrs to 5yrs;6m (mean age = 5;1 years sd = 3.2) who were the Older group. All children spoke Italian as their first language. Four children were excluded from analysis because they showed very low interest in the test during the training session. None of the children in this experiment participated in the other experiments, and all participants were shown the complete set of 30 scenes.

Results

Descriptive statistics for two age groups are shown in Table 3. Scores on the two subscales were analyzed with 2-factor ANOVA with Intentionality (intentional vs. non-intentional) as the within-group factor and Age (younger group vs. older group) as the between-group factor. As in Experiment 1 and 2, we found significant main effects for Intentionality: F (1,38) = 150.63, p < .001; and for Age: F (1,38) = 130.81, p < .001, showing that performance increases with age and that intentional items are understood more accurately than non-intended ones. Again there was a significant interaction between Intentionality and Age, F (1,38) = 18.10, p <.001 (see figure 5), which showed that an increase with age for accuracy of the non-intentional items, compared to the intentional ones (see figure 5). The results thus confirm the findings of Experiments 1 and 2.

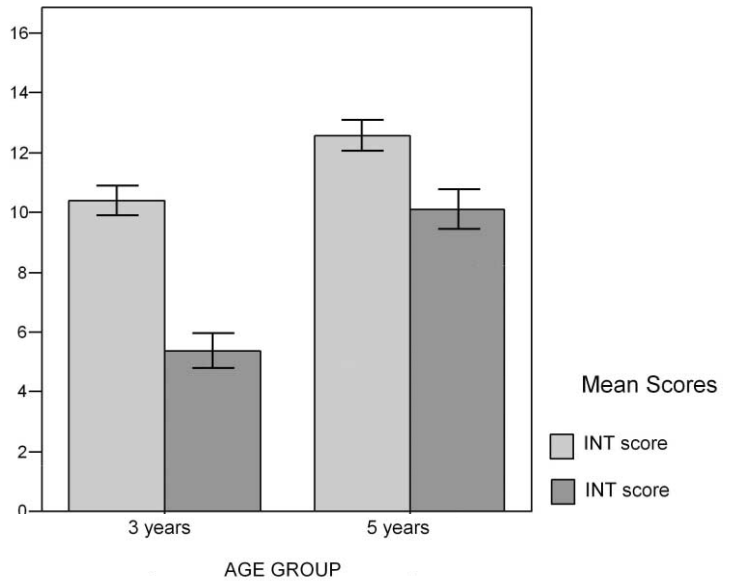

Fig. 5. Mean scores in the two age groups (experiment 3). Bars = 95% confidence intervals.

Once again we tested for difference between mistake-action videos and non-goal-videos. Results showed in the Younger group were better on mistake-action videos (52%) compared to the non-goal videos (29%), $p = .002$. The Older group were also better on the mistake-action videos (80%) compared to the non-goal action videos (63%), $p = .004$.

Discussion

The performance of the children in Experiment 3 replicates the results found in Experiments 1 and 2. Older children correctly distinguished between intentional and non-intentional actions. The younger group again judged most non-intentional actions as intentional, suggesting they over-generalise intentionality. However the effect was reduced in both groups. The non-verbal procedure facilitated the younger group's recognition of non-intentional actions. The better performance in non-intentional action recognition comes at the cost of a lower performance on the intentional items, reducing the size of the intentional over-attribution effect found in Experiment 1 and 2. However, the major failure in non-intentional action recognition by 3-year-olds is consistent with the results from Experiments 1 and 2, and shows that differences in linguistic ability and response biases cannot explain our findings.

The performance of the older children was also consistent with results from Experiments 1 and 2, as they once again showed good understanding of both intentional and non-intentional actions. In this group the non-verbal procedure resulted in slightly lower performance for both conditions, however the difference was only significant for the non-intentional items. Since five year old children rely more on language than 3 year olds, a possibility is that the older group may have been more bored with the non-verbal procedure, or might have found it redundant and not immediate.

General Discussion

The 3 experiments reported here measure the ability of children at two different ages to distinguish between intentional and non-intentional actions using minimal social cues. Results showed that 5-year-olds are significantly better than 3 year olds at recognizing intentionality. In particular, the 5 year

olds are better able than 3 year olds to correctly understand non-intentional actions. Not only were 3 year olds worse at recognising non-intentional actions in others, but they tended to misinterpret the non-intentional behaviours as intentional, even when they could choose a response indicating they did not know.

These findings are consistent with ideas that the development of intentional understanding is gradual during childhood, with early basic understanding developing into a fuller understanding by 4 to 5 years of age (Tomasello et al, 1995). Indeed, evidence suggests that infants detect intention in behaviour and can respond according to other's intended action, but that they have little if any conceptual understanding of it. A further interesting finding in our study concerns the two types of non-intentional actions involved in the videos: mistake-actions and non-goal actions. The results showed that videos with mistake-actions facilitated performance for both groups compared to the videos with non- goal actions. This may have been due to the fact that mistakes involve understanding the agent's desires, which have not been successfully carried out. The literature shows that desire is a more basic concept than intentionality, and evidence shows children have a well-developed understanding of desire before the age of 3 (Astington and Lee 1991; Astington 1993). However, since the numbers of videos with mistakes were quite low (four), we limit the discussion about this point and suggest further research is required in this area.

As various authors suggest, the analysis of intentional actions may involve different levels of analysis (Searle, 1983). An action is considered intentional when the agent has a desire for an outcome, and a belief that the action would lead to that outcome, and an intention to perform the action, and the skill to perform the action, and awareness of fulfilling the intention while performing the action (Malle & Knobe, 1997). Children acquire this full-fledged concept of intentionality only around the age of five (Shultz and Wells, 1985). The achievement of 5-year-olds may lie in their appreciation of intention and action as important mediation between some mental states (such as desires and belief) and the outcome. Command over intention concept involves the differentiation of action relevant mental states into the triad of belief, desire and intention that are partially confounded at an early age (Moses, 2001). Awareness that actions are usually guided by states of mind does not necessarily yet involve a

differentiation between different mental states involved in action.

Our findings suggest that under experimental conditions where social information islimited to body movements without extra facial cues, 3-year-old children tend to over-attribute actions as intentional, while 5-year-olds are better at correctly identifying the presence or absence of intentionality underlying others behaviour. In particular, there was little difference between the two age groups on the intentional items, whereas there was a sizable improvement for the non-intentional items across the age groups.

In view of this, a major challenge in intentional development during early childhood seems to be related more to learning appropriate use of intention attributions, and to distinguishing between different mental states that underly intentional actions (intentions, desires, believes). The over-interpretation of intentionality was initially suggested by developmental accounts of Piaget (1932), but these ideas have received less attention in more recent experimental literature. We could argue that early intentional detection may lead to a full understanding of intention later on, which involves intention as a representation independent from action, perhaps through a mechanism of representational redescription in which language development plays a part (Karmiloff-Smith, 1992). In line with these ideas, a full understanding of intention may depend on the emergence of meta-representational abilities that typically emerge around 4 to 5 years of age. This inferential system allows human beings to understand the complex link between actions and intentions and to make more fine-grained distinctions (Moses, 2001; Astington, 2001; Wellman and Woolley, 1990).

From an evolutionary perspective the bias to over-attribute intentions to human action has the advantage of preparing the observer to respond. Malle and Pearce (2001) show for example that adult observers tend to read more actions as intentional compared to when they are in the position of agents. From the observer's point of view, intentional events have greater relevance than non-intentional events. This is because intentional events demand a response, and allow the observer to produce a rapid response. Even if the response is unwarranted (e.g., interpreting an accidental bump as a deliberately aggressive act, and responding with a threat of counter-attack), such a bias or error might have more survival value than the opposite kind of bias (assuming that acts are accidental when they are not).

It could be argued that our experimental paradigm has limited ecological validity as participants didn't have access to all the sources of social information to detect an agent's intentions, including facial and vocal emotional expressions (Golan et al, 2006). However our approach involving videos also has advantages such as allowing for close matching of intentional vs. non-intentional items, and in the variety of simple motor actions used. Thus videos are a useful tool to assess intentional recognition of action on the basis of motor-action information. The 3 experiments in the present study converge on the same conclusion, namely, that 3-years-old find it difficult to recognize something as being non-intentional without the help of context, whilst 5-years-old do not have any difficulty in differentiating intended and unintended actions. Therefore, we can conclude that during development children become more accurate in intentional attribution, even when contextual information is absent. Such a task might be of particular value not just in testing for delays in development of intentional understanding, but also for investigating the delay in clinical groups such as autism or Asperger Syndrome, and for studying the brain basis of intentional understanding using fMRI. Such studies are underway in our lab.

In conclusion, the understanding of actions in intentional terms is complex and is not mastered in a single moment of development, but develops gradually with age. Although some basic understanding of intentional action is evident early in development, the acquisition of a full appreciation of the role of intentions in guiding human behaviour is likely to be only apparent at a later age, suggesting a metarepresentational mechanism may be required.

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