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Recognition of Biological Motion in children with Autistic Spectrum Disorders

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Abstract

It is widely accepted that children with autism experience difficulties in processing and recognizing emotions. Most of the studies that lead to this conclusion have explored the perception of faces. However, facial expressions are far from being the only source of emotional information. Context and bodily gestures are also sources from which we derive emotional meanings. Our study was aimed at exploring further abilities to extract emotional information from bodily movements in children with autistic spectrum disorders (ASD). We tested 23 high functioning children with autism and 23 corresponding typically developing children on a task exploring their abilities to recognize point-light displays of a person's actions, subjective states and emotions. Also in a control task children had to recognize point-light displays of everyday objects. The children with autism only differed from the comparison participants in their abilities to name the emotional point-light displays. This suggests that children with autism can extract some complex meanings from bodily movements but that they may be less sensitive to higher-order emotional information conveyed by human movement. The results are discussed in the context of a specific deficit in emotion perception in children with autism.

Keywords: Biological motion, Emotion recognition, Configural processing, Autism spectrum disorder.

Introduction

Humans are an intensely social species. As a consequence, the human visual system may have evolved to rapidly and effortlessly detect and extract socially relevant information, even from perceptually degraded stimuli. One classic example of this process is demonstrated in people's responses to human point-light displays (PLDs). Human PLDs are made by attaching a set of point-lights to the joints of a human who is then filmed moving in a dark room (e.g., Maas and Johansson, 1971). Studies have demonstrated that these displays provide sufficient information for typical adults and children to derive very subtle meanings about the person filmed, such as the kind of action they are executing (e.g., Dittrich, 1993), their gender, their identity (Cutting, 1978; Troje, 2002), their deceptive intentions and even the emotional state of the person (Dittrich et al., 1996; Pollick et al., 2001).

People with Autistic Spectrum Disorders (ASDs) are reported to have perceptual difficulties (e.g., Deruelle et al., 2006), and their perception of motion may be particularly impaired (e.g., Milne et al., 2002). Consequently, one might suspect that people with autism would have difficulties in perceiving the meaning of human PLDs. Furthermore, while deficits in emotion processing in faces are well documented in people with autism (e.g. Beeger et al., 2006), less is known about their abilities to perceive emotions in gestures. If emotion perception is a general problem then one might expect children with autism to be poor at picking up the emotional gestures depicted in human PLDs.

To date there have only been a few studies of children with autism's responses to human point-light displays. The first was conducted by Moore and colleagues (1997) who tested the ability of typically developing children, children and adolescents with mental retardation and children and adolescents with ASD to recognize a moving person's action and emotion-related attitudes when presented in point-light form.

Surprisingly, given the problems that people with ASD are reported to have in motion perception (e.g., Milne et al., 2002), Moore et al. (experiment 1) found that the adolescents and children with and without autism were similarly able to rapidly identify what a point-light display represented, whether it was a person or a moving everyday object, suggesting, for this sample of children at least, that their basic ability to recognize the underlying form of human point-light displays was relatively intact. However, differences were found in the abilities of the children with autism to name the person's emotional and subjective states (experiments 2 & 3).

Moore et al. compared mentally retarded children and adolescents matched for chronological and mental age with children and adolescents with autism. They found that the participants with autism were specifically impaired in naming subjective states compared to children with intellectual difficulties of similar IQ but had little problems in naming human actions. The study also showed no differences between the performance of the children with learning difficulties and typically developing children matched on mental age. However, as the children with autism had low IQs, with CAs ranging from 10 to 18 years and verbal MAs ranging from 6 to 8 years, it was possible that the difficulties these children had with emotion recognition might have been related to other intellectual difficulties specific to autism.

A more recent study by Blake et al (2003) explored the abilities of younger children with autism aged 8 to 10 years to discriminate and perceive point-light displays. Blake, et al presented participants with 1-second clips of point-light displays which represented a person engaged in actions such as throwing, jumping and kicking or out-of phase, scrambled, and thereby meaningless, versions of these original actions. Children were asked to decide whether the display represented a person or not and this was repeated over 50 trials. Performance of children with autism was compared to that of typically developing children matched on mental age (range 5 to 10 years). Findings indicated that, compared to typically developing children, children with autism were impaired in discriminating human from scrambled motion in these brief point-light displays, while being similar in their performance on another visual discrimination task.

The discrepancy between these data and those of Moore et al. may originate from differences in the methods. Whereas Moore et al. (1997) in experiment 1 used a task that required participants to identify from brief video clips an object or a person only once, Blake et al (2003) employed a task in which participants had to discriminate over many trials. As Hubert and collaborators (Hubert et al., 2007) commented, it may be that the identification task used by Moore et al made fewer sustained attentional demands on children with autism than the prolonged discrimination task used by Blake and colleagues. Repeated discrimination tasks with short clips may make demands on working memory that are IQ-related. As Blake et al's comparison group did not appear to be IQ-comparable, with some of the ASD children who were aged eight and above having MAs of five years, and with the control group having normal IQs, it is not possible to discount effects that IQ-related information and motion processing abilities might have had on the PLD task performance of the younger children with autism.

While Blake et al did administer a control task on which the children with and without ASD performed similarly, this control task was very different from the target task. It consisted of a step-wise signal detection task where participants had to detect a static global circular form amongst changing degrees of visual noise. Given that the target biological motion task was examining ability to discriminate between moving displays, whereas the control task was examining abilities to detect static forms in amongst noise, it is not clear that the control tasks is appropriate for determining if there is a specific problem with biological motion per se – in that it did not actually control for general motion perception abilities, which are known to be poorer in children with autism. Differences in performance between the target and control task in the children with autism may have been a product of general motion perception problems and poorer thresholds of general motion detection in children with autism rather than a product of any specific problem with biological motion. These would be expected to have an additional constraint leading to more errors specifically on the target task, which may be more likely to be apparent over a large number of trials with trials of short durations. In Blake et al's biological motion discrimination task there were 50 trials with exposure to the moving stimulus lasting only 1- second duration, whereas in the control task with static stimuli children had as long as they needed to point out the location of the shape. In contrast, in Moore et al's experiment 3, the clips of biological motion of actions lasted for 5 seconds. Here no difficulties were found for the children with autism, compared to IQ-comparable children with IDs, when labelling the actions of the human PLDs. Thus, while there may be problems in motion detection in children with autism it is not yet clear from Blake's findings alone that there are additional specific problems with the detection of biological motion.

Another source of differences between the findings could rest in the different age range with the autistic participants being younger in the Blake et al. (2003) than in the Moore et al. (1997) study. It may be that the ability to recognize and discriminate between human and non-human point-light displays improves with age. To partly reconcile these issues, Hubert et al. (2007) replicated experiment 3 of Moore et al. (1997)'s study. However, to exclude the possible impact of IQ-related effects they explored the responses of high-functioning adults with ASD who did not have mental retardation. Consistent with Moore et al. (1997)'s data, their findings indicated that the adults with ASD performed as well as the comparison group in describing (5 second) point-light movies depicting simple actions and in identifying manipulated objects. In contrast, the high-functioning ASD adults performed significantly poorer than comparison participants in the emotion and state labeling condition.

The finding that the adults with ASD had few problems in identifying actions, but had a specific problem with recognizing subjective states and actions suggests that the recognition of higher level subjective meaning may be a core deficit for adults and older children with autism. However, a remaining question is whether younger children with ASD show a general deficit in perceiving PLDs or also show a selective deficit in perceiving the emotional meaning they convey.

The purpose of this study was first to assess the performance of high-functioning children with autism and compare this with IQ-comparable typically developing children to see if the problems identified in low-IQ children with autism (Moore et al., 1997) and in high functioning adults with autism (Hubert et al., 2007) were also found in high functioning children with autism. The second objective was to compare performance of the high functioning children with autism to the data reported by Hubert et al. (2007) to see whether there were any developmental trends in the perception of these displays as from childhood to adulthood.

The children and adolescents tested here were similar in age to those tested by Moore et al. (1997) and also were closer in age to those tested by Blake et al. (2003), although of higher ability. As with the Hubert et al study we used the stimuli developed by Moore et al. (1997) and partly replicated experiment 3 of this study showing children human point-light displays depicting actions, subjective states, emotions and also control displays that showed point-light displays of moving objects. Our main questions were 1) whether high-functioning children with autism showed the same specific problem with perceiving emotional content in these displays and 2) to what extent performance is comparable or not to that reported for high-functioning adults with autism.

Method

Participants

Two experimental groups participated in this study. The first group included 23 children with ASD (20 boys and 3 girls) aged 7 to 18 years (M = 11 years 7 months; SD = 3 years 2 months). They were diagnosed according to the DSM-IV (APA, 1994) and /or the ADI-R (Lord et al., 1994). In addition, parents of all subjects were asked to answer the Autism Spectrum Screening Questionnaire (ASSQ Ehlers et al., 1999), during a semi-directive interview. All participants scored positively on the ASSQ. Full-scale IQ scores were measured using the WAIS-III or WISC-III (Wechsler 1997, 1996, respectively), according to the subject's age. IQs ranged from 85 to 120 (M = 93.7; SD =15). Note that no significant difference was observed between verbal and performance IQ scores (M verbal = 93, SD =19.4, M Performance = 89, SD = 13; t(1-22) = 0.91, p = .36).

As the mean score of IQs were in the normal range, the ASD participants were matched to a control group of 23 typically developing children (20 boys and 3 girls) on the basis of gender and CA (M age = 12 years, SD = 2 years 5 months). These children were recruited via local schools and day-care centres and they all attended normal classes corresponding to their age level. Their teachers were asked to select children on the average level of the class thus avoiding including children either particularly advanced or delayed relative to their age.

Children with ASD were recruited via the Department of Child Psychiatry at the local hospital (Sainte-Marguerite Hospital, Marseille). They all attended normal classes at local schools. At the time of testing, none of the participants had known associated medical disorders nor overt physical handicap. All participants were native French speakers and had normal or corrected-to-normal vision and audition. Informed consent was obtained for all subjects and the experimental procedure was approved by the local ethics committee

Tasks and stimuli

Tasks and stimuli were similar to those used in Moore et al. (1997, Experiments 2 and 3). There were a total of 20 video clips each of around 5-seconds duration displaying dynamic PLDs. Ten video clips were of a male actor performing actions, (see Table 1 for a detailed description). The human point light displays were the same as those used in Moore et al (1997). There were also five clips of the actor displaying subjective states – that is actions that reflect an underlying state such as itchiness or tiredness, and five clips of the actor depicting emotional actions – happy, angry etc (again see Table 1 for detailed descriptions). There were also a further five control stimuli of manipulated PLDs of everyday objects: a ball rotating, a pair of kitchen balance scales moving as a weight was added, an ironing board being opened and closed, a dustpan and brush sweeping and a saw in action. In each case ten reflective point-lights were distributed across the object in a manner that meant the object was not recognizable from a still image.

Insert Table 1 about here

Procedure

Participants were individually tested, in a quiet room at the National Centre for Scientific Research. They were seated in front of a computer screen at a viewing distance of 60 cm. Participants were told that they were going to be presented with short movies and that they were going to be asked to describe orally what they had seen. Verbal responses were noted by the experimenter. Responses were scored as correct when participants accurately captured the object, the action, the state or the emotion portrayed by the PLDs. It is important to note that responses were also considered as correct when participants provided a synonymous word that indicated the object, the action, the state or the emotion captured by the PLDs. Each subject underwent a total of 25 trials: 10 in action condition (Act), 5 in the subjective states condition (Subj), 5 in the emotional states condition (Em), and 5 in the object condition (Obj). The order of trials presentation was randomized across subjects.

Results

Accuracy rates[1] obtained by the two groups in the four conditions were analyzed using a two-way ANOVA with Group (ASD vs. Control) as the between-subjects factor and Condition (actions v subjective states v emotions v objects) as the within-subjects factor. Both the main effect of Group ($F(1,44) = 14.3$, $p < .001$) and Condition were found to be significant ($F(3,132) = 46.4$, $p <. 001$).

Most importantly, the Group by Condition interaction was also significant ($F(3,132) = 6.5$, $p <. 001$), (see Figure 1). To further explore the source of the interaction effect, post-hoc analyses were conducted using Tukey HSD tests. Results of these analyses revealed that performance of ASD children differed from that of the TD children group in the emotion condition ($p < .001$) but not in the other three conditions (all *p*s > .05). In addition, results of Tukey HSD tests showed that typically developing children were more accurate on the emotion than on the object condition ($p < .001$). By contrast, no such difference between emotion and object recognition was found for ASD children ($p > .05$).

Insert Figure 1 about here

In order to assess the possible effect of IQ on performance of the ASD group, analyses of covariance (ANCOVA) were conducted on accuracy rates using condition (action, subjective state, emotion and object) as a within-subjects factor and with IQ as a covariate.

These analyses revealed that the IQ did not modulate differences found across conditions ($F(1,87) = 3.01$, $p > .05$).

Additional analyses of regression were also conducted to further track results. In particular, these analyses aimed at determining whether the ability to perceive the emotional meaning of PLDs might change with age. To this aim, we pooled together data from 46 children (current study) and 38 adults with ASD (Hubert et al., 2007; see footnote 2 for a detailed description of adult participants). Note that data from adults with ASD were collected using the same experimental paradigm as that used in the present study. Analyses of regression were thus conducted on 84 individuals with ASD. The basic regression model used in this analysis comprised a group contrast (control = -1, ASD = +1) and chronological age (months). Analyses on performance in the emotion condition yielded an overall effect for the basic model, $F(2,81) = 19.78$, $p < .0001$ ($R^2 = .32$). The group contrast was a significant negative predictor of emotion recognition, $F(1,81) = -5.99$, $p < .001$ ($\beta = -.54$), suggesting that the ASD group was less accurate than the comparison group in the emotion condition. In contrast, chronological age was not a significant predictor of emotion recognition, ($\beta = .15$), indicating that the performance in emotion condition was unrelated to age. Interestingly, multiple regression analyses on the other three conditions showed a significant age effect on actions ($F(1,81) = 2.69$, $p < .01$ ($\beta = .27$), subjective states ($F(1,81) = 3.07$, $p < .01$ ($\beta = .30$), and object conditions (($F(1,81) = 4.52$, $p < .001$ ($\beta = .45$).

Note that the factor gender was not included because preliminary analyses showed no significant effect on performance.

Discussion

This study compared the perception of emotional and non-emotional biological motion in children with autism and typically developing children. Several important conclusions can be drawn from this experiment.

The main finding of the current study is that children with ASD do have the ability to extract meanings from PLDs. Yet, this ability was found to be dependent of the nature of stimuli displayed. In fact, children with ASD were impaired in interpreting PLDs depicting emotions, but performed as accurately as typically developing children when point-light movies depicted simple personal actions, subjective states or objects. These results clearly indicate that children with autism understood the task demands and were able to correctly label PLDs. The interpretation of point-light biological motion displays undoubtedly requires the ability to integrate information to extract the form of the animate figure (e.g., Johansson, 1973). In that respect, our findings are at odds with Blake's results showing that children with autism were impaired in discriminating between point-light displays. However, our findings are consistent with both Moore et al. (1997)'s and Hubert et al. (2007)'s results, which showed selective impairments on the identification of the meaning of PLDs depicting emotions.

Findings of the present study take us further in our understanding of how ASD children without mental retardation recognize biological motion. Interestingly, IQ (in this range) was not found to influence ASD children's overall ability to perceive PLDs. In particular, the low accuracy rates on the emotion condition were unrelated to ASD children's IQ, suggesting that deficits in emotion interpretation in autism are independent of the overall level of functioning, at least with ASD children in the normal IQ range. The relationship between emotional discrimination and mental retardation has been widely questioned. Although some studies have demonstrated that participants with mental retardation do not perform as well on emotion recognition tasks as comparison participants do (e.g., McAlpine et al., 1991; Rojahn et al., 1995), the nature of these deficits is unclear (see Moore (2001) and Santos et al. (in press) for a review on this topic). Results of the present study support the idea that basic emotion-perception capacities are unrelated to IQ. In this case, one may hypothesize that difficulties in decoding emotional meaning in autism are due to a specific deficit in emotional processing rather than the result of lower intellectual functioning.

The second main finding of this paper concerns the absence of a developmental trend in emotional processing in autism. The study demonstrated that while the performance of children and adults with ASD on object, action and subjective state conditions increased with age, the children with ASD exhibited difficulties with labelling emotional PLDs, and that these difficulties were similar to those found in adults with ASD (Hubert et al., 2007). This suggests that difficulties in processing emotional information are a constant throughout the development of individuals with ASD. These results appear is in line with previous studies showing emotional deficits in both ASD adults (e.g., Hefter et al., 2005) and children (e.g., Robel et al., 2004). However, the results appears at odds with previous reports demonstrating a developmental trend in several cognitive competences that are supposed to be directly involved in emotion processing, in particular configural processing. For instance, visual configural processing abilities have been shown to increase with age in ASD individuals with meaningless stimuli, such as Gabor patches, (Del Viva et al., 2006) or geometrical stimuli (see Rondan & Deruelle, 2005), and with meaningful facial stimuli (i.e. Rondan & Deruelle, 2004). However, none of these previous studies which have investigated competencies in configural processing that are proposed to underpin emotional competence have actually used emotional materials. Indeed, our results suggest that while improvements with age may apply to the processing of meaningful objects and human actions, they may not apply to emotional stimuli.

Taken together, current findings are in line with previous studies highlighting specific emotional face-processing deficits in the autistic population (e.g., Celani et al., 1999; Hobson et al., 1988). This conclusion is strengthened by the finding that whereas typically developing children recognize emotional states better than moving objects, no such difference between emotion and object recognition was found for children with ASD. In others words, emotions seem to have no special status relative to objects for children with autism. This lack of difference between emotional stimuli and objects is reminiscent of several previous reports on ASD pathology. In Hubert et al. (in press), electrodermal activity was significantly increased for emotional faces compared to objects in typically developing adults but not in adults with autism. In another study, brain event-related potentials (ERPs) were recorded in children with and without ASD who were presented with photos of the face of the child's mother versus an unfamiliar female face and photos of a favorite versus an unfamiliar toy (Dawson et al., 2002). Data clearly showed that ERP amplitudes were different between familiar and unfamiliar faces and between familiar and unfamiliar objects in typically developing children. Children with ASD failed to show any differences in ERPs to a familiar versus an unfamiliar face, but they did show amplitude differences to a familiar versus an unfamiliar object. Furthermore, neuroimaging studies have shown that during face recognition tasks individuals with autism activate areas that are thought to underlie object recognition when activated in typically developing individuals (e.g., Schultz et al., 2000). Together with our findings, this suggests that individuals with autism fail to attribute special status both to emotional faces and bodies.

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Authors’ notes

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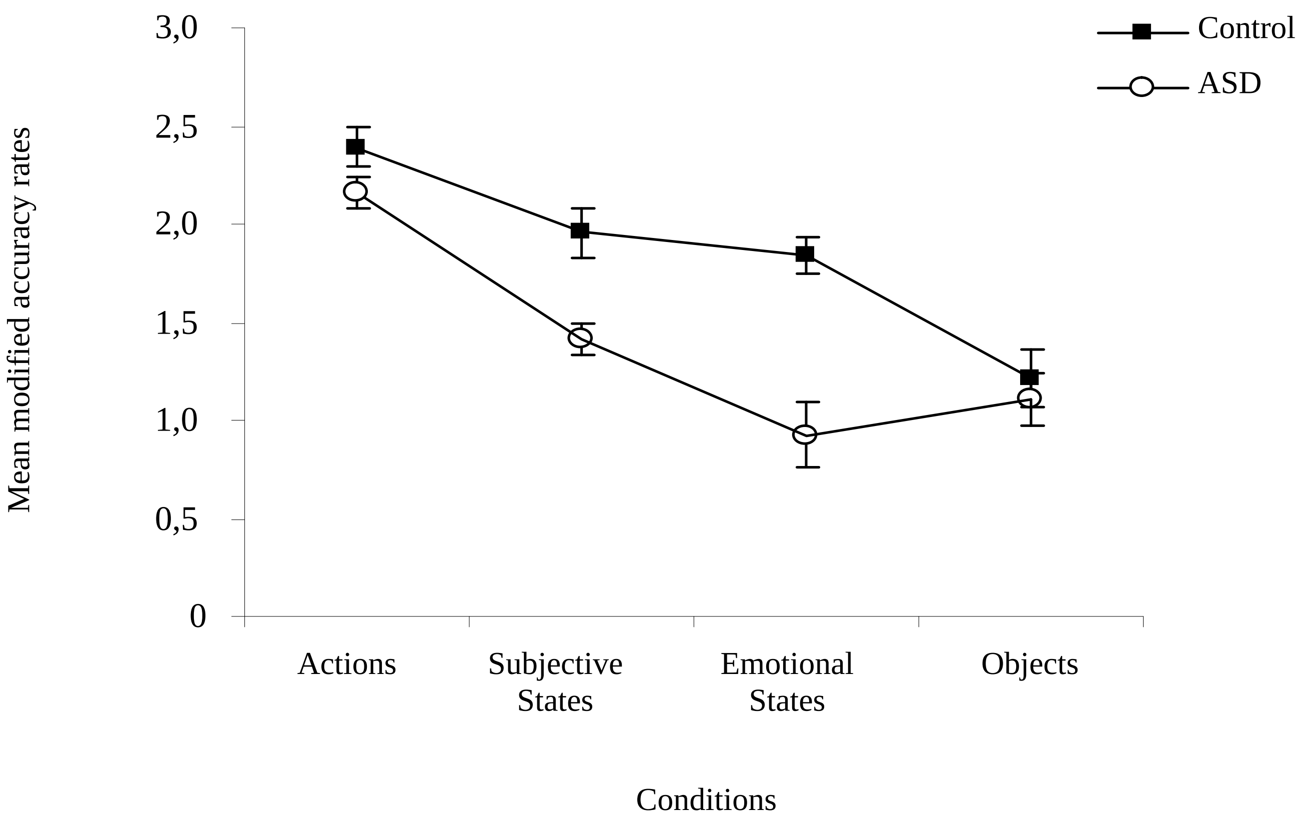
Control
ASD
Mean modified accuracy rates
3,0
2,5
2,0
1,5
1,0
0,5
0
Actions
Subjective States
Emotional States
Objects
Conditions

Figure 1

Figure captions

Figure 1: Illustration of the mean modified accuracy rates and corresponding standard errors in the four conditions of point-light displays (Actions, Subjective states, Emotions, Objects) for the ASD and the typically developing groups.

Footnotes

[1] In order to normalize the distribution of the percentage of correct answers, modified accuracy rates were calculated [2 x (ASIN (RACINE (%correct answers/100))] for each subject in each condition (action/expression/subjective state/object). Before normalization average percentage of correct responses were: Action = 82.7% (SD = 2.8) ; Emotion= 61.3% (SD = 4.7), Subjective states = 58.6% (SD = 4.2), Objects = 38% (SD = 4.5) for the ASD group and Action = 77.2% (SD = 2.9); Emotion = 34.4% (SD = 4.9), Subjective states = 45.1% (SD = 4.4) , Objects = 34.8% (SD = 4.8) for the comparison group.

[2] Nineteen high-functioning adolescents and adults with autism or with Asperger syndrome (M age = 21 years 6 months, SD = 6 years 1 month; 17 men and 2 women) were included in Hubert et al. (in press a)'s study. They were all diagnosed according to the DSM-IV (A.P.A., 1994) and the ADI-R (Lord et al., 1994) criteria for autism. The ASSQ scale (Ehlers et al., 1999) defined 15 participants with Asperger syndrome and 4 as high-functioning autistic individuals. IQ scores were measured with the WAIS-R (Wechsler, 1981) and ranged from 60 to 112 (M = 83.3; SD = 15.9). None of them had known associated mental or physical disorders at the time of testing and visual examination was found to be normal.

Table 1: Description of the actions, subjective states, emotional states as depicted.

	Actions		Subjective states and emotions
lifting	The person walks forward, bends down and lifts a (non-visible) box, standing up in the process. The person then leans over and puts the box down, and stands up again.	itchy	The person scratches his body and legs vigorously.
clapping	The person stands facing the front and claps his hands together several times.	bored	The person stands with arms crossed, and fidgets.
hopping	The person faces the front and hops on his left leg. After 2 seconds he hops on his right leg.	tired	The person stretches his arms sideways and above his head.
kicking	The person walks forward and pretends to kick a football off the ground with his right foot.	cold	The person shivers, rubs himself and wraps his arms around his body
jumping	The person jumps up and down on both legs, swinging his arms by his side.	hurt	The person limps along and then rubs his foot. He tries to step on it, flinches and limps again.
pushing	The person bends down and pushes a (non-visible) chair across the screen from left to right.	surprised	Person walks forward then suddenly checks his stride and throws out arms to the side, this is followed by a sigh of relief.
digging	The person picks up a (non- visible) spade and digs in front of him , pushing the spade into the ground with his foot. Using the spade he throws the (non-visible) soil to the right of the screen. (This is repeated twice)	sad	Person walks forward slowly and then slows and sighs. Person then sits down on chair, lifts hands slowly and puts head in hands.
sitting	The person walks forward and positions himself beside a (non-visible) chair on which he sits down.	frightened	Person steps forward then stops and backs away slowly with arms held apart from body at sides. Occasionally the person steps/jumps back quickly and with a start.
climbing	The person climbs up a stack of (non-visible) boxes from the bottom right to the top left of the screen.	angry	The person walks forward and punches downwards with sudden movements. The person turns left and right in an irritated and frustrated manner and stamps down a foot at the same time as punching downwards.
running	The person runs on the spot, at one point running with lifted knees.	happy	The person jumps and skips around swinging his arms, as if dancing.