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### **Acknowledgements**

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### **Abstract**

While there is increasing interest in the impact of animal interactions upon children's wellbeing and attitudes, there has been less attention paid to the specific characteristics of the animals which attract and engage children. We used a within-subjects design to explore how differences in animal features (such as their animacy, size, and texture) impacted upon pre-school children's social and emotional responses. This study examined pre-schoolers' interactions with two animal-like robots (Teksta and Scoozie), two insect types (stick insects and hissing cockroaches) and a dog (Teasel, a West Highland Terrier). Nineteen preschool participants aged 35-57 months were videoed while interacting with the experimenter, a peer and each stimulus (presented individually). We used both verbal and nonverbal behaviours to evaluate interactions and emotional responses to the stimuli and found that these two measures could be incongruent, highlighting the need for systematic approaches to evaluating children's interactions with animals. We categorised the content of children's dialogues in relation to psychological and biological attributes of each stimulus and their distinctions between living and non-living stimuli; the majority of comments were biological, with psychological terms largely reserved for the dog and mammal-like robot only. Comments relating to living qualities revealed ambiguity towards attributes that denote differences between living and non-living creatures. We used a range of nonverbal measures, including willingness to approach and touch stimuli, rates of self-touching, facial expressions of emotion, and touch to others. Insects (hissing cockroaches and stick insects) received the most negative verbal and nonverbal responses. The mammal-like robot (rounded, fluffy body shape, large eyes, and sympathetic sounds) was viewed much more positively than its metallic counterpart, as was the real dog. We propose that these interactions provide information on how children perceive animals and a platform for the examination of human socio-emotional and cognitive development more generally. The children engaged in social referencing to the adult experimenter rather than familiar peers when uncertain about the stimuli presented, suggesting that caregivers have a primary role in shaping children's responses to animals.

**Keywords: Children, Dogs, Insects, Robots, Interaction, Emotion**

## Introduction

Animals play a large role in children's lives from an early age (Serpell 1999). They feature frequently as toys, in books and games, and many children have pets. Some children play an economic role in caring for working animals (Punch 2004). As humans tend to anthropomorphise by placing human characteristics on non-human entities; albeit often on a perceptual level (Mitchell, Thompson and Miles 1997), animals are considered as helpful to children's development of self-identity (Myers and Saunders 2002) and in distinguishing between self and 'other' (Hindley 1999). Myers (2007) contended that animals offer an extension to the child's experience of self, goal-setting, and desires. Such awareness, arising from feelings of affinity, may facilitate the development of empathy and prosocial behaviour (Covert et al. 1985, cited by McNicholas and Collis 2001). For example, the presence of a dog was found to have a positive impact upon levels of attention and social behaviours in the classroom (Kotrschal and Oberbauer 2003). Nevertheless, we have limited understanding of which specific features impact upon children's engagement (Myers 2007), or how the children's individual characteristics impact upon engagement (e.g. Wedl and Kotrschal 2009) and even less about how these factors combine during the interactions or their potential longer term impact on attitudes.

Early experiences impact upon attitudes to animals throughout life (Muris et al. 2008), but we know little about how attitudes are formed and whether they are amenable to change, e.g. when promoting conservation or welfare issues in adults (Ollendick, King and Muris 2002; Knight 2008). Human-animal interaction does not occur in isolation. Interactions are embedded within a wider social and cultural context. Some experiences facilitate responsible, caring, empathic attitudes, whilst others have the propensity to induce chronic phobias, resistant to extinction. Children's early attitudes to animals may emanate from parental or peer modelling (Paul and Serpell 1993) or due to an evolutionary survival mechanism that is compounded by negative experience (e.g. Heerwagen and Orians 2002). By examining children's interactions with real and robot animals, in the presence of peers and an adult, we can examine what features elicit which socio-emotional responses and better understand how attitudes to animals are established in childhood.

We know that in early childhood infants begin to distinguish between living and non-living things, and to develop appreciation of behavioural cause and effect (Quinn and Eimas 1996; Kamewari et al. 2005; Myers 2007). Specific attributes such as the creature's appearance, especially facial features and behaviour patterns (e.g. movement and sound) and their affective state, become reference points for establishing whether approach or engagement is safe. Myers (2007) suggests that contingency between child and animal, the animal's body, and its patterns of arousal all had an effect on interaction; children had expectations of a particular animal's appearance (coherence), how it would interact with them (contingency), and that they

could predict most of the interaction (continuity) between them. Violation of any of these expectations engendered confusion, re-evaluation of the stimulus, and a shift in interactive behaviours.

Thus, if by 3 years of age, children can discriminate characteristics of living and non-living things, with understanding of biological properties developing further between the ages of 4 and 10 (Chouinard 2007), how would the children view the robots, and might this impact on their understanding of live creatures? Studies in the field of human-robot interaction suggest that robots form a categorical anomaly. Technological exemplars, such as robotic animals, may ambiguate traditional ontological categories, leading to children's ambivalent interactions towards them as semi-living/non-living objects (e.g. Kahn et al. 2006; Melson et al. 2009). Nigam and Klahr (2000) concluded that children can deny robots biological properties, yet still give them psychological attributes, such as thinking, feeling and having free will. This has been supported by Ayuko, Kurata and Takeshi (2007) who examined whether children have created a new classification for robots that exists between living and non-living categories; half of the children (aged 5-6 years) said the robot dogs were alive and over 90% gave them mental attributes. Even in older children (7-15) around 60% were willing to attribute mental states to an animal robot (Melson et al 2009).

Our sample group was also able to verbalise their emotions and knowledge about other species. Rather than ask children their preferences for stimuli following brief interactions (e.g. Ribí et al 2008) or explicitly asking them to classify stimuli (Ayuko, Kurata and Takeshi, 2007), we transcribed and analysed free verbal utterances throughout these encounters in order to better ascertain their behavioural responses and their understanding of the stimuli characteristics. Previous studies (Nielson and Delude 1989) have examined both the verbal and nonverbal responses of children and suggested that these are sometimes incongruent, but only the total amounts of 'talking too' and 'talking about' were used as measures. We analysed verbal content more fully and also examined whether the verbal exchanges led to changes in affect and engagement during the interaction. Accordingly we were able to analyse more fully circumstances where verbal and non-verbal behaviours did not match (Nielson and Delude 1989, Ribí, Yokoyama and Turner 2008).

Children's interactions with both animals and robots are sensitive to differences in both behavioural and physical characteristics. Without a more systematic understanding of how children respond to different species' attributes it is difficult to interpret their responses to robot stimuli within a wider developmental context. Previous research indicates that specific behavioural characteristics can impact upon encounters; anecdotal evidence suggests children become more fearful and avoidant if animals face them, perhaps an affective response to facial features (e.g. Zajonc 1980, Myers 2007). Even in adulthood, student participants were found to conceptualize animals like snakes, bats and spiders quite differently from mammals and birds: concepts that appear to be based on both physical appearance and cultural myths (Knight 2008).

Nielsen and Delude (1989) studied the responses of kindergarden children to different animals (a tarantula, cockatiel, two breeds of both rabbit and dog) and to stuffed animals. The children produced unique response patterns to these different animals and their behaviour also differentiated between real and toy animals. The toy animals attracted little interest, suggesting the importance of animacy (Myers 2007). Approaching and talking about were positively correlated (cockatiel and dog) while spiders were often talked about but seldom approached. The two mammalian species resulted in the highest amounts of physical contact between the children and animals but the children talked to the cockatiel the most. Given the role of animals in facilitating social interactions and improving behaviour in educational contexts and therapeutic settings, it is important to understand better whether the presence of different types of animals may lead to different outcomes.

The current study investigated how the preschoolers approached different animal stimuli, specifically two different robot animals (Teksta, a robotic metallic dog and Scoozie, a squirrel-like robot), two insect species (stick insects and hissing cockroaches) and a small dog (Teasel, a West Highland Terrier). While previous studies directly compared interactions with robots and animals, the evaluation of those interactions has been limited, for example, to simple measures of physical proximity or touch frequency (Melson 2003; Ribi, Yokoyama and Turner 2008). Such measures neglect affective responses, and how behaviour relates to dominant cultural themes such as care, trust, and social constructs of biologically-based responses, such as disgust and fear of contamination. To further examine the impact of animacy and mammalian-like characteristics upon interactions, we presented a fluffy and a metallic robot rather than stuffed toy animals (Nielsen and Delude 1989).

Although we did not evaluate the characteristics of the children (e.g. Wedl and Kotschal 2009) we used a repeated-measures design so that we could compare children across interactions with each stimulus allowing us to identify patterns of verbal and nonverbal responses to the different types of stimuli. We used several distinct behavioral measures to stimuli: willingness to approach and avoidance were assessed using proximity and posture (leaning towards or away); willingness to engage - in terms of frequency and durations of stimulus touch; facial expressions of emotion during interactions (disgust, fear, and smiling); and touches to self and other as a measure of arousal or comfort seeking (e.g. D'Alessio and Zazzetta 1989). We expected to find clear differences in responses to the different stimuli presented (Nielsen and Delude 1989; Myers 2007). It was also hypothesised that length of stimulus touch, would relate to approach and avoidance of stimuli (prolonged touch for positive stimuli and only brief touches for less appealing stimuli).

We also noted any instances of social referencing (SR) as this is one possible mechanism for learning about animals. SR measures change within an interaction by noting whether information is sought from others when an ambiguous object or context is encountered (e.g. Feinman 1982). By attending to the facial and

vocal responses of others, an individual can interpret the emotional valence of a situation and alter their own behaviour accordingly. SR is defined as a distinct pattern of gaze (cf. Table 2) between the object and referent which leads to behavioural outcomes congruent with the referent's emotional status. Most SR studies have focused on infancy (10-12 months, Walden and Ogan 1988) and on infant-mother interactions in highly-controlled experimental paradigms (Feinman 1982). However, SR is likely to occur throughout the lifespan, whenever individuals need to gather information or seek reassurance about uncertain situations. In terms of children's interactions with animals, insects or robots, SR could be a mechanism for learning during interactions and also an indicator of emotional valence (cf. Hornik and Gunnar 1988). Both robots and animals have been included in previous SR studies to create ambiguous contexts, without focusing on the nature of the interactions with either stimulus specifically (for example, Walden and Ogan's (1988) unfamiliar mechanical toys: a walking Santa Claus and a wheel-based robot, both playing music intermittently; or Hornik and Gunnar's (1988) rabbit). We were interested in when, why and to whom SR might occur (familiar peer or unfamiliar adult) and how it may relate to other aspects of these interactions such as nonverbal responses to different stimuli. It was hypothesised that certain stimuli would produce higher patterns of social referencing than others, specifically those perceived as being least predictable (e.g. the dog) and those with more negative connotations (i.e. the insects). We were less sure of the directionality of these references, in terms of whether attention would be directed to the adult or to peer.

Verbal content of interactions was transcribed and analysed for emotional content and references to stimuli characteristics, such as biological or psychological states. The children's understanding of features such as agency, contingency, biological and psychological was examined using questions and statements *they* uttered. Biological attributions were expected to be more frequent than psychological ones (Jipson and Gelman 2007; Chouinard 2007) although it was also anticipated that the robots would have a specific effect on the types of expression children used, imbuing them with living yet non-biological qualities (Nigam and Klahr 2000; Ayuko, Kurata and Takeshi 2007). By including both verbal and non-verbal aspects of interactions, we aimed to find markers of socio-emotional and cognitive processes and examine their relationship in terms of differentiating between stimulus types and hence as tools for evaluating interactions.

## **Methods**

### *Participants*

We recruited 20 children aged 35-57 months ( $N = 20$ ; 14 male and 6 female) from the University of Stirling's playgroup. Advice against participation was given to children with known phobias, allergies, or an anxious disposition. Two children (one male, one female) participated in 2 of the 3 conditions and 1 male only participated in one session (so his data were excluded from analyses). The children were allocated to peer pairs by nursery staff, according to their availability (not currently engaged in other structured activities),

and subsequently randomly assigned to one of three counterbalanced conditions with presentation order of stimuli differing between groups. Gender composition of the pairings consisted of four male-male, four male-female and one female-female dyads. The median difference in age between the partners was 8 months (a mean of 8.77). British Psychological Society ethical guidelines (BPS 2008) and internal Psychology Departmental Ethics Committee protocols were followed to ensure child participant wellbeing was protected.

### *Materials*

Observations of participants occurred in a room adjoining the playgroup with a Sony Handycam digital camera positioned in one corner to record interactions and allow for subsequent coding and transcription of dialogue. The stimuli were: two robot animal toys and live stimuli borrowed from two separate sources, insects from a local visitor attraction and a well-trained dog from an acquaintance. See Table 1 for details of the stimuli presented.

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### ***Table 1 here***

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The Association for the Study of Animal Behaviour guidelines (ASAB, 2006) and direct advice from live stimuli suppliers were followed for their care. Insects were given an appropriate environment, temperature, nourishment and space, taking care to avoid dehydration. The dog was selected as she is an experienced show dog and accustomed to travelling, novel environments and unfamiliar people; she did not exhibit any signs of anxiety during interactions. She had her travelling cage and familiar bedding, fresh water was freely available, and rest breaks were given frequently to minimise possible stress, including short walks around the campus.

### *Procedure*

The experimenter took the children to the test-room, and asked them to sit in the corner opposite the camera. Interactions took place on the floor and camera angle was checked regularly to ensure the children were within view. Participant pairs were given a minute to settle in to familiarise themselves with the researcher. She explained the procedures: that they would be introduced to different 'animals' and allowed to interact with them if they wished. They were reminded that they could end the session at any time and return to the playgroup. Whilst there were five stimuli, the robots were presented one after the other in one encounter, and this also occurred during the presentation of the insects. To prevent distraction, the second robot/insect was kept out of view on a table top and in a box. On producing a stimulus for the first time, the researcher again allowed time for participants to consider it within its container (box, tank, or cage) before accessing it directly. There was *no specific timescale* allocated to the encounters, so that the participants did not feel pressured to begin or terminate interactions sooner than they wished. Stimuli were presented individually; in the robot and insect conditions this meant that each of the two stimuli was pseudo-randomly

presented in turn. To provide a more relaxed environment for interactions, the researcher engaged with participants to facilitate interaction and dialogue; but having no *set* script enabled the children to *lead and develop* the encounter. Some children chose to touch the stimuli; others declined physical contact but talked about them instead.

An ethogram was devised to code the non-verbal behaviours of interest (see Table 2). To record longer duration state behaviours (posture and facial expressions) we used point sampling at 15 second intervals to give proportions of time in each behavioural state. General posture was used to measure approach (< 90° towards the stimulus) and avoidance levels (>90° away from stimuli). Positive facial expressions of smiling (and laughter) and negative facial expressions of frowning and disgust were also recorded. For shorter duration behavioural events (touch, social referencing) we recorded all occurrences to obtain frequency counts (Bakeman and Gottman 1997; Martin and Bateson 2007).

All occurrences of touch were categorised according to duration; briefer touches (< 3s) and longer (> 3s) to determine uncertain from more positive contact, respectively. We recorded point samples and frequencies for a duration of 5 minutes (even though the encounters could be shorter or longer than this) from the start of the interaction, giving a total of 20 point samples for each child within an interaction, when participants disappeared from camera view, this was also recorded. Inter-observer reliability was carried out on a sample of data (6% of total observations for each of posture, touch, and facial expressions; and 25% of instances for social referencing) and agreement was over 75% for all behaviours analysed. To avoid pseudo-replication of data, proportions and frequencies were calculated for each child and these individual values were used in all analyses after being corrected for duration of each encounter (if less than the 5 minute maximum). Paired comparisons were judged to be significant if  $p \leq 0.05$ .

**TABLE 2: nonverbal data coded for analysis**

<b>Nonverbal</b>		<b>Definition</b>	<b>Interpretation</b>
<i>Stimuli touches</i>	<i>Brief</i>	Touch <3secs	Some anxiety shown but threat assumed to be minimal
	<i>Long</i>	Touch >3secs	No real perceived threat, desire to show affection, affinity.
<i>Self touches</i>	<i>Positive</i>	Relaxed, natural touches	Normal patterns of behaviour observed in a particular individual
	<i>Negative</i>	Pulling, picking, scratching at clothes, skin, hair	Signs of discomfort, distress, anxiety.
<i>Touch other</i>		Making contact with adult, peer, or own toy	Reassurance-seeking, calming effect
<i>Posture</i>	<i>Approach</i>	Adopting position <90°	Desire to interact with stimuli, lack of threat, show of interest
	<i>Withdrawal</i>	Adopting position >90°	Possible anxiety, reaction to threat, rejecting interaction
	<i>Neutral</i>	Adopting position = 90°	Relaxed, not necessarily engaged
<i>Social referencing</i>	<i>Adult</i>	Gathers affective and instrumental information from another person adding to own affect and cognitions to evaluate an ambiguous circumstance	Looks at, or listens to adult or peer prior to observing ambiguous stimulus, then re-references to the adult/peer again, reaching a cumulative evaluation.
	<i>Peer</i>		
<i>Affect</i>	<i>Positive</i>	Smiling	Relaxed, calm, unconcerned
	<i>Negative</i>	Frowning, disgust, shrugging shoulders, shivering, showing fear/uncertainty	Anxious, stressed, uncomfortable
	<i>Neutral</i>	Passive, no emotional valence in facial expressions, body language unstated	Neither engaged nor distressed

## Results

### Approach/ Withdrawal

We categorised posture relative to the stimuli: positive/approach <90°, neutral = 90° and negative/withdrawal >90° and compared the proportion of time spent in positive and negative postures across the stimuli. Robot Scoozie had the highest ratio between positive and negative postures, with a value of 3.21:1. Robot Teksta, 1.96:1, and dog Teasel, 1.59:1 respectively while the insects were more evenly-divided between positive and negative, with the stick insects (SI) = 1.16:1, and the hissing cockroaches (HC) = 1.21:1 respectively.

The range of time spent in encounters with each of the stimuli was as follows (Scoozie: 3.45 – 6.30 mins; Teksta: 2.30 – 9.45 mins; SI: 2.15 – 13.57 mins; HC: 1.30 – 6.35 mins; and Teasel: 5.30 – 15.25 mins). The proportion of an encounter spent in a positive posture (leaning towards the stimuli) did not differentiate between the stimuli ( $F(2.41, 31.38) = 1.32, p = 0.28, \eta^2 = 0.09$ ). However, comparing negative postures did indicate significant differences according to stimuli:  $F(4, 52) = 6.90, p < 0.001, \eta^2 = 0.35$ , where Scoozie, mean = 2.44 ( $SD = 2.00$ ); Teksta, mean = 3.53 ( $SD = 4.98$ ); SI mean = 7.64 ( $SD = 4.02$ ); HC mean = 5.83 ( $SD = 3.37$ ); and Teasel, mean = 3.08 ( $SD = 2.26$ ). Within-subject contrasts showed that the number of negative postures reached significance between Teksta and SI ( $p \leq 0.001$ ) and Teasel and HC ( $p = 0.016$ )

### Facial expressions

The proportion of time spent displaying positive and negative affect was coded as neutral (expressionless face), positive (smiling or laughing) and negative (frowning or disgust) by point sampling at 15 second intervals. Across all stimuli, the mean for neutral affect = 7.80; for positive affect = 7.42, and for negative affect = 3.85. A repeated-measures ANOVA showed a significant effect of stimulus type upon the display of negative expressions ( $F(4, 44) = 5.96, p = 0.001, \eta^2 = 0.34$ ). Paired comparisons revealed that the insects both elicited more negative expressions (SI mean = 6.2, HC = 7.2) than all the other stimuli presented, which did not differ from one another (Teksta = 2.8, Scoozie 1.3, dog = 1.9). For positive expressions, there were also significant differences between stimuli ( $F(4, 44) = 5.96, p = 0.001, \eta^2 = 0.33$ ), paired comparisons revealed that Scoozie (mean = 10.71) provoked significantly more positive affect than all other stimuli except for the dog. Mean proportions were as follows: Scoozie, mean = 10.32; Teksta, mean = 6.49; SI, mean = 5.64 ( $SD = 3.14$ ); HC, mean = 4.5 and the dog, Teasel, mean = 8. These data suggest that mammalian-type creatures were viewed the most favorably, with Scoozie and Teasel receiving the most positive and least negative affect.

### Contacting stimuli

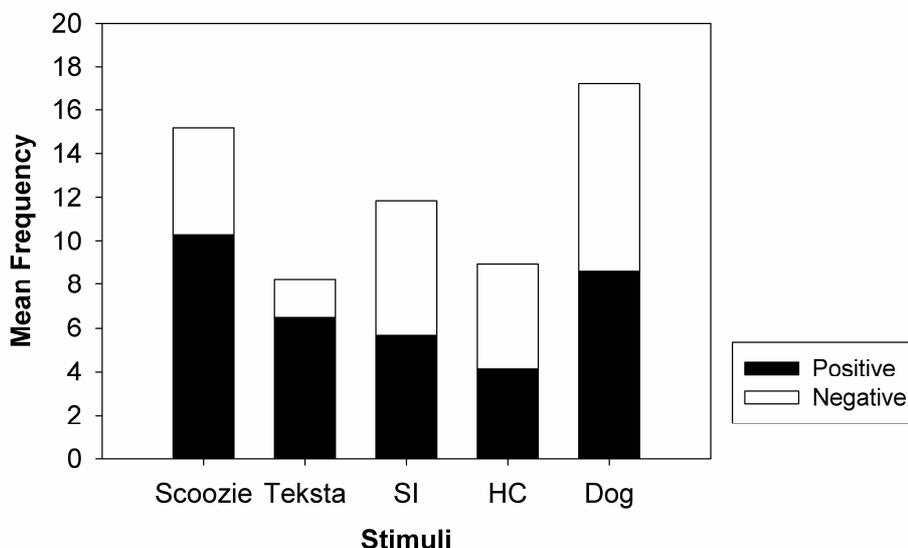
A repeated measures ANOVA indicated that the mean frequency of both brief and long touches to the stimuli were significantly different across stimuli: brief touches,  $F(2.56, 33.24) = 7.06, p = 0.001, \eta^2 = 0.35$ ; long touches  $F(1.57, 20.45) = 5.7, p = 0.02, \eta^2 = 0.31$ . The children's willingness to make physical contact clearly differed according to stimuli attributes. Both robots (Scoozie: mean long touch (mlt) = 4.44, mean short touch (mst) = 6.25; Teksta: mlt = 4.46, mst = 5.97) and Teasel: (mlt = 2.63, mst = 2.59) received the most touches overall. For brief touches, the insects received significantly fewer than the robots and the dog, which did not differ significantly from one another. Post-hoc comparisons for longer touches indicate that the robots received more than the dog and both robots and dogs received significantly more than the insects. The insects were touched significantly less than robots and dog, with no long touches to the HC (a brief touch induced the hissing sound from the insect, mean brief touch = 1.19); the SI received even less touch overall

(0.18 mean brief; 0.53 mean long). There was no significant difference between insects for either short touches or long touches.

### Self and other touch

The effect of individual stimuli on the frequency of touching others was examined; touching others during interactions was relatively uncommon (mean = 3.41). Most touches to other occurred during interactions with Teksta (mean = 6.53) with all others showing similarly low rates (combined mean = 2.63) and this difference approached significance,  $F(2.2, 26.4) = 3.12, p = 0.056, \eta^2 = .21$ . There was no significant difference in the rate of positive self touch across stimuli (Scoozie = 7.1, Teksta = 4.2, SI = 7.4, HC = 6.7, dog = 9.5;  $F(4, 44) = 1.87, p = 0.13, \eta^2 = 0.15$ ). However, there was a significant difference in negative self touch ( $F(4,44) = 4.38, p = 0.005, \eta^2 = 0.285$ ), with Scoozie, mean = 4.89; Teksta, mean = 1.96; SI, mean = 7.25; HC, mean = 4.78; and Teasel, mean = 4.47. Pairwise comparisons show that significant differences occurred between Teksta and Scoozie ( $p = 0.031$ ), Teksta and SI ( $p = 0.001$ ) and Teksta and HC ( $p = 0.001$ ). Figure 1 shows the amount of positive and negative self-touching per stimulus).

**FIGURE 1: Frequency of positive and negative self touch in response to the different stimuli**



### Social referencing<sup>1</sup>

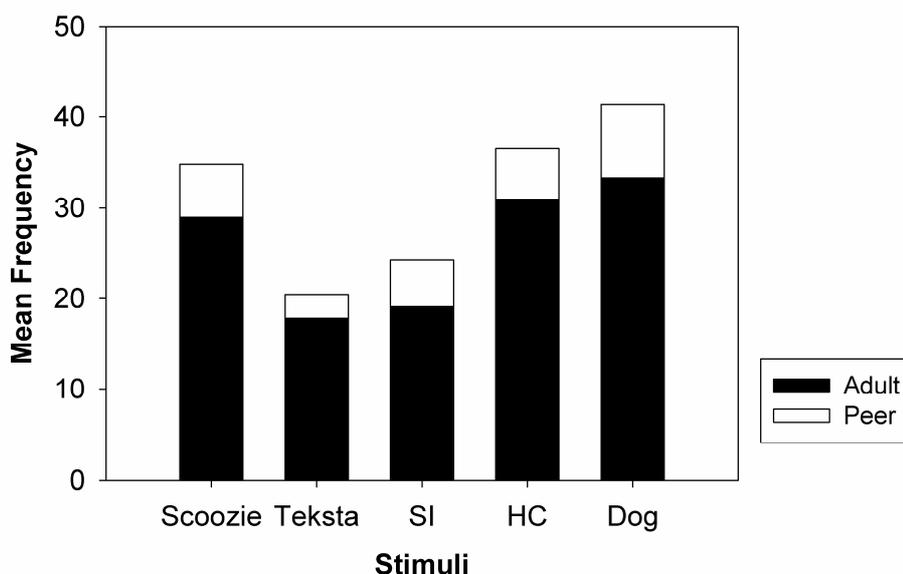
Whilst it was anticipated that social referencing would decrease as the children got older, there was no correlation between these measures (Spearman  $r_s = 0.273, N = 18, p = 0.27$ ; there were also no significant correlations with age for referencing to adults or to peers when analysed independently). All the children used social referencing at least once when presented with novel stimuli. A Wilcoxon-Signed Rank test was conducted on the SR to the adult ( $Mdn = 27.40$ ) and to peers ( $Mdn = 4.2$ ), and indicated that SR to the adult

<sup>1</sup> Analyses showed that sphericity was violated for SR to peers, and therefore Spearman and Wilcoxon scores are reported.

occurred more than SR to peers ( $T = 0, z = -3.72, p < 0.001, r = -0.88$ ). Thus, participants referenced to the unfamiliar adult rather than to familiar peers, suggesting it related to information seeking rather than reassurance in an ambiguous setting.

For social referencing to the adult, a repeated measures ANOVA indicated that there was a main effect of stimuli  $F(4, 48) = 9.21, p < 0.001, \eta^2 = 0.434$ . Mauchly's test was not significant. Paired comparisons showed that encounters with Teksta (mean = 17.85) and SI (mean = 19.1) were both associated with significantly lower levels of social referencing than the other stimuli, which did not differ significantly from each other (Scoozie = 28.96, HC = 30.98 and dog = 33.32). There was also a significant relationship between negative self touch and SR ( $r_s = 0.50, N = 18, p = 0.03$ ) but not between SR and touching other ( $r_s = 0.131, N = 18, p = 0.13$ ), suggesting that referencing was related to self-regulatory behaviour and uncertainty.

**FIGURE 2: Frequency of social referencing to adult and peers across the different stimuli**

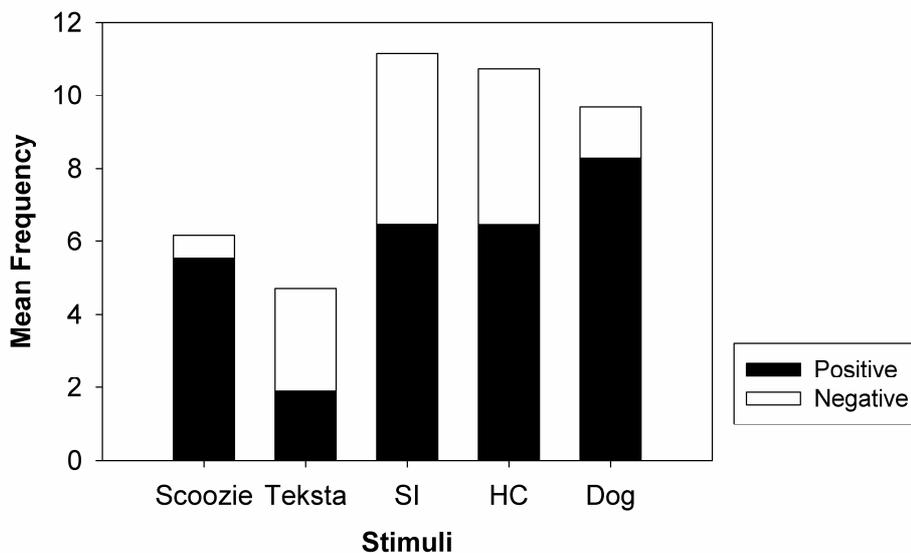


### Verbal

Verbal data were coded directly from participants' free utterances; these were not prompted by specific questions or a script. The children tended to focus on why stimuli acted in particular ways, whether they were feeling specific emotions, and whether they would sting/bite. Most positive verbal utterances were found to occur during encounters with the dog (mean = 8.28), followed by both types of insect (SI = 6.473, HC = 6.471), then the two robots (Scoozie = 5.54, Teksta = 1.89). Figure 3 shows these data. A repeated measures ANOVA revealed a significant main effect between stimulus type and number of positive utterances made:  $F(4, 48) = 5.21, p < 0.001, \eta^2 = 0.30$ , with paired comparisons showing that the only significant difference was that Teksta prompted fewer positive comments than any of the other stimuli. For negative comments, there was also a significant main effect of stimuli  $F(4.48, 5.03), p = 0.002, \eta^2 = 0.296$

with paired comparisons revealing that the both insects (SI = 4.67, HC = 4.26) received significantly more negative comments than Scoozie (0.64) and the dog (1.4), but none of these differed significantly from Teksta (mean = 2.81). Scoozie and Teasel prompted the most questions from the children; categorization questions referred to Teasel were subtle – concerning her breed, body parts, and her independent/dependent status, while living/nonliving distinctions were predominantly targeted at the robots and the insects.

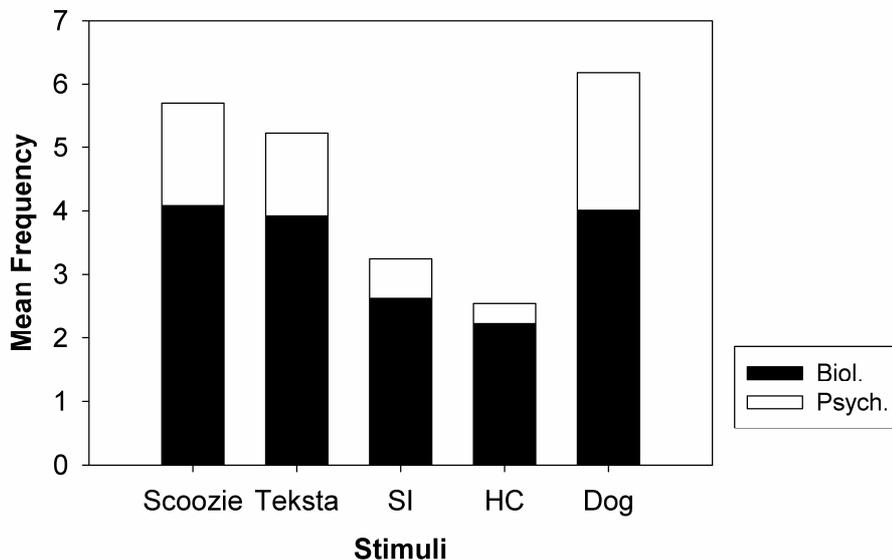
**Figure 3 – Comparison of verbal comments made during interactions with each of the stimuli**



There was a main effect of stimuli on the frequency of biological comments  $F(94, 48) = 2.67, p = 0.043, \eta^2 = 0.18$ , with paired comparisons indicating that Scoozie (4.08) received more comments than both types of insects (SI = 2.62, HC = 2.23) but did not differ from Teksta (3.92) or the dog (4.01), which both received more biological comments than the HC. The stimuli also elicited different utterances in relation to psychological states  $F(2.41, 28.88) = 4.157, p = 0.02, \eta^2 = 0.26$  with paired comparisons indicating that Scoozie (1.61), Teksta (1.31) and Teasel (2.17) received more psychological comments than either insect (SI = 0.62 HC = 0.31).

The insects elicited the fewest comments in relation to psychological and biological characteristics and Scoozie and the dog received the most, Teksta lying in-between; this lends some support to the claim that children perceive robots to have psychological qualities, although our sample gave them some biological qualities too (see Figure 4).

**FIGURE 4: Mean frequency of biological and psychological verbal statements made in response to the stimuli**



## Discussion

This study investigated social and emotional responses of preschool children during encounters with animal and robot stimuli. Using a variety of measures we found that touch patterns (to self, the stimuli, and to others), facial expression, posture and social referencing rates all differed according to stimuli attributes. We also found differences in the verbal content of those interactions, relating to positive and negative affect, and attribution of biological and psychological characteristics. A general pattern emerged with Teasel (the dog) and Scoozie (mammal-like robot) evoking most positive responses (touch, expressions, proximity), and the insects receiving most negative responses (negative self touch, negative facial expression). Teksta (metallic robot) fell in-between, notably receiving fewest positive comments of all the stimuli. This implies that specific characteristics, especially facial features such as the eyes and mouth, as well as predictable movement, rather than simple size or nature (robot or animal) of stimuli influenced responses. We suggest that fluffy mammalian stimuli elicited the most psychological comments and more positive interactions. There were few references to affect for the insects or to Teksta in comparison to Teasel and Scoozie. Importantly, measuring negative and positive comments highlighted subtle differences which cannot be captured with an overall measure of talking during interactions (Nielson and Delude 1989).

### Affect and touch

Different affective reactions to the two robots emerged due to specific features: Scoozie's tail moved minimally, whilst the greater speed of Teksta's drew much attention, both positive and negative; Scoozie's eyes blinked in a mammalian-fashion whilst Teksta's flashed red and blue. This led to high behaviours of

touching other in response to Teksta, but not social referencing, whilst the mammal-like Scoozie showed high levels of social referencing. We suggest that touching others may relate more to arousal/affect-sharing than to reassurance-seeking (see Feinman 1982). Affect-sharing occurs when a child merely wishes to share the emotion with their partner rather than seek reassurance or information from them. The insects evoked predictable patterns of initial reactions, possibly in part due to previous experience with insects in general: they seemed to provoke greater feelings of unease, negative comments and facial affect, resulting in very low levels of willingness to contact. Expressions of danger/disgust tended to be highest with insect stimuli, again often associated with movement or when stimuli faced the participants directly (Myers 2007). Nevertheless, some individuals were appeased by the experimenter's verbal reassurances regarding the insects than others. Teasel, the dog, was a calm interactant, and the children focused on her agency. This paradox between her independence, yet her need for protection from environmental elements such as traffic and getting lost had some resonance with comments made during encounters with 'Scoozie' (for example, its need for protection from Teksta if they had already been exposed to this other robot).

#### Social referencing and touch

The SR data indicate that participant uncertainty was not necessarily related directly to positive and negative emotional responses, as shown by the behavioural and verbal data. SR results for the robots imply that the specific characteristics of the robots impacted upon how the children perceived their behaviour beyond a simple living/robot division (Melson et al 2009). Teasel, the dog, provoked the highest amounts of SR and negative self touch, indicating some uncertainty during these encounters. Indeed most participants sought reassurance prior to touching her, possibly a reflection of cultural attitudes and also socialization patterns. With the robots, behaviours appeared to approximate those for Teasel rather than for the insects, implying that characteristics such as having facial features and movement help create a positive image.

Findings also showed that SR did not decrease with age and that an adult, regardless of familiarity, remained the prime source for information and reassurance-seeking. The type of stimulus had an effect on whether children touched them or not but the duration of touches (long or short) was not significant as a measure of the children's affect towards them. All these differences across stimuli indicate that social referencing may be a useful measure for assessing uncertainty in child-animal interactions.

#### Verbal highlights

Children's verbal categorizations and expectations of the stimuli undoubtedly affected their behaviour towards them; participants sought to place the stimuli within recognizable animal groups. Many believed Scoozie was a living entity: mammalian due to its furry appearance, facial configuration, and sounds, as evidenced by the verbal comments; frequent queries regarding its status (age, sex and species). Most treated it as infantile, and vulnerable, leading to relatively more references to Scoozie's affect; some cradled it,

claiming *it* feared Teksta – possibly projecting their own anxieties. In contrast, whilst many of the children spoke of Teksta as *real*, they were also clear about its robot credentials; metallic body, flashing eyes, lack of mouth, and mechanical movement. Consequently, there were few questions regarding its ‘affect’, and none regarding its typology; comments predominantly related to its movement, especially if approaching, suggesting an anxiety regarding control and intention. Thus, although the robots were essentially similar in terms of animacy and some limited contingent responses, clearly the appearance of these robots differentiated the children’s responses, especially in relation to affect, with Scoozie receiving more positive affect than Teksta.

For the insects, participants most often attempted to find associations with more familiar bugs, such as ladybirds, or snails; there was a strong theme of biting or stinging linked to them, and often a reluctance to accept that they might do neither. It was notable that children frequently repeated expressions of disgust when approaching the fear-relevant stimuli, especially the insects. This might suggest a combination of innate revulsion towards them and/or an expression of shared cultural beliefs about them. In a study by Muris et al (2008) a link between disgust-related information and increased fears of animals (deemed to be disgusting) was found. They primed 159 non-clinical children, aged 9-13, with information related to dirt or cleanliness, linked these to unknown animals, and measured the children’s reactions to them. They found that such priming not only enhanced children’s levels of disgust but also increased their fears of the creatures. In our study, whilst most of our participants approached the insects tentatively, some also expressed concern for them: for example, ‘don’t hurt him!’ Most wiped their hand or arm after touching, sometimes raising their T-shirts to create a barrier between them. Further study is needed to determine whether this reflects different affective responses or cultural attitudes to the acceptability of expressing negative affect. For example, fear was expressed differently: Compare: ‘You know what...I’m a little bit scared of dogs’ to the more direct: ‘Ugh! They’re disgusting!’ for the insects. It may be culturally more acceptable to express disgust towards insects but much less so for companion animals.

Alternatively, their reactions may be indicative of biologically-salient evolutionary threats. For example Heerwagen and Orians (2002) suggested that children develop ‘predator-detection and predator-avoidance mechanisms’ from the time they begin to crawl; adding that less than 3 years, fear responses are more targeted towards small creatures, (insects), whereas children more than 4 tend to show fear aversion to larger animals (dogs). This study sample was too small to support or reject Heerwagen and Orians (2002) contention; however, the overall distribution suggests insects create a negative affective response regardless of age; participants watched the movement of the stimuli, and several expressed anxiety if they either faced or approached them. Such findings also support Myers’ (2007) assertion that anxiety is raised under such conditions. Measuring anxiety traits and querying parents and children about their fears prior to testing, whilst including a robust measure of attention-capture during the test itself, might highlight aspects such as

susceptibility to phobias. Indeed, further study of how the children's individual personality characteristics shape interactions with animals is needed (Wedl and Kotschal 2009).

#### Living/non-living distinctions

Where participants were unsure of the living/non-living dimension of the stimulus, they either asked directly if it were real, or looked for supporting features. As suggested by Myers (2007), contingency plays an influential role in child-animal interactions, so it was clear that the children used this in their cognitive evaluations of the stimuli. They asked why the stimuli approached them, why they made certain noises, why they had certain affect. "Why's he face me?" (Teksta)/ "Will she woof?" (the dog)/ "What does he want?" (Scoozie)/ "He's big...will he bite?" (Hissing Cockroach).

The appearance of the robots led to a distinction in how they were approached. Teksta was often seen as nonliving (although noticeably more biological/psychological comments were made towards it than to the insects). Many questions ensued regarding categorization and living properties of Scoozie. This highlights the importance of facial qualities, as well as movement and bodily appearance to the definition of objects in our environment. For example, one child was confused by the robot dog/real dog distinction. On hearing that Teasel was a mother, he asked: 'but is her puppy a robot dog?' Other children asked if the insects were real or robots, (if their encounter with the robots had previously occurred). All these examples suggest a categorization system in transience; the children are constructing a fuller understanding through asking questions and engaging with the available resources (Melson et al 2009)

For all stimuli, it was apparent from the verbal content that the children experienced some cognitive conflicts during interactions, especially in relation to perceptions of animacy, living/non-living attributes, and contingency. This might explain the higher degree of SR towards the adult rather than the peer. As some participants altered, even temporarily, their initial responses to certain stimuli (for example, approaching to touch the insects or dog after initial fears), it also suggests that children weighed up additional information in order to refresh their cognitive positions towards certain experiences, rather than merely imitate others' attitudes or remain fixed in their initial affective response. That is, human-animal and human-robot interactions occur within a dynamic social context and it is important to reflect this when evaluating interactions. This is a crucial point when comparing the current study with some previous studies of interactions. For example, Ribí, Yokoyama and Turner (2008) had tightly controlled conditions and it is unclear whether investigators actively engaged with the participants. Despite the inherent difficulties with participant observation, it was an advantage within this study to enter into dialogue with the participants, allowing them to withdraw or approach freely as well as to choose their favoured distance from the stimuli in order to base the observations on as naturalistic and spontaneous interactions as possible (Myers 2007).

### Evaluation methods

Overall, the results from these different behavioural and verbal measures show that human animal/robot interactions are rich exchanges. It is important to consider the value of multiple measures in investigating children's interactions rather than rely on single indicators to assess interaction quality. For example, we found that verbal and nonverbal measures can produce rather different impressions of the interaction (especially when related to facial expressions and stimuli touch patterns). We suggest that the richness of interpretation is not possible by using some grosser measures of interaction such as proximity to animal or robot alone. Our method, taking point samples for behavioural states and recording all occurrences for behavioural events (Martin and Bateson 2007), rather than one-zero sampling for events used to examine interaction in previous studies (e.g. Ribi, Yokoyama and Turner 2008), also allowed a more detailed picture of the dynamics of interactions to emerge. By observing spontaneous contact with each stimulus for five minutes only, investigators were also able to avoid factors such as participant fatigue, anticipation, or over-familiarisation, which could change their behaviour with subsequent stimuli

Finally, as the current cohort's age range was 35 to 57 months, many children were on the cusp of cognitive and socio-emotional changes and it would be interesting to examine a wider age range. For example, Ayuko (2004), and Chouinard (2007) showed that children over 4 years' old appear to appreciate mental states more than their younger counterparts. A larger cohort could also enhance intimations of cognitive differences in the children's understanding of the attributes they assigned to different stimuli and further exploration of factors such as attachment style and temperamental differences would be an exciting line of research.

### Conclusion

This study examined children's socio-emotional responses to a variety of stimuli and found that both nonverbal and verbal responses differentiated between stimulus types. The most important features seem to be fluffiness, size, facial features, especially the eyes and mouth, tails, general movement, and agency. Interestingly, the robots were perceived as more animal-like than insect-like as evidenced in the children's interactions, willingness to engage and in their verbal comments. The questions children ask and how their cognitions may shift during interactions relate to other concurrent developmental processes. Categorization of robots may highlight whether young children's views of living/ non-living, and real versus artefact differ qualitatively from those of older children and adults. Finally, while our aims were to examine how stimuli characteristics impact upon behaviours, our data also indicate that interactions with animals and robots create an excellent arena for examining children's socio-emotional competencies and development more broadly.

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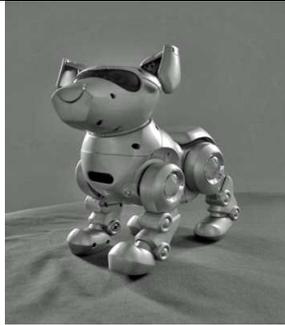
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**TABLE 1: characteristics of stimuli presented**

					
STIMULI – (ACCESSORIES)	Scoozie (water melon slice)	Teksta (remote control; with a bone and a ball)	Dog - West highland terrier	Stick insects	Hissing cockroaches
ANIMATE	No locomotion but body parts move (below)	Walks forwards and back, animate body parts (below)	Yes	Yes	Yes
FACE	Mammalian-like features	Robot-like, no mouth, lights for eyes.	Mammalian	Eyes visible on closer inspection	Eyes visible on closer inspection
FLUFFY	Yes	No	Yes	No	No
CONTINGENCY	To touch - cries if being ignored	To touch - cries if being ignored . Aware of obstacles. Barks when nose pressed	Yes	Yes	Yes
BEHAVIOUR	Eye blinks Ear wiggles Mouth opens Slow tail movement Giggles Cries Gurgles	Eye flashes (red /blue) Ear wiggles Turns head Rapid tail movements Barks and cries Crunches bone. Asks to play or for bath	Body and facial movements, such as wagging tail Responds to voice Responds to touch Barks?	Antennae visibly move Crawls Silent	Antennae visibly move Crawls Hisses when air-sac in stomach pressed