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Using Gaze Direction to Learn Words at 18 Months: Relationships with Later Vocabulary

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There is a well-documented relationship between an infant's early ability to follow the gaze of an adult and their later receptive and expressive language. However, what is less well known is the degree to which a child's ability to learn new words through gaze following predicts later vocabulary knowledge. The current study explored this question by giving 18-month-old infants a word-learning task that required them to follow the gaze of a speaker in order to determine the referent of a novel word. Vocabulary measures were also taken when children were 18, 24 and 30 months old. Results showed that infants' scores on the word-learning task at 18 months were significantly related to their receptive and expressive vocabulary scores both concurrently and longitudinally. These results suggest that the ability to follow gaze direction to identify unfamiliar words' meanings is one of the key strategies used by infants to build their vocabulary.

1. Introduction

The ability to follow the gaze of another person is an important social skill that begins to develop in the first year of life. The very beginnings of gaze following can be seen in infants as young as 24 to 120 hours old, at which age newborns will shift their gaze towards a target on screen more rapidly if it appears on the side towards which a face had previously been looking (Farroni et al. 2004). In a more naturalistic setting, infants have been shown to be able to accurately follow the head turn of an adult by the age of 3 months, providing that the object being gazed upon is within the infant's visual field (D'Entremont et al. 1997). Once this skill has begun to emerge, infants become more sophisticated in their ability to follow gaze; at 9 months, infants will follow the head turn of an adult when the adult's eyes are closed, but a 10-month-old understands that the eyes are of significance, and will only follow the head turn when the adult has their eyes open (Brooks & Meltzoff 2005). At 10 months, infants will also reliably follow the gaze of an adult to an object that is not in the infant's immediate visual field (Corkum & Moore 1998). Thus, by their first birthday, infants have become highly skilled in following the gaze of another person.

Gaze following is an important social skill to acquire because it allows the infant to engage in joint attentional episodes. The literature distinguishes between responding to joint attention (whereby an infant responds to a bid for shared attention by an adult) and initiating joint attention (whereby the infant instigates the shared attention episode), but in both cases, joint attentional interactions provide many social opportunities for infants. That is, if an adult is looking towards an interesting object and the child is able to follow their gaze towards this object, the child and adult are able to engage in a triadic interaction whereby they are both attending to the same thing. Such episodes allow infants to link the language (and specifically words) used by the adult to the object on which both partners are focused.

Several longitudinal studies have explored whether an infant's early ability to follow gaze (and/or respond to or initiate joint attention) is related to their vocabulary knowledge later on in development. It has been found that individual differences in responding to joint attention at 6, 8, 12 and 18 months are positively related to individual differences in expressive

vocabulary size at 30 months (Morales et al. 2000a). Similarly, it has been shown that an infant's ability to respond to joint attention at 6, 8 and 10 months is positively correlated with expressive vocabulary scores at 24 and 30 months and receptive vocabulary scores at 30 months (Morales et al. 2000b). Gaze following and simultaneous vocalisations at 10 to 11 months are positively correlated with receptive language scores at 14 and 18 months, and time spent looking at the object of another's attention at 10 to 11 months predicts accelerated vocabulary development between 10 and 24 months (Brooks & Meltzoff 2005, 2008). It appears, therefore, that the ability to follow gaze is important for the development of language.

There are good reasons why gaze following might be useful for learning new vocabulary. If an adult utters a novel word in the presence of several unfamiliar objects, they might, in principle, be referring to any of the items in view. However, by engaging in joint attention and following the gaze of the adult, the infant might notice that the adult is looking towards a particular object among those available. Their ability to follow the gaze of the speaker would in this way allow them to disambiguate the referent of the novel word. However, although infants are able to reliably follow gaze by the end of their first year, it is not until the middle of the second year that they use this skill to disambiguate the referents of new words.

Seminal work by Baldwin (1991) demonstrated that infants are able to use the speaker's direction of gaze to determine the meaning of a novel word at the age of 18-19 months. These studies employed a paradigm whereby both child and experimenter each hold a novel toy. In the follow-in labelling condition, the experimenter waits until the child is looking at his own toy and the experimenter then looks at the same toy and utters a novel word, "toma". In this condition, the object at the focus of the speaker's direction of gaze is the same as the object at the focus of the listener's direction of gaze. At test, the child is shown both objects and asked, "Where is the toma?" In the discrepant labelling condition, the experimenter once again waits until the child is looking at his own toy; the experimenter then instead looks towards her own toy and utters the novel word. In this condition, the object at the focus of the speaker's direction of gaze is different to that at the focus of the listener's direction of gaze. Once again, at test children are asked for the "toma" (and also the "peri", to ensure that children have not simply learnt that the target toy is special in some way). As a group, infants aged 16 to 19 months attached the novel label to their own toy in the follow-in condition; the older children (aged 18 to 19 months) were also successful in the discrepant condition. However, while the younger infants did not make mapping errors in the discrepant condition – they did not attach the novel label to their own toy – they did have trouble in correctly attaching that novel label to the experimenter's toy, indicating that the ability to use gaze direction to learn a new word develops at around 18 months. Baldwin (1993) later demonstrated that whilst 14- to 15-month-old infants' choice of own object at test did not significantly differ between the follow-in and discrepant labelling condition, 16- to17-month-olds chose their own object significantly more in the follow-in condition, while at 18 to 19 months infants chose their own object significantly *less* than chance in the discrepant condition. These studies indicate that, by 18 to 19 months, children can not only learn a novel label for a toy at the focus of their own attention, but also understand that a novel label does not refer to the object they are attending to if the speaker is attending to a different object. Other work has also shown that, by 18 months, infants will spontaneously consult the speaker for gaze cues to word meaning (Moore et al. 1999; Dunham & Dunham 1992).

More recent work has indicated that infants may be able to use gaze following to learn novel words as young as 15 months of age in a laboratory-based task, where the measure of learning was infant looking times. Houston-Price et al. (2006) showed infants a digital recording of an adult turning to look towards one of two novel objects while they heard a novel label. They found that, even at 15 months, infants were able to follow the direction of the adult's gaze, and use this to attach labels to the objects at the focus of the adult's gaze. However, such early evidence has only been seen when infants' looking behaviour is the

measure of learning; it is not until 17 to 18 months that infants are able to demonstrate their learning by selecting a named object.

Around this same age, infants begin to develop another strategy for word learning, known as the mutual exclusivity bias (Markman & Watchel 1988; Markman 1989). Children who possess this bias will assume that objects only have one label; as such, when presented with one name-known, familiar object and a novel nameless object, they will presume that a novel label refers to the novel object. This is relevant in experiments (such as the current study) that aim to teach infants two novel labels through gaze following because, once an infant has learned the name for one novel object, they could use their knowledge of mutual exclusivity as an additional cue to guide their learning of the second object. However, it is important to note that infants would still need to employ gaze following in order to correctly map the first label to its referent, and that mutual exclusivity would therefore only be of benefit to an infant who was also able to use gaze direction to learn new words.

While it is clear that infants are able to use gaze following to learn new words in laboratory tasks, what is not clear is whether their ability to do so is at all related to their receptive and/or expressive vocabulary scores, either concurrently or longitudinally. As yet, no-one has explored whether the ability to *use* gaze following to learn new words might explain the relationship between early gaze-following ability and later vocabulary size. If children do indeed draw on speaker gaze direction as one of the primary strategies for adding new words to their vocabularies, one might expect the children who do well in these experimental tasks to have large vocabularies in relation to their peers. The current study therefore explored whether 18-month-old children's performance in a word-learning task requiring gaze following is related to their receptive and/or expressive vocabulary scores at 18 months, 24 months and 30 months.

2. Methods

2.1. Participants

At the first time point, 48 infants (20 boys & 28 girls) were recruited from the University of Reading's Child Development Group, a database of families who have expressed an interest in taking part in research. Infants had a mean age of 18 months 12 days (range 17 months 8 days – 18 months 26 days) at the first time of testing. Infants were all healthy, born no more than 3 weeks pre-term and had no known hearing or visual impairments. The majority of participants were Caucasian (N=46) and had at least one parent who was educated to degree level (N=45). In most instances, infants were accompanied on visits to the University by their mothers, although a small number were accompanied by their father or a grandparent.

At the second time of testing, 42 children returned to the University (17 boys, 25 girls) at a mean age of 24 months 19 days (range 24 months 3 days – 25 months 6 days). Finally, 36 children (16 boys, 20 girls) completed testing at the third time point, at a mean age of 30 months 15 days (range 30 months 0 days – 31 months 10 days).

2.2. Materials and apparatus

The gaze-following task was designed to determine whether infants were able to follow the gaze of a speaker and use this to infer the referent of a novel label. Infants were presented with two large red boxes, each with an open face. During the task, infants were shown two objects at a time, one inside each of the boxes. The test objects consisted of two novel, name-unknown toys, shown in Figures 1 and 2 below. The yellow stacking toy in Figure 1 was presented without the coloured rings to ensure the object was unfamiliar to children. The toy has a small button on the side which, when pressed, makes the stick of the toy light up temporarily and make a "whoosh" sound. The spinner toy in Figure 2 contained small balls

which span around inside the dome when the blue plunger was pushed. Toys were chosen to be similar in visual appeal and size, and of roughly equal salience in terms of their functions.

Figure 1. Unfamiliar "stacking" toy.

Figure 2. Unfamiliar "spinner" toy.

When infants were 18 and 24 months old, parents were sent and asked to complete a copy of the Reading Communicative Development Inventory (CDI), a British English Adaptation of the MacArthur-Bates CDI (Words and Gestures) (Fenson et al. 1994). This parental report measure of infant vocabulary is a checklist of 662 words that are commonly understood and said by infants aged 18-24 months. For each word, parents were asked to mark whether their child understood the word, understood and also said the word, or neither. At 24 and 30 months old, the Receptive One-Word Picture Vocabulary Test (ROWPVT-4) was used as a measure of receptive vocabulary, and at 30 months the Expressive One-Word Picture Vocabulary Test (EOWPVT-4) was used to assess expressive vocabulary. These are normed vocabulary assessments, which allow each individual's raw score to be transformed into a scaled score according to their age (accounting for any differences in age at the time of testing). Both assessments are designed to have a mean scaled score of 100 and a standard deviation of 15.

2.3. Design and procedure

When infants were 18 months old, parents were asked to complete the CDI questionnaire prior to their visit. When parents and infants came to the University to complete the gaze-following task, the experiment took place in an observation lab, which contained a one-way mirror to allow the procedure to be videotaped. Infants were seated on their parent's lap at a large table, opposite the experimenter; the set-up for this task is shown in Figure 3.

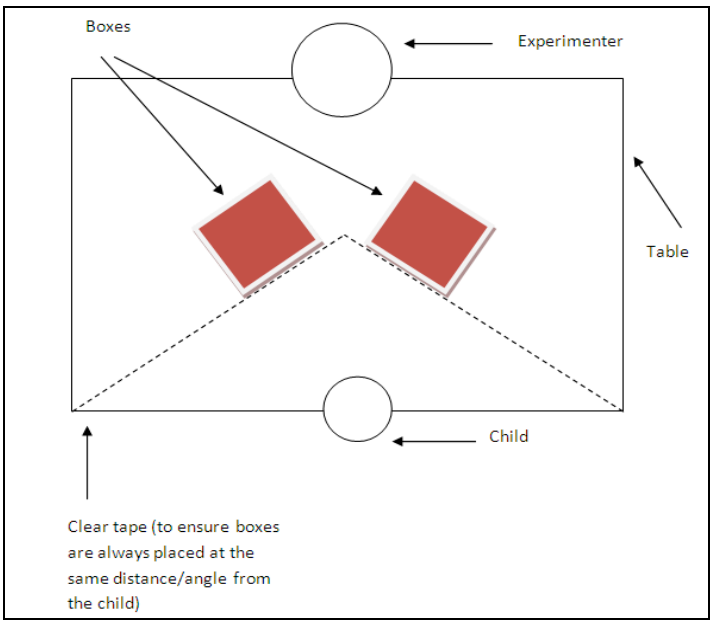

Figure 3. Diagram of the experimental setting.

The task consisted of two experimental phases: a gaze-following/word-learning task and a retention test. Infants' responses were recorded by the experimenter during both phases, and sessions were also videotaped to enable checks on the reliability of the experimenter's coding.

Gaze-following/Word-learning task. Once the infant was seated at the table, the two novel toys were each placed inside a red box. The experimenter turned the boxes to face the child, and then looked towards the child and repeated her name until she gained eye contact. The experimenter then said, "Look at the *modi*! Can you see the *modi*? Emma, look at the *modi*! Wow, a *modi*, a modi! Can you see the *modi?"* Underlined words indicate the experimenter looking towards the child and words in italics indicate the experimenter looking towards the target object. At all times, the experimenter was centrally positioned between the two boxes, only turning her head slightly to look between the child and the object in the box. The experimenter then looked towards the child and asked, "Emma, where's the modi? Can you show me the modi?" Both boxes were then pushed forwards to allow the child to make her selection. After this, the objects were placed back in their boxes and the procedure was repeated with the second object. The two novel labels used were "modi" and "blicket". Label-object pairings and the order in which toys were labelled were counterbalanced between participants.

Retention test. After the word-learning phase, infants were allowed to play with the two novel objects for one minute before the retention phase began. The experimenter asked the parent to place one toy back in each box, stating that it did not matter which box each toy was placed in (so that the experimenter was blind to the location of each toy). The experimenter asked the child, "Emma, where's the blicket? Can you show me the blicket?" and then pushed both boxes forward. Once the child had selected a toy, the toys were replaced and the procedure was repeated for the second toy. The order in which toys were requested was counterbalanced between participants.

Follow-up assessments. Infants returned to the University to complete language assessments at 24 months and 30 months. When children were 24 months, parents completed the CDI vocabulary checklist for a second time, and children completed the ROWPVT-4, a test of receptive vocabulary. For this test, children were shown a flip book one page at a time and were asked to point to one of the four pictures on each page, which often depicted objects but also occasionally actions. The experimenter followed the standard protocol of repeating the request up to three times if the child did not initially respond and the task continued until the child responded incorrectly (or failed to respond) to six out of eight consecutive items. Raw scores were standardised according to the child's age (in months).

When children returned at 30 months, they completed the ROWPVT-4 and the EOWPVT-4. For the EOWPVT-4, a test of expressive vocabulary, each page depicted only one object (or action), and the child was asked, "What is this?" The request was repeated up to three times if needed and the response was marked correct if the child responded with an appropriate label (certain synonyms were acceptable). The test continued until the child responded incorrectly (or failed to respond) to six consecutive items. Raw scores were then standardised according to age.

4. Results and discussion

4.1. Performance on word-learning task

Table 1 shows infants' performance on both the gaze-following/word-learning and retention phases of the task. Because these were forced-choice tasks, and in each phase infants heard requests for two different objects, infants might score 0, 1 or 2 for each phase, with a probability of 0.25, 0.5 and 0.25 respectively. We classified infants who answered both requests correctly as 'passing' the task. As only small numbers of infants scored 0 in each

phase, and because infants who had learned nothing would be expected to score 1 out of 2 by chance, we classified infants who scored either 0 or 1 as 'failing' the task. The probabilities of passing and failing each stage of the task were therefore 0.25 and 0.75 respectively.

Table 1 shows that infants performed better than would be expected by chance in the gaze-following/word-learning stage of the task. Weighted chi-square analysis confirmed that the distribution of scores in the word-learning stage of the task was significantly different from chance, $\chi^2(1)=14.00$, $p<.001$. However, scores in the retention stage of the task were not significantly different from chance, $\chi^2(1)=0.29$, $p=.593$. These results indicate that, at 18 months, infants were able to use the gaze of the speaker to map novel labels to novel objects, but were unable to retain these mappings after a one-minute play period.

	Gaze-following/ word-learning	*Retention*
Pass	23 *(12)*	13 *(12)*
Fail	25 *(36)*	35 *(36)*
Total	48	48
χ^2	14.0 ($p<.001$)	0.29 ($p=.593$)

Table 1. Number of infants passing and failing each stage of the task (numbers in parentheses reflect the distribution expected by chance).

Further analyses confirmed that infants' behaviour was not affected by the labels used for each object, nor by the infants' preferences for individual objects themselves. Infants chose the correct object equally often when they were asked for the "blicket" as they did for the "modi", and the stacking toy was correctly chosen as often as the spinner toy (all *p*s>.05).

4.2. Summary of vocabulary measures collected

At 18 and 24 months, scores on the CDI were used as measures of receptive and expressive vocabulary. At 24 months, there was some evidence of a ceiling effect in the CDI measure for receptive vocabulary, as shown by a negatively skewed distribution, and therefore scores on the ROWPVT-4 were used as an additional measure of receptive vocabulary. At 30 months, scores on the ROWPVT-4 and the EOWPVT-4 were used as measures of receptive and expressive vocabulary respectively. The mean and median values and ranges for each of the language measures we collected are shown in Table 2 below.

	CDI Comp 18m	*CDI Prod 18m*	*CDI Comp 24m*	*CDI Prod 24m*	*ROWPVT Comp 24m*	*ROWPVT Comp 30m*	*EOWPVT Prod 30m*
Mean	208.06	58.77	455.21	177.10	103.82	106.79	107.28
Median	227	40.5	432	302	103	103	108.5
Range	30-411	0-216	138-646	8-623	88-128	87-136	69-142

Table 2. Mean and median number of words (CDI) and standardised scores (ROWPVT-4/EOWPVT-4) and ranges across all three time points.

Table 3 overleaf shows that there were positive, often very strong, correlations between each of the vocabulary measures, the only exception being that between receptive vocabulary scores at 18 months and expressive vocabulary scores at 30 months.

	CDI Prod 18m	*ROWPVT-4 24m*	*CDI Comp 24m*	*CDI Prod 24m*	*ROWPVT-4 30m*	*EOWPVT-4 30m*
CDI Comp 18m	.681** (N=52)	.499** (N=39)	.841** (N=43)	.634** (N=42)	.376* (N=38)	.192 (N=36)
CDI Prod 18m		.430** (N=39)	.631** (N=43)	.786** (N=42)	.539** (N=38)	.508** (N=36)
ROWPVT4 24m			.575** (N=38)	.596** (N=37)	.463** (N=34)	.537** (N=35)
CDI Comp 24m				.815** (N=42)	.360* (N=38)	.428** (N=36)
CDI Prod 24m					.546** (N=37)	.639** (N=35)
ROWPVT-4 30m						.502** (N=36)

Table 3. Correlations between receptive and expressive vocabulary measures across all three time points (* indicates p<.05 and ** indicates p<.01).

4.3. Relationship between word-learning ability and vocabulary size

Approximately half of infants passed the gaze-following stage of the task at 18 months, and half failed (see Table 1). The next set of analyses explores whether performance on this task was concurrently and/or longitudinally related to vocabulary size. We employed two approaches to analysis. First, vocabulary scores were used as continuous variables and t-tests were adopted to compare each measure for infants who passed and failed the word-learning task. Table 4 below shows that infants who passed the gaze-following/word-learning task at 18 months had significantly higher scores on all vocabulary measures across the three time points than infants who failed (the only exception being receptive vocabulary scores at 30 months). Note that there tended to be larger differences between groups on measures of production compared to measures of comprehension, implying that performance on a gaze-following/word-learning task may be more related to a child's productive vocabulary than to receptive vocabulary.

	CDI Comp 18m	*CDI Prod 18m*	*CDI Comp 24m*	*CDI Prod 24m*	*ROWPVT Comp 24m*	*ROWPVT Comp 30m*	*EOWPVT Prod 30m*
Pass	234.5 (104.6)	85.7 (66.7)	494.8 (106.9)	383.9 (167.5)	108.0 (8.4)	109.7 (11.3)	111.1 (6.6)
Fail	184.8 (99.2)	37.5 (46.7)	414.2 (128.9)	246.8 (171.9)	99.7 (10.7)	104.4 (11.4)	103.9 (15.7)
T-value (1-tailed)	1.69 p=.049	2.88 p=.003	2.17 p=.018	2.56 p=.008	2.62 p=.007	1.41 p=.084	1.73 p=.047

Table 4. Mean scores on each of the vocabulary assessments according to performance (pass/fail) on the gaze-following/word-learning stage of the task. Standard deviations are given in parentheses.

Second, infants were placed into a high or low receptive vocabulary group, and separately, into a high or low expressive vocabulary group at each age (using median split); chi-square tests were then conducted to see whether there was any association between performance on the word-learning task at 18 months and vocabulary groups at 18, 24 and 30 months.

Table 5 below shows infants' performance in the word-learning task according to receptive and expressive vocabulary group at the same age (18 months). Chi-square analyses revealed a significant association between task success and receptive vocabulary group, $\chi^2(1)=4.09$, p=.022, as well as a significant association between word-learning score and expressive vocabulary group, $\chi^2(1)=5.30$, p=.011 (one-tailed). Weighted chi-square analyses revealed that infants in the low receptive and expressive vocabulary groups did not succeed

significantly more often than would be expected by chance, while those in the high vocabulary groups were highly successful on the word-learning task.

	Receptive Vocabulary Group 18m			*Expressive Vocabulary Group 18m*		
	Low	*High*	*Total*	*Low*	*High*	*Total*
Pass	8 *(6)*	15 *(6)*	23	7 *(6)*	16 *(6)*	23
Fail	16 *(18)*	9 *(18)*	25	17 *(18)*	8 *(18)*	25
Total	24	24	48	24	24	48
χ^2	0.89 (p=.346)	18.00 (p<.001)	χ^2	0.65 (p=.419)	19.84 (p<.001)	

Table 5. Scores in the gaze-following/word-learning task at 18 months, according to receptive and expressive vocabulary groupings at 18 months (numbers in parentheses are frequencies expected to pass/fail by chance).

At 24 months, 42 children returned to the University; of these, 37 completed the ROWPVT-4 and 40 had a complete CDI. Table 6 below shows children's scores on the word-learning task at 18 months according to their vocabulary groups at 24 months. There was no association between word-learning success at 18 months and CDI receptive vocabulary group at 24 months, $\chi^2(1)=1.21$, p=.136, likely due to the ceiling effect already noted for this measure. There was, however, a significant association between word-learning success at 18 months and CDI expressive vocabulary group at 24 months, $\chi^2(1)=3.60$, p=.029, and a significant association between task success at 18 months and the ROWPVT-4 receptive vocabulary group, $\chi^2(1)=9.75$, p<.01 (all one-tailed). Weighted chi-square analyses confirmed that children in the low receptive and expressive vocabulary groups at 24 months had not performed differently from chance on the word-learning task at 18 months, while those in the high vocabulary groups had succeeded at the task. Thus, performance on the gaze-following/word-learning task at 18 months was highly predictive of vocabulary size six months later.

	CDI Receptive Vocabulary Group 24m			*CDI Expressive Vocabulary Group 24m*			*ROWPVT-4 Receptive Vocabulary Group 24m*		
	Low	*High*	*Total*	*Low*	*High*	*Total*	*Low*	*High*	*Total*
Pass	8 *(5)*	12 *(5.3)*	20	7 *(5)*	13 *(5)*	20	5 *(4.5)*	15 *(4.8)*	20
Fail	12 *(15)*	9 *(15.8)*	21	13 *(15)*	7 *(15)*	20	13 *(13.5)*	4 *(14.3)*	17
Total	20	21	41	20	20	40	18	19	37
χ^2	2.40 p=.121	11.57 p=.001	χ^2	1.07 p=.302	17.07 p<.001	χ^2	0.07 p=.785	29.49 p<.001	

Table 6. Scores in the gaze-following/word-learning task at 18 months, according to receptive and expressive vocabulary group at 24 months (numbers in parentheses are frequencies expected to pass/fail by chance).

Finally, at 30 months, 36 children completed the ROWPVT-4 and 34 of these also completed the EOWPVT-4. There was a significant association between word-learning success at 18 months and expressive vocabulary group at 30 months, $\chi^2(1)=2.94$, p=.043, but not with receptive vocabulary group at 30 months, $\chi^2(1)=1.78$, p=.09 (both one-tailed). As shown in Table 7, once again, only the children in the high vocabulary groups at 30 months had succeeded on the word-learning task at 18 months.

	Receptive Vocabulary Group 30m			*Expressive Vocabulary Group 30m*		
	Low	*High*	*Total*	*Low*	*High*	*Total*
Pass	7 *(4.5)*	11 *(4.5)*	18	6 *(4.3)*	11 *(4.3)*	17
Fail	11 *(13.5)*	7 *(13.5)*	18	11 *(12.8)*	6 *(12.8)*	17
Total	18	18	36	17	17	34
χ^2	1.85 p=.174	12.52 p<.001	χ^2	0.96 p=.327	14.29 p<.001	

Table 7. IScores in the gaze-following/word-learning task at 18 months, according to receptive and expressive vocabulary group at 30 months (numbers in parentheses are frequencies expected to pass/fail by chance).

In summary, our findings show that infants' ability to learn new words using gaze following at 18 months is concurrently related to expressive and receptive vocabulary scores. Furthermore, task success at 18 months is longitudinally related to receptive and expressive vocabulary scores at 24 months (although the strength of the relationship with receptive vocabulary varies depending on the vocabulary measures used). Finally, task performance at 18 months was longitudinally related to expressive, but not receptive, vocabulary scores at 30 months. This demonstrates that a child's ability to disambiguate the referent of a novel word using the speaker's gaze is related to their expressive and receptive vocabulary scores up to one year later. Although previous work has shown that responding to joint attention at 18 months is related to expressive language at 30 months (Morales et al. 2000a), results from the current study show that it is not only the component skill of gaze following that is related to language scores, but also the child's ability to utilise this skill to learn novel words. These findings might help to explain the longitudinal relationship between gaze-following ability and vocabulary size – that is, the link may not be direct, but it may be mediated by the child's ability to use gaze direction to disambiguate the meanings of new words. It is therefore not surprising that young children with autism, who commonly fail to spontaneously follow the gaze of others (Baron-Cohen et al. 1997), often have delayed language (Frith 1989). Responding to joint attention has been found to be a concurrent predictor of receptive language scores in 18- to 33-month-olds with autism (Luyster et al. 2008). Perhaps more interestingly, triadic gaze switching has also been shown to be positively related to later language scores in this population (Charman 2003). Further research might explore whether success at a gaze-following/word-learning task of the type employed in the current study also mediates the link between social skills and language skills of the ASD population.

The findings from the current study suggest that the relationship between a child's score on the gaze-following task and their language scores differs depending on whether we examine children's receptive or expressive vocabularies, and depending on the vocabulary measures used. In our first set of analyses, t-tests showed significant differences between children who passed/failed the word-learning task at 18 months in both the CDI and ROWPVT-4 measures of receptive vocabulary at 24 months. However, when we conducted chi-square tests there was only a significant association between task success at 18 months and ROWPVT-4 receptive vocabulary group at 24 months. This indicates that the ROWPVT-4 measure of vocabulary may be more sensitive to differences in children's receptive vocabularies at 24 months than the CDI.

There is an ongoing debate with regards to the validity of the CDI as a measure of word understanding during the second year. Recent studies have shown that parents may not be particularly accurate when reporting whether their child knows a specific word (see Houston-Price et al. 2007; Styles & Plunkett 2009). However, parents *are* thought to be reasonably accurate in their relative estimates of how many words their child understands in total (Bates et al. 1988; Dale et al. 1989), which was of primary interest in this study. It is worth noting that there is no evidence to suggest that any alternative vocabulary assessment is more accurate than the CDI at 18 months. However, there is evidence that the CDI may vastly underestimate the number of words a child knows at 24 months (Robinson & Mervis 1999),

not due to parental misreport, but because children know more words than are listed on the questionnaire. This is supported by our observation of a ceiling effect in children's CDI comprehension data at 24 months. We would therefore argue that the CDI is not a useful tool for assessing receptive vocabulary, and that the ROWPVT-4 better reflects the positive relationship between task performance at 18 months and receptive vocabulary size at 24.

In addition to the significant associations seen between task performance and receptive vocabulary scores at 18 and 24 months, we found significant relationships between task performance and expressive vocabulary scores at all three time points. As there are no grounds to suspect any lack of validity in the ROWPVT-4 measure of receptive vocabulary at 30 months (c.f. the CDI issue discussed above at 24 months), it would appear that, task success at 18 months is only significantly related to expressive vocabulary one year later. It is difficult to identify the reasons behind this from the current study; however, one possibility is that infants who are better adept at following an adult's gaze are also those who tend to initiate joint attention more frequently, and therefore develop larger expressive vocabularies due to the increased amount of time they spend interacting with adults.

It must be noted at this point that social pragmatic skills, such as gaze following, are by no means the sole strategy by which children can add new words to their vocabularies. There are a number of other strategies and heuristics that young children are able to employ to assist them in disambiguating the referent of a novel word (see Hollich et al. 2000 for a comprehensive review). However, it would appear that a child's ability to utilise their social skills to learn novel object labels during the second year of life is particularly important for later language development. There is a growing body of literature suggesting that the relative importance of various word-learning cues and strategies may alter throughout a child's development, depending on the cues they are able to make use of at any given point (e.g. Hollich et al. 2000; Woodward 2000). However, it has been suggested that infants learn the vast majority of the words in their vocabulary through social, triadic interactions (Tomasello & Todd 1983). The current findings of a longitudinal relationship between word learning through gaze following and vocabulary size provides further evidence for this view.

5. Conclusions

The findings of this study corroborate the crucial role of gaze following in language development. However, we have also demonstrated a link between an infant's ability to learn words using gaze following and their receptive and expressive language 6 to 12 months later. This finding raises several questions with regards to the development of gaze following, the use of gaze direction to learn words, and vocabulary growth. Specifically, what is it that enables an infant to become adept at gaze following – is the development of this skill internally-driven, and/or is there a significant role to be played by the infant's caregivers? Similarly, is an infant's ability to follow gaze early in the first year of life indicative of their ability to implement gaze following as a word-learning strategy later in the second year? These questions could, to some degree, be answered by longitudinal studies examining the development of gaze-following and word-learning abilities during the first two years of life. Such studies would provide further insight into how infants become such skilled social word-learners before their second birthdays.

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