‘Early walker’ or ‘Early talker’? The effects of Infant Locomotor status on Infant Language acquisition

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ABSTRACT

The link between motor development and language acquisition among infants has been extensively explored. Evidence highlights a significant increase in language acquisition with walking onset as reported by parental questionnaires. However, due to discrepancies observed within parental report measures, this link between language and motor development cannot be determined. The present study, therefore, aimed to verify parental questionnaire validity using infant preferential task measures, further examining the influence of locomotor status (crawler vs. walker) on infant language acquisition. 26 infants’ (aged 9 to 17 months) receptive vocabulary was reported using parental responses to the ‘Oxford Communicative Developmental Inventory’ (CDI) – a vocabulary questionnaire. To verify the CDI validity, infants were tested using a preferential looking paradigm in relation to whether parents had reported words known and unknown. Infants watched eight videos; four pairs of reported known words and four pairs of reported unknown words. Results showed a significant positive relationship between infant vocabulary scores and motor ability. However, the preferential looking task highlighted that parents of walkers were more accurate at reporting words their infant was familiar with than parents of crawlers. This suggests parental discrepancies when estimating words their infant understood to be a consequence of infant locomotor status. The present study, provides primary evidence not only for the links between language acquisition and motor development but also for the accuracy of parental questionnaires and the effects locomotor status has on parental perceptions of infants’ language abilities.

KEY WORDS:	LANGUAGE ACQUISITION	MOTOR ABILITY	PARENTAL REPORT	PREFERNTIAL LOOKING	INFANTS	WORD LEARNING

Introduction

Were you an 'early walker' or an 'early talker'? Long-standing speculation and discussions among parents and researchers have led to assumptions that infants cannot develop both language and motor developmental milestones simultaneously (Tipps, Mira, & Cairns, 1981). Infants are therefore, commonly characterised as either 'early walkers' or 'early talkers'. Such deliberations encouraged researchers to establish the links between the acquisition of motor abilities and language among infants. Despite parental assumptions that such milestones are achieved independently, the relationship between the two is still unclear.

Vast research highlights that by the age of one, infants' acquire a range of crucial developmental skills. Such acquired skills include improved hand-eye coordination, social and emotional development and enriched cognitive capabilities, specifically object permanence (Guerin, 2010). Research illustrates that motor milestone achievements are closely linked to such physical and psychological skill development (Thelen, 1995). Gottlieb (as cited in Walle & Campos, 2014) described this process as a catalyst in which one transitional motor developmental stage dramatically altered infants' cognitive, emotional and social development. It is therefore plausible, contrary to parental assumptions, such a catalyst may also exist between motor milestone onset and language development as infants at the age of one are reported to progress rapidly in both developmental skills (Iverson, 2010).

A longitudinal study by Walle and Campos (2014) explored the relationship between walking onset and language acquisition among 10 to 13.5 month-old infants. Parents were asked to report infant language and locomotor development consecutively every two weeks, over a 3-month period through an online questionnaire. The questionnaire asked parents to confirm their infant's current locomotor status in addition to when specific motor milestone onset was achieved. Language development measures were compiled within the questionnaire using a vocabulary checklist in which parents recalled which words their infants understood, receptively and productively. Findings suggested locomotor transitioning to have advantages on language acquisition proposing, with walking onset came an explosion in both receptive and productive vocabularies among infants. Such findings therefore, suggest a progressive relationship between motor milestone achievement and language development among infants.

Although the results highlighted clear developmental links between language and motor domains, it is plausible that such findings could be interpreted differently. One limitation within this study was the use of parental questionnaires to solely determine both language and locomotor measures. Such a concern was reinforced by criticisms regarding the validity of parental questionnaire use (Law & Roy, 2008), therefore implicating Walle and Campos' (2014) findings to be inaccurate. Nevertheless, it is also possible that the reported relationship between motor and language development was reasonable, however, the underlying cause for such an association was a result of a third factor. A conceivable third factor could be alterations to infants' social environment as a result of walking onset, which in turn encourages language acquisition advances. It is also plausible parents' perceptions of their infant's language acquisition was influenced by locomotor changes (Iverson, 2010). It may be suggested, that consequential, inaccurate parental reports resulted in the observation of a link between developmental advances. It is consequently questionable whether parental reports can solely be reliable in determining the relationship between motor milestone achievement and language acquisition among infants.

When examining the reliability of the parental report measures within Walle and Campos' (2014) study, it is evident parental questionnaires are a popular and common technique used for measuring infants' development due to their quick and easy application (Wilson, Kaplan, Crawford, Campbell, & Dewey, 2000). Several studies, however, highlight discrepancies in parental report measures for both infant locomotor and language progression. Adolph, Mondschein, and Tamis-LeMonda (2000) highlighted parents' abilities to falsely estimate infants' motor performance. Results showed that although both boys and girls reached early motor milestones at similar ages, mothers underestimated girls' crawling abilities while mothers of boys, overestimated boys' crawling performance. The study further showed mothers' estimations of infant crawling abilities were consistently inaccurate. Such findings suggest discrepancies in parents' abilities to accurately report infant locomotor capabilities.

A study by Houston-Price, Mather, and Sakkalou (2007) further highlighted such discrepancies in relation to language measures. They compared parents' Oxford Communicative Development Inventory (CDI) score reports to infant preferential looking tasks in order to measure infants' vocabularies. Infants aged 15 to 21 months observed pairs of familiar images reported known or unknown by parents through eye-tracking technology. Results showed infants displayed similar knowledge of words thought known and unknown by their parents thus, suggesting infant word comprehension was underestimated in parental reports**.** Tomasello and Mervis (1994) highlighted similar discrepancies, however, found parents overestimated their infant's vocabulary knowledge. These studies highlight clear concerns for the validity of parental questionnaires for infant developmental measures, suggesting parental estimations may impact on the accuracy of motor and language developmental research reports.

Another possible explanation for Walle and Campos' (2014) findings was the influence of locomotor development on infants' social environments. A second study by Walle and Campos (2014) involving a naturalistic observation of parent-child interactions confirmed an increase in language acquisition with walking onset, however, additionally highlighted the infants' social environment to be influenced by locomotor advances. Furthermore, results suggested infants' social environment including increased maternal input and increased activity in turn to be key predictors of the language acquisition enhancement. Biringen, Emde, Campos, and Appelbaum (1995) explored the effects of infant motor development on parent-child exchanges**,** and observed parent-child interactions altered as a result of walking onset. As locomotor status changed, parents perceived their infants to be more action independent, displaying advanced personality traits. It may be suggested, if parents perceive infants to be more physically and cognitively advanced it may alter their attitudes, thoughts, interactions and behaviours towards their child, therefore affecting the infant's linguistic environment. It is evident psychosocial factors interact with infants' motor and linguistic transitioning (Campos, Kermoian, & Zumbahlen, 1992). Additional research has highlighted that significant changes to infants' environmental interactions are a consequence of increased movement, object and social interactions (Ishak, Tamis-LeMonda, & Adolph, 2007). Such alteration of the infants' social environment and transformed parent-child interactions may be contributing factors explaining findings of language acquisition advances during walking onset.

Exploring the effects of motor milestone development on infant social environment further, Hendrix and Thompson (2011) observed altered maternal behaviour to be a consequence of infant locomotor status change. Therefore, parents' perceptions of infant locomotor status may impact on an infant's environment and consequential language development. Karasik, Tamis-LeMonda, and Adolph (2014) explored the effects of motor milestone achievement on maternal verbal interactions with 13 month-old infants. The research showed mothers displayed greater action-directive speech towards walking children compared to crawling children who were double as likely to engage in non-verbal interactions with their mothers. Such a notion suggests infant locomotor status alters infants' social interactions, further influencing maternal verbal response. This may provide further support for Walle and Campos' (2014) findings which suggest increased verbal responses, resulting from walking onset, impact on infant language acquisition.

Another possible explanation for Walle and Campos' findings (2014) was the prospect, motor milestone development could influence maternal perceptions of infant acquisition. Hendrix and Thompson (2011) suggested infant locomotor transitioning may be a significant event for parents regardless of any alterations in the infant's socio-emotional behaviour or environment. It has been illustrated that parental locomotor perceptions occur before the infant is capable of significant self-produced locomotion. Therefore, reported increase in language acquisition may be a consequence of parental expectations rather than actual crawling-walking onset (Hendrix & Thompson, 2011). These findings are consistent with Clearfield (2010), suggesting mothers' parenting beliefs impact on their social interactions with their infants, thus influencing the foundations and building blocks for developmental outcomes. Hence, social environmental changes during motor milestone achievement may be just as much a function of maternal perceptions and expectations as infant behaviour alterations (Clearfield, Osbourne, & Mullen, 2008).

If parents perceive their infants to be more 'adult' with developed locomotor skills, they may have false perceptions of language development resulting in an inaccurate estimation of language scores. Campos et al. (1992) studied parents' observations of infants' visible development in the context of successful locomotor transitioning. Parents reported that more advanced locomotor infants used increased verbal cues in comparison to pre-locomotor infants. Although such findings suggested locomotor infants had more advanced verbal skills than pre-locomotor infants, further observations indicated parents of locomotor infants had greater expectations for infant communication, thus impacting on parental perceptions of infant verbal cues. Not only did this highlight parents' perceptions of both infants' motor and linguistic development are closely linked, but may further suggest false parental perceptions of infants' behaviour confound parental development reports and questionnaires, thus reducing the reliability of the commonly used technique.

Such findings raise the question of whether motor development is directly linked to vocabulary development highlighted by Walle and Campos (2014), or whether other factors of infant social environment including parental perceptions and consequential interactions explain the links found in previous research and variations in parental report outcomes. Consequentially, the present study aims to explore whether vocabulary development is linked to motor development, or whether increases in language acquisition with walking onset, is a consequence of parents' perceptions influenced by developmental advances. Accordingly, the present study will explore whether parents' estimations of infant vocabulary scores are influenced by changes in infants' locomotor status. If parents have increased expectations of infant developmental abilities after the onset of walking, they may overestimate their child's vocabulary comprehension scores, in comparison to parents of crawlers who may oppositely underestimate their infant's linguistic development (Fenson et al., 2000). Another possibility is that this study will confirm the great increase of language acquisition with walking onset proposed by Walle and Campos (2014), thus verifying Walle and Campos' findings that walking infants have a greater receptive vocabulary than crawling infants.

Method

Participants
26 full-term 9 to 17 month-old infants (*boys* =13, *girls* = 13) from English-speaking families were tested and included in the analysis (*Mean age* = 12 months, 11 days, *Age Range* = 9 months, 13 days to 17 months, 29 days). 24 additional infants were tested and excluded from analysis because they did not meet the inclusion criteria (see exclusion criteria for further details). A further three infants did not complete testing due to extensive crying or technical problems. Infants were recruited via the 'BabyLab Participant Database', approved by the University Research Ethics Committee (UREC).

Materials

Vocabulary measures
An online adaptation of the Oxford Communicative Development Inventory (CDI) questionnaire (Hamilton, Plunkett, & Schafer, 2000) using Qualtrics software (See Appendix 1) was used to estimate infant receptive and productive vocabulary size.

Parents were asked to complete this questionnaire prior to their visit to the BabyLab. The questionnaire asked parents to report which words from a list of 416 within a range of categories (*i.e. sounds, animals, vehicles, toys, food and drink, body parts, clothes, furniture and rooms, outside objects, household objects, people, action words, adjectives, routines, time, questions, pronouns and prepositions*) their infant 1) understood but did not yet say, 2) understood and also said and 3) words their infant did not know yet. Words marked as 'understood but did not say yet' were labelled as known whilst words not known yet were labelled unknown. All known and unknown words were separated into two lists before independently being put into an online random word generator (Haarh & Haarh, 1998). The generator was used to randomly select eight familiar name-known object words and eight familiar name-unknown object words for the infants' observations.

Only specific sections of the CDI were used to produce object and speech stimuli *(i.e. animals, vehicles, toys, food and drink, body parts, clothes, furniture and rooms, outside objects, household objects)*. This was to eliminate possible uncertainty among the presented images, as some sections of the CDI could not be presented visually. When parents identified less than eight words their child understood within these categories, the most commonly selected words from other parents' questionnaires with infants of a similar age were used as known words (*n*= 9 infants tested, n= 4 infants included within analysis).

Stimuli

Speech stimuli - Sounds for the stimuli were recorded in a sound-attenuated room by an English native female, using infant-directed speech. Three versions of each stimulus were recorded: 1) Can you see the [target]? 2) Look at the [target]! 3) Where is the [target]? These were then edited on Adobe Audition CS6 software, reducing noise and assuring the stimuli timings for all audio recordings were the same. Each auditory stimulus lasted 2.5 seconds.

Object stimuli - Cartoon versions of objects were selected in order to control for varying characteristics among infant object representation, which could impact on results (see Appendix 2). Images for each stimulus were acquired through online websites or created for the purpose of the study. Any additional editing was made using Adobe Photoshop CS6.

Videos - The videos for each participant's observation were created on Adobe Flash CS6. Each video consisted of eight trials, each containing one pair of images (known or unknown). The images, which were similar in size, were presented side by side whilst moving up and down in synchrony. These were presented with the word 'Look!'. Trials were five seconds long each. Every infant watched eight different trials within the video session. Four trials consisted of known paired words and four trials displayed unknown paired words according to the parental questionnaire.

Demographics

Parents were also asked to fill out an information sheet about themselves and the infant. These involved demographics including age, ethnicity, gender and aspects of the infant's environment including siblings and languages heard (see Appendix 3).

Design

The two independent variables for this study included; Age group (9-11 months, 12-14 months, 15-17 months) and Motor ability (walker or crawler). The number of known and unknown words infants knew in the preferential looking task was the dependent variable. This was measured by 'Proportion of Looking Time' - overall proportion of time spent looking at the target, and 'Longest Looking Time' - the longest single fixation towards the target.

All participants completed both the locomotor assessment and word comprehension assessment. The locomotor assessment was the same for all participants however; due to the nature of the study every child watched a different set of trials in the word comprehension assessment. This was a consequence of variability of known and unknown words reported among parents.

Participants were randomly assigned to one of four groups for the word comprehension assessment to eliminate any order effects. This counterbalancing determined which stimulus sound within each pair (right or left) was presented, the order in which known and unknown pairs were presented and whether ‘can’, ‘look’ or ‘where’ version of the stimulus were used (see Appendix 4).

Procedure

Once greeted, the infants were given time to play with surrounding toys, parents and the researcher, allowing time to get used to the new environment. During this time, parents read the participant information sheet (see Appendix 5), signed the consent form (see Appendix 6) and the locomotor observation took place.

Locomotor Observation

Participants were tested in an observation room containing a range of toys and child-friendly objects. The first observation involved an infant motor ability assessment to determine their status as either ‘walker’ or ‘crawler’. Mirroring Walle and Campos’ (2013) walking assessment, infants were encouraged to cross a 10 feet distance to the parent successfully on two out of three trials in a naturalistic environment. All infants who walked on two or three trials were labelled ‘walker’ while those unable to meet the criteria were labelled ‘crawler’.

Preferential looking task

Participants were tested individually in a sound-attenuated room. Infants sat on their parent’s lap, approximately 65cms in front of a monitor and an eye-tracker (Tobii Pro TX300) in a semi-dark room and observed images accompanied with auditory words on the monitor (990 x 720 pixel resolution). Parents were instructed to avoid eye-contact with the screen and remain quiet in order to avoid interference. The experimenter controlled the presentation of the stimuli on a DELL PC computer from a nearby room, invisible to the infant with participants’ behaviour supervised through a video camera. The eye-tracking system was mounted below the monitor. The preferential looking task began with a five-point calibration. An attention getter was displayed in the centre of each screen before each trial to capture the infant’s attention.

Trials showing pairs of images were presented to the infant while only one of the pair’s labels was vocally presented. Pairs of images included either those both known to the infant or unknown according to the parental vocabulary questionnaire. It was crucial none of the paired objects were from the same category, preventing interference effects so that the object images were perceptually distinct (Arias-Trejo & Plunkett, 2010). Each five-second trial began when the infant was focused on the screen. During the first 2500 ms, the images were presented from 0 to 5 ms with the audio ‘look!’. This was the pre-naming phase. The target word (T) was presented with one of the speech stimuli (‘Can you find the T?’ or ‘Look at the T!’ or ‘Where is the T?’) 367ms before the post-naming phase started at 2500s (See Figure 1). This time was chosen as research highlights this value to be the amount of time infants need to respond through eye movements (Mani & Plunkett, 2007, as cited by Gonzalez-Gomez, Poltrock, & Nazzi, 2013). The session consisted of eight trials and therefore, infants observed 16 images in total, four known pair words and four unknown pair words. The experiment lasted approximately five minutes and none of the objects or words were presented twice. Initial fixation preference was also recorded by comparing eye fixations within both the prenaming and postnaming phase, in order to reduce any visual preference affecting results.

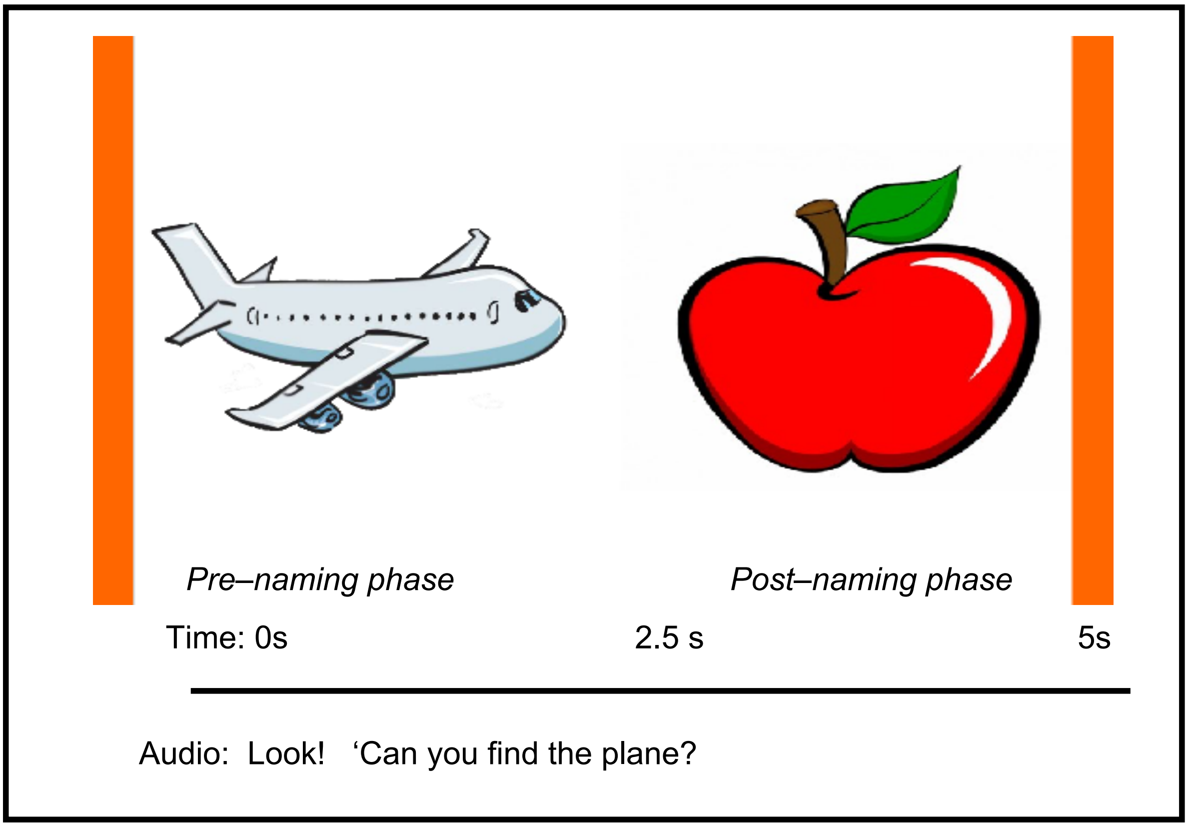

Figure 1: Trial example of image pair (Plane and Apple) and speech stimuli in the prenaming and postnaming phase.

Exclusion Criteria

Upon analysis the duration and proportion of time infants looked to the target (T) and distractor (D) within each of the eight trials was calculated, acknowledging proportions for both the prenaming and postnaming phase. In order to examine this, two areas of interest within each trial were highlighted (see Appendix 7), each containing one of the two object images and highlighting the target and distractor (431 x 541mm). Data cleaning was achieved by excluding trials that did not meet the experimental requirements. Therefore**,** three exclusion criterions were applied. The first exclusion criterion was established to remove any trials in which infants had an evident object bias within the prenaming phase. Therefore any trials were discounted in which infants looked no more than 10% (250 +10) of the total duration of the prenaming phase towards the target (T) or distractor (D). 225 trials were excluded at this stage. The second exclusion criterion involved discounting trials with 50% of the data missing. These ensured infants were focused on the task. 16 trials were excluded in this stage. Finally, infants with less than three trials remaining were excluded in order to improve reliability measures during analysis. Eight infants were excluded at this stage. Overall, 24 infants were excluded from the analysis resulting in an exclusion of 48% of participants. Although this exclusion percentage appears high, it is a common result of studies involving eye-tracking measurements among such an age range of 9 to 17 month-old infants (Smith, as cited in Gonzalez-Gomez, Poltrock, & Nazzi, 2013).

Results

Proportion of Looking Time

Infant measures of label recognition were calculated using the proportion of looking time at the target (T) during both the prenaming and postnaming phases for each trial. A mean label recognition score was calculated for both the naming (prenaming/postnaming) and for the trial conditions (known/unknown), resulting in four proportionate values per infant (known-prenaming/known-postnaming/unknown-prenaming/unknown-postnaming).

Age was split into three groups to examine the effects further (see Table 1).

Table 1
Number of infants per age group and motor ability status.

Motor Ability	**Age (N=26)**		
	9 -11 months (*n*=10)	**12 – 14 months** (*n*=12)	**15-17 months** (*n*=4)
Crawler(*n*=18)	9.00	7.00	2.00
Walker(*n*=8)	1.00	5.00	2.00

A two-way repeated measures ANOVA was conducted to investigate the effects of age group (9-11 months, 12-14 months, 15-17 months) and motor ability (crawlers, walkers) on label recognition with naming (prenaming, postnaming) and trial (known, unknown) as within-subject factors, and age group and motor ability as between-subject factors. A significant main effect of naming, $F(1,20)=4.37$, $p=.049$, $\eta^2=.18$, was revealed showing overall infants looked significantly longer at the postnaming phase ($M=54\%$, $SD=14\%$), compared to the prenaming phase ($M=53\%$, $SD=11\%$). This suggests infants were able to recognise the target word.

A marginal significant effect was found between naming and age group, $F(2,20)=2.90$, $p=.08$, $\eta^2=.22$. A pairwise comparison with a Bonferroni correction showed significant differences for the postnaming phase ($p<.001$) in relation to age group. Consequently, 15 to 17 month-old infants looked significantly longer at the postnaming phase ($M=55\%$, $SD=20\%$), in comparison to 9 to 11 month-old infants ($M=52\%$, $SD=14\%$), suggesting infants' recognition of the target increased with age. Furthermore, a pairwise comparison t-test revealed a significant difference between motor ability and age group, $t(25)=-3.33$, $p=.003$, showing walkers ($M=13.63$ months, $SD=2.07$) to be older than crawlers ($M=11.83$ months, $SD=2.04$). This suggests walking infants were older than crawling infants.

No significant effect was found for trial among infants, $F(1,20)=.54$, $p=.47$, $\eta^2=.03$, suggesting overall infants increased their proportion of looking time to both known and unknown words similarly. The analysis, however, highlighted a significant interaction between naming and motor ability, $F(1,20)=25.29$, $p<.001$, $\eta^2=.56$. Pairwise comparisons with a Bonferroni correction showed a significant naming difference only among walkers ($p=.023$). Thus, walking infants looked significantly longer at the postnaming phase (M=61%, SD=16%), compared to the prenaming phase (M=46%, SD=10%), implying walking infants showed significant recognition of the target word.

The interaction between naming, trial and motor ability was also significant, $F(2,20)=9.08$, $p=.007$, $\eta^2=.31$. Pairwise comparisons revealed a significant difference only for walking infants ($p=.013$) recognition of known words in the prenaming and postnaming phase (see Figure 2), showing walking infants looked longer at known words in the postnaming (M=72%, SD= 14%), in comparison to the prenaming phase (M=48%, SD=9%). No significant differences were found for walkers' recognition of unknown words in the prenaming and postnaming phase. Therefore, findings suggest walking infants not only responded to the known target word but parents accurately reported words their walking infants' comprehended.

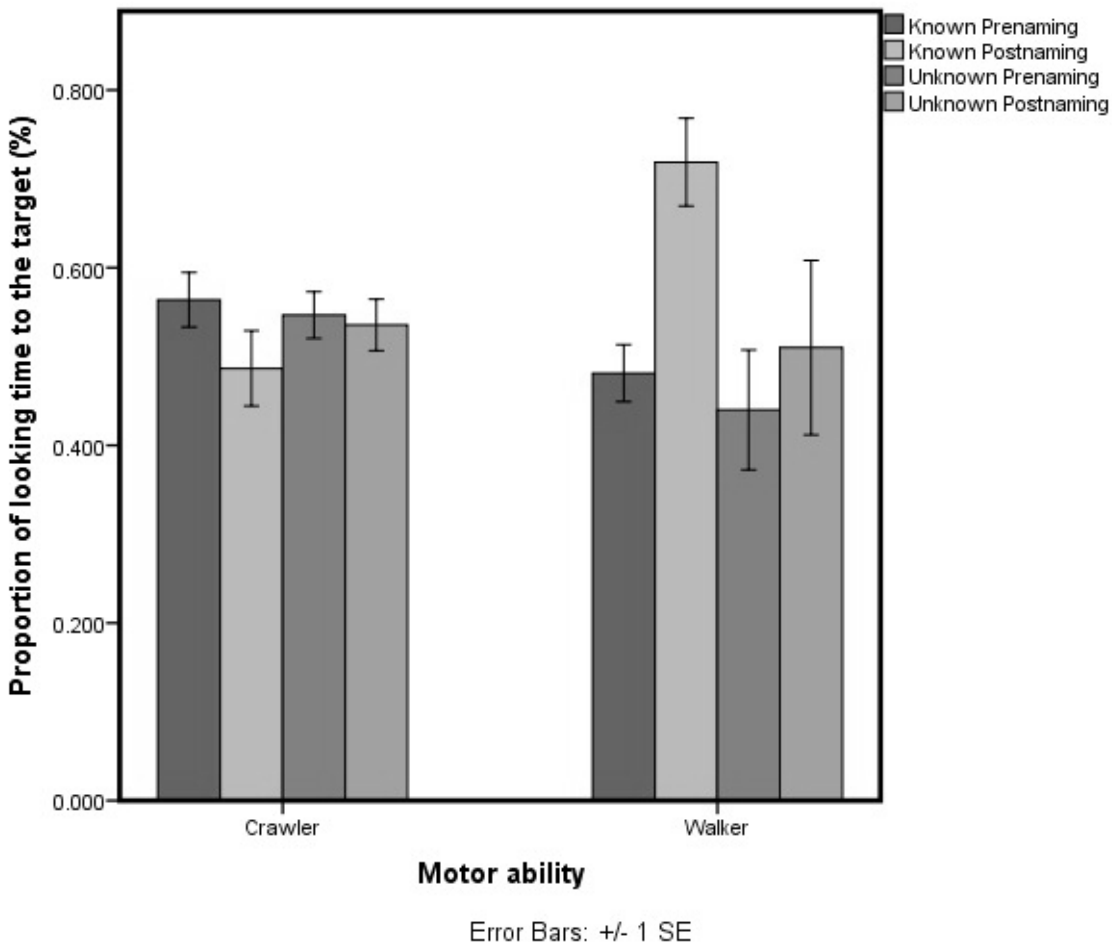

Figure 2: The proportion of looking time to the target for motor ability (crawler, walker), naming (prenaming, postnaming) and trial (known, unknown).

Research suggests longest looking measures to be as widely used a measure, in preferential looking paradigms, as proportion of looking time measures among young infants (Luche, Durrant, Poltrock, & Floccia, 2015). Analysing both measures may help in identifying factors which cause variation among infants' abilities to successfully look at the target image (Courage, Reynolds, & Richards, 2006). Pairwise comparisons revealed such variation, by showing walkers (M=61%, SD=16%) looked significantly longer (p <.001) at the target in the postnaming phase in comparison to crawlers (M=51%, SD=11%). Longest individual looking time to the target was, therefore, also measured in order to provide richer data for motor ability effects.

Longest Looking Time

Infants' mean scores for longest looking time to the target (T) were calculated before and after target word onset, using each trial in relation to naming and trial condition. A two-way repeated measures ANOVA was conducted mirroring the ANOVA measure for the proportion of looking time, however, longest looking time was the new dependent variable.

Results showed no significant effect of naming, $F(1,20)=1.49$, $p=.236$, $\eta^2=.07$, highlighting infants looked at the postnaming phase (M=909.00 ms, SD=339.85 ms) and the prenaming phase (M=825.15 ms, SD=245.33 ms) at a similar rate. A significant interaction, however, was revealed for naming and motor ability, $F(1,20)=5.90$, $p=.025$, $\eta^2=.23$. Further pairwise comparison using Bonferroni corrections showed a significant difference only between walkers and the prenaming and postnaming phase (p=.026), indicating walkers looked significantly longer at the postnaming phase (M=1031.25 ms, SD=299.72 ms) compared to the prenaming phase (M=775.25 ms, SD=203.00 ms). This implies walking infants showed recognition of the target word.

A strong significant interaction between naming, trial and motor ability, $F(1,20)=8.75$, $p=.008$, $\eta^2=.30$, was also revealed. Therefore, a further repeated-measure ANOVA was conducted by separating cases by crawling and walking**.** Findings showed a significant interaction between naming and trial, $F(1,15)=7.85$, $p=.013$, $\eta^2=.34$, among crawlers (see figure). Pairwise comparisons revealed that significant differences for crawlers were exhibited in the postnaming phase for known and unknown words (p=.006**)** as well as a marginally significant difference for known words between the prenaming and postnaming phase (p=.060). Analysis indicates crawlers looked longer at unknown words in the postnaming phase (M=1018.89 ms, SD=468.42 ms) in comparison to the prenaming phase (M=821.61 ms, SD= 217.75 ms), but known words were looked at longer in the prenaming phase (M=870.17 ms, SD=416.46 ms) in comparison to the postnaming phase (M=870.17 ms, SD= 416.46 ms). This suggests inaccuracy in parental report measures as crawling infants showed recognition of unknown words but not known words (see Figure 3).

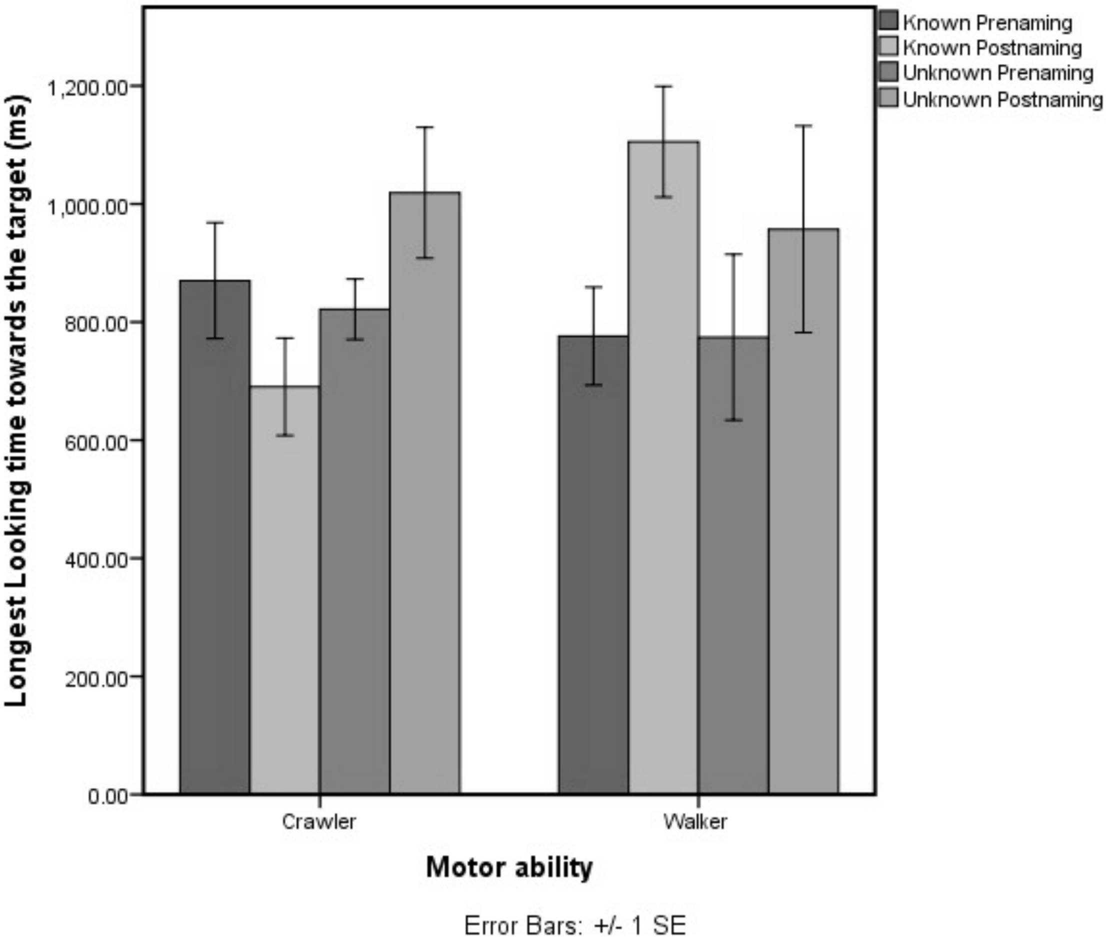

Figure 3: The longest looking time to the target for motor ability (crawler, walker), naming (prenaming, postnaming) and trial (known, unknown).

When examining walking infants, a marginally significant effect was found for naming, $F(1,5)=5.44$, $p=.067$, $\eta^2=.52$, and naming with trial, $F(1,5)=6.22$, $p=.055$, $\eta^2=.55$. A pairwise comparison using a Bonferroni correction showed significant differences ($p=.033$) only for walkers' known words, showing an increase from the prenaming ($M=776.25$ ms, $SD=234.45$ ms) to postnaming phase ($M=1105.28$ ms, $SD=265.61$ ms) in comparison to unknown words, suggesting parents were accurate in estimations of walking infants' word comprehension (see Figure 3).

Vocabulary Influence

Receptive and productive scores for each infant were calculated by adding up all words parents reported their infant to understand and not say yet (Receptive score) and understand and say (Productive score). A total vocabulary score for each infant was calculated by adding up both their receptive and productive scores. A paired samples t-test revealed a significant difference between motor ability and total vocabulary scores, $t(25)=4.56$, $p<.001$, with vocabulary scores found to increase with walking onset (see figure.4), crawling (M=39.67 words, SD=32.00 words) and walking (M = 97.70 words, SD=97.70 words). A paired samples t-test further, showed a significant difference between motor ability and receptive scores, $t(25)=5.30$, $p<.001$, suggesting walking infants (M=82.88 words, SD=62.48 words) knew significantly more receptive words than crawling infants (M=36.11 words, SD=31.61 words). No significant difference was found between motor ability and productive scores, t(25)=1.48, p=.15. Therefore, interpretations can only be made to suggest walking infants had larger receptive vocabulary scores than crawling infants. Pearsons' correlations further showed a positive association was also significant between receptive and productive scores r(26)=.67, p <.001, suggesting infants with a greater receptive vocabulary also had a larger productive vocabulary.

A naming score was created using the difference 'post naming scores' minus 'prenaming scores' for the proportion of looking time and longest looking time for both known (Kpostpredifference / KLkdifference) and unknown (Upostpredifference /ULkdifference) trials. Pearson's correlation showed that not only was total vocabulary scores positively correlated with the known postprenaming difference r(26) =.52, p=.006, but also positively correlated with the unknown postprenaming difference r(26)=.47, p=.016 in regards to proportion of looking time. This suggests that the number of known and unknown words infants recognised, was larger with a greater vocabulary score. Additionally, significant interactions were observed between known words for longest looking time postprenaming differences and total vocabulary scores r(26)=.44, p=.026, suggesting the longest looking time to known words was greater among infants with larger total vocabulary scores.

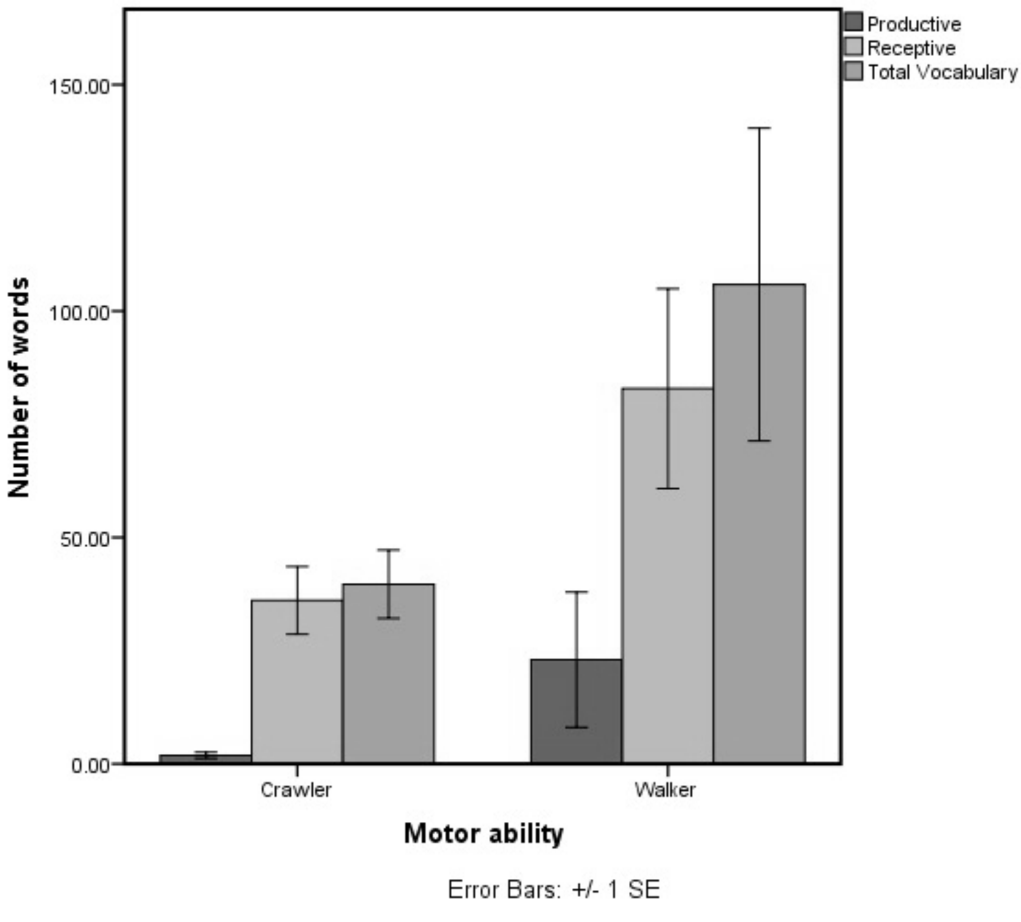

Figure 4: The number of words (receptive, productive, total vocabulary) parents reported crawling and walking infants to understand.

A significant, positive association between age group and productive scores $r(26)=.39$, $p=.049$ was also revealed, implying infants with a larger productive vocabulary were older than those with a smaller productive vocabulary.

Discussion

The goal of the present study was to explore whether vocabulary growth was directly linked to motor development. Another aim was to further examine whether any observed relationship was a consequence of parents' perceptions influenced by locomotor advances, thus shedding light on the accuracy of parental questionnaires. Results highlighted a relationship between language acquisition and motor development showing, with walking onset came an increase in total vocabulary scores among infants. However, such differences were only observed in regards to receptive scores, illustrating that with walking onset came an increase in receptive vocabulary scores. The preferential looking task suggested parents' perceptions of infant vocabulary were influenced by walking onset. Specifically, parents of walking infants were more accurate at reporting receptive words that their infant understood and did not understand, in comparison to parents of crawlers.

The present study supported Walle and Campos' (2014) observations that infant vocabulary scores increased with locomotor development from crawling to walking. An association between receptive and productive scores must also be acknowledged, suggesting, with receptive score increase came a growth in productive scores. Such findings have also been reported by Bates, Bretherton, and Snyder (1988). When examining receptive and productive scores, however, only receptive scores showed an increase with walking onset. This contradicts findings of Walle and Campos (2014), who additionally observed a productive score increase with locomotor status change. One tentative explanation for this conflicting outcome is the limited number of walkers compared to crawlers in the present study sample. Overall mean productive scores were considerably smaller than mean receptive scores, therefore, making any significant motor ability differences among the productive scores difficult to detect.

There are a number of plausible explanations for the outcome illustrating an increase in language vocabulary with walking onset. Such possibilities include additional developmental domain advances, reduced biochemical constraints and socio-environmental alterations, which promote language acquisition (Walle & Campos, 2014). It may be suggested, a third developmental milestone is accomplished as a consequence of locomotor status change, which in turn, enhances language acquisition growth. Aspects of cognitive development have been reported to progress among infants at the age of one (Thelen, 1995). Research shows links between both motor development and language acquisition with increased memory capabilities (Campos, Kermonian, Witherington, & Chen, as cited in Walle & Campos, 2014; Strid, Tjus, Smith, Meltzoff, & Heimann, 2006). It is plausible, walking onset promotes enhancement of such infant cognitive functioning, in turn, increasing infant acquisition of language. Other possible explanations for such an outcome include altered social environments with walking onset, which promotes language growth (Ishak et al., 2007). Research shows parent-infant interactions are increased with walking onset. This is a possible consequence of altered parental perceptions of their infant and increased infant movement (Hendrix & Thompson, 2011). Such environmental alterations may provide a richer linguistic setting for infants, promoting vocabulary growth. The preferential looking task provided greater understanding for the accuracy of the observed motor-language development relationship. However, the contributing factors presented should be considered as the underlying determinants of the promising associations between walking onset and vocabulary growth.

The present study additionally supports the findings of Houston-Price et al's. (2007) preferential looking task. When analysing infants' proportion of looking time and longest looking time to the target image, overall, infants showed similar recognition and, therefore, understanding of both known and unknown words reported by parents. This implies parents were inaccurate when reporting infant vocabulary scores. Although it appears Houston-Price et al's. (2007) findings were reflected, when examining the effects of motor ability on the outcome, interesting observations were noted. Overall, results showed infants looked longer at the postnaming phase than the prenaming phase, suggesting infant recognition of the target word. However, when analysing motor ability differences, only walking infants looked for a longer proportion of time at the target in the postnaming phase compared to the prenaming phase, suggesting understanding as a result of target word onset. Conversely, the proportion of looking time for walkers was only significant for known words in the postnaming phase compared to the prenaming phase. This implies, parents were more accurate in estimating words their walking infant understood, as well as more accurate with reporting unknown words, in comparison to crawling infants.

Examining longest looking time towards the target allowed greater understanding of crawlers' achievements on trials. Interactions regarding naming, trial and motor ability provide reasoning between locomotor status dynamics. Results revealed that crawlers' longest looking time towards unknown words were significantly greater in the postnaming phase compared to the prenaming phase suggesting recognition of unknown words. However, the opposite effect was observed for crawlers' recognition of known words, showing crawling infants looked longer at known words in the prenaming phase in comparison to the postnaming phase. This suggests infants showed no recognition of known words. One tentative explanation for a prenaming to postnaming decrease for known words could be the result of a reduced familiarity to the known target words. Luche et al. (2015) proposed that an initial bias towards the target or distractor in the prenaming phase was due to reduced familiarity to that specific object. Therefore, an increase in initial fixation resulted. Therefore, if infants were less familiar with the known target word, than known distractor, initial attention may be in favour of the unfamiliar target image. Consequently, this suggests, parents of crawlers were inaccurate at reporting their infant's language comprehension in relation to both known and unknown words.

When examining motor ability effects it is evident that, whilst proportion of looking time shows more significant findings for walking infants, longest looking time in contrast, provides greater significant understanding for crawling infants. One tentative explanation for this could be the characteristics of each dependent variable. While proportion of looking time towards the target measures the overall time spent looking at the target in the prenaming and postnaming phase, longest looking time is a measure, representing the longest single fixation towards the target within the trial. Courage et al. (2006), observed that with an increase in age, infants looked longer and therefore, had greater attention towards cartoon images. The present study showed a positive relationship between age and motor ability, implying walkers were older than crawlers. Corresponding with Courage et al's. (2006) observations, the present study's findings showed, walkers looked longer within trials than crawlers. Therefore, data for proportion of time spent looking at the target was potentially not an accurate measure for crawling infants in comparison to walkers. In contrast, it may also explain why the longest looking time data showed greater significant outcomes for crawlers compared to walkers.

When examining the differences between postnaming and prenaming phases, proportion of looking time and longest looking time were greater, in line with larger total vocabulary scores. This is consistent with Brooks and Meltzoff's (2007) longitudinal study findings showing, one year-old infants, who had greater vocabulary growth, looked longer at the target object in comparison to those who had slower vocabulary growth. Such findings imply that preferential looking tasks are a good indicator of vocabulary growth and parental report congruency.

Although findings regarding positive associations between motor ability and vocabulary scores support Walle and Campos' (2014) research, the preferential looking task within the present study highlights possible inaccuracy with parental report measures regarding 9 to 17 month-olds infants' word comprehension. In contrast to proposed outcomes that parents of walkers would overestimate infants' language acquisition, results suggested, parents of walkers were more accurate at understanding and reporting infants' word knowledge than parents of crawlers, proposing a locomotor status effect on parental report accuracy. This may additionally aid understanding of the explosion of language acquisition with walking onset highlighted by Walle and Campos (2014), implying parental perceptions influenced results. As infants develop locomotor skills, parents may develop better intentionality and a more accurate understanding of their infant's comprehension abilities, however, reasoning behind such outcomes in still unclear.

One possibility for this outcome in which parents are more accurate in reporting infant language acquisition with locomotor status change is that increased communication was facilitated and promoted by walking onset. Research by Ishak et al. (2007) showed infants' environmental interactions were altered with walking onset, increasing infant social interactions and promoting parent-infant communication. Such findings are supported by Biringen et al.(1995) who observed parent-infant exchanges improved with locomotor advances. Consequently, increased communication during parent-child interaction may aid parents' skills in distinguishing infant language comprehension.

Another possibility for vocabulary accuracy among parents of walkers is increased parental attention and observation towards infants' with locomotor development. Research shows that walking onset influences parent-child interactions thus, making parents more attuned to their infant's knowledge and interactions (Hendrix & Thompson, 2011). Hendrix and Thompson (2011) observed the positive effects of walking onset on maternal behaviour. Not only were mothers found to increase verbal responses to walking infants in comparison to crawlers (Karasik et al., 2014), but also increase their attention to their infant's physical and psychological cues (Clearfield, 2010). One may propose that such parental changes towards their infants may facilitate parents to become more attuned to infant's comprehension of words, promoting accuracy of vocabulary reports.

Both explanations aid understanding of the motor-language developmental relationship observed in Walle and Campos' (2014) study. This reported increase in infant language acquisition with motor milestone advances may be explained by Walle and Campos' (2014) further observation regarding infants' social environments. Such observations include increased maternal input and altered activity to be key predictors in the language acquisition enhancement, which may promote accuracy of parental vocabulary reports among walkers in comparison to crawlers. It would be beneficial to incorporate naturalistic observations into preferential looking task and parental report studies to effectively examine such possibilities.

It can be interpreted from the preferential looking task that parents of crawlers inaccurately reported the words that their infant understood. Dosso (2013) highlighted the challenge for parents to make assumptions in regards to non-verbal perceptions, as it encourages more subjective estimates. During the time of infant language acquisition growth, it may be difficult for parents to determine the specific words that their infant understands. However, it cannot be assumed that parents' approximate estimations regarding the amount of words that their infant is familiar with, is inaccurate. If parents are able to make consistent judgements about their infant, in comparison to other infants, the differences may still be systematically accurate to a varying magnitude (Mayor & Plunkett, 2011). Therefore, associations observed between total vocabulary scores and motor ability should still be acknowledged, despite the reported preferential looking task findings.

It is important to acknowledge that findings provide implications for the reliability of parental vocabulary reports and aids growing knowledge of the inaccuracy of such measures (Feldman et al., 2000). Not only did the findings tentatively suggest parents to be inaccurate with words that their infant understood receptively, but it proposed other aspects of development, specifically motor advances influenced such parental perceptions. Further research by Houston-Price et al. (2007) supports this concept showing parental inaccuracy in the Oxford CDI report to be a consistent characteristic of British samples across gender types. From observation and discussion with parents on visits to the Babylab and via telephone calls, many parents acknowledged that they felt unsure of whether their reports were accurate or not and thus, were over or under cautious with their vocabulary responses. This could explain such discrepancies between parental reports and the preferential looking task, suggesting parents were aware of their inaccuracies whilst completing the CDI. Therefore, such factors should be acknowledged in future research in order to reduce parents' apprehensions, which might have impacted on the present study's reported outcomes.

Clear methodological limitations are highlighted within this study. Firstly, the design did not predict or take into account the possibility that parents would report that their infant understood only a limited number of words. The initial study design was devised based on the prospect that parents would report their infant to know at least eight words. However, nine parents confirmed that their infant knew less than eight words within the selected target categories. Consequently, future research replicating or expanding on the present study should take this into account and modify the method accordingly.

Secondly on discussion and reflection, some parents acknowledged certain words they marked as known were presented differently in image form to what they perceived their child to associate the word with. (Example: 'milk' associated with breast compared to 'milk' associated with milk in a cup). The present study assumed infants could distinguish and perform mechanisms of categorization (Harnad, 2005). Therefore, if infants understand the word 'car', they should be able to identify a cartoon car with the label 'car'. This assumption was informed by research suggesting at 10 months old, infants are successfully able to categorise and label such objects (Marescal & French, 2000). However, one cannot assume that the infants of the present study were able to successfully categorise the representation of the objects in the preferential looking task. It may have impacted the reported results, if the target object was distinctly different from the object that the parent reported their infant to understand. In order to avoid this problem, it is advisable that future research accounts for this factor within the vocabulary questionnaire. Parents should be asked to report words that they believe their infant understands, and additionally highlight when these words vary from a generalised depiction of the word label.

Although the reported findings imply that walking onset influences parents' accuracy in reporting infant vocabulary, it cannot be determined whether such observations are a direct result of locomotor status change. Future research should explore this notion further. It would be advisable to examine specific environmental effects altered by walking onset to determine whether such changes impact parental report accuracy. These environmental changes include altered maternal behaviour, increased infant-child interactions and advanced maternal verbal cues (Clearfield, 2010). Such factors are reportedly altered by motor milestone advances (Hendrix & Thompson, 2011). Replicating this study would provide greater understanding of the effects of motor ability on parental perceptions of infant capabilities. Furthermore, by incorporating socio-environmental factors through naturalistic observations, the possible direct or indirect interplay between the motor development and language acquisition could be explored in greater depth.

In conclusion, this is the first study to compare parental perceptions of infant comprehension through both parental reports and a preferential looking task in relation to motor ability. It provides further supporting evidence that motor ability increases with language acquisition, proposing a relationship between motor and language development among one-year-old infants. Preferential looking task outcomes, however, raise queries for parental report accuracy and the possible influence that motor ability plays on parents' accurate perceptions of infant vocabularies. The present study therefore, provides initial evidence to suggest infant locomotor status may influence parents' abilities to accurately come to conclusions regarding infant comprehension capabilities. To determine whether language acquisition is a direct response to motor development cascades, or an indirect response to the infants' social environment through parental perceptions, it is arguable that this area within infant developmental research requires greater exploration.

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