"Shhh! We’re Tryin’ to Concentrate": Attention and Environmental Distracters in Novel Word Learning

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ABSTRACT. The authors’ purpose in this study was to evaluate the role of attention, as a central dimension of temperament, in children’s real-time acquisition of novel vocabulary. Environmental distractions were administered to 47 22-month-old children as they acquired novel vocabulary in a fast-mapping task. Two distraction conditions impeded novel word acquisition, but only 1 impeded attention allocation. Attention allocation was correlated with novel word acquisition under conditions of distraction, but not in their absence. Results suggest that attention allocation is especially important for word learning under conditions of distraction. Given that in their day-to-day lives children often encounter new words amid a host of environmental distractions, children with constitutionally fewer attentional resources, such as temperamentally difficult children, may be at a vocabulary-learning disadvantage.

Keywords: attention, language, learning, temperament

CHILDREN WITH ASPECTS OF A DIFFICULT TEMPERAMENT tend to have smaller vocabularies in infancy and toddlerhood and poorer grammatical development in early childhood, relative to children with aspects of a less difficult temperament (Dixon & Shore, 1997; Dixon & Smith, 2000; Karrass, Braungart-Rieker, Mullins, & Lefever, 2002; Kubicek, Emde, & Schmitz, 2001; Morales, et al., 2000; Sajaniemi et al., 2001; Slomkowski, Nelson, Dunn, & Plomin, 1992; Spere, Schmidt, Theall-Honey, & Martin-Chang, 2004). Although the specifics of what constitutes temperamental difficulty varies from researcher to researcher, we define temperamental difficulty as comprising biological predispositions that make children’s day-to-day interactions with their social or physical environments difficult for themselves or others (Putnam, Sanson, & Rothbart, 2002). Such predispositions might include short attention span, social wariness, negative emotionality, perceptual sensitivity, and high intensity responsiveness. Attention span may be a particularly important temperamental component for our understanding of the
link between temperament and language development because it may regulate a number of other dimensions of temperament (Rothbart & Bates, 1998).

Because researchers have begun to report on temperament–language links only recently, most modern models of language acquisition have yet to consider the potential roles of temperament in language acquisition. Perhaps the most promising model within which to couch temperament–language relations is the Emergentist Coalition Model (ECM; Hollich, Hirsch-Pasek, & Golinkoff, 2000). The ECM comprises a complex interplay of various separable component parts working together toward the emergence of language within the child. Included in the model are children’s abilities to develop cognitive constraints presumed to simplify word learning, their abilities to develop sociopragmatic skills that they can use to guide their interpretations of actor intentions when making word-referent associations, and, perhaps most basically, their abilities to employ simple attentional skills for detecting word-referent correspondences. A comprehensive review of the ECM is beyond the scope of this article. However, the utility of this model with respect to the potential roles of temperament is that it attempts to incorporate under a single theoretical umbrella a wide range of otherwise disparate theoretical perspectives, along with their respective empirical findings, with the explicit recognition that vocabulary development is multifaceted and may require a variety of contextual and developmental mechanisms.

Although a case could be made for how various aspects of temperament might contribute to each separate constituency of the ECM, the present investigation focuses on the relation between language acquisition and individual differences in attention allocation. As a component of both temperament and vocabulary acquisition, attention allocation is an appropriate place to begin looking for the origins of temperament–vocabulary associations. First, the light is better here. Attentional dimensions of temperament are always among those found to correlate with language development (Dixon & Shore, 1997; Dixon & Smith, 2000; Karrass, et al., 2002; Kubicek, et al., 2001; Morales, et al., 2000; Sajaniemi et al., 2001; Slomkowski, et al., 1992; Spere, et al., 2004). Second, temperamental attention has been found to correlate with a host of other temperament dimensions.

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also correlated with language development (Gartstein & Rothbart, 2003; Putnam, Rothbart, & Gartstein, 2004; Rothbart, Ahadi, Hershey, & Fisher, 2001; Wolfe & Bell, 2004). Third, despite its own complexity as a theoretical construct, attention allocation is arguably the most basic element of the ECM (Hollich, et al., 2000) and requires the most parsimonious assumptions (Smith, Jones, Yoshida, & Colunga, 2003) of any element of the ECM.

Researchers outside the field of temperament also have had considerable interest in attentional development. Aspects of attention in the nontemperament literature have been linked to language in a variety of contexts. Visual habituation rate in infants (Tamis-LeMonda & Bornstein, 1989), compliance self-regulation in toddlers (Kaler & Kopp, 1990), and working-memory/inhibitory control (Wolfe & Bell, 2004) and internalizing behavior (Carson, Klee, Perry, Muskina, & Donaghy, 1998) in preschoolers, all have been linked to linguistic proficiency. The attention–language connection also has intuitive appeal. It makes sense that children who allocate little attention in the service of processing targeted environmental stimuli, or who are particularly susceptible to environmental distractions while attempting to process targeted environmental stimuli (Bloom, 1993; Rothbart & Bates, 1998; Ruff & Rothbart, 1996), would be disadvantaged in acquiring vocabulary because they would have fewer attentional resources to allocate to the task of detecting word–referent correspondences. In contrast, children capable of engaging in extended focused attention, or inhibiting attention to peripheral environmental distractions, should have larger vocabularies simply by virtue of the available cognitive resources they can bring to bear on detecting word–referent correspondences (Bloom).

However, causal conclusions regarding the attention–language relationship have been preempted because investigations linking the two constructs have incorporated only correlational analyses. A causal argument regarding the impact of attention on language acquisition would necessitate experimentation on children’s attention allocation in the context of real-time, online word learning. Unfortunately, although a great deal of researchers have demonstrated the feasibility of manipulating infants’ and children’s attention allocation under controlled conditions (e.g., Cohen, 2002; Gemenyuk, Korzyukov, Alho, Escera, & Naatanen, 2004; Harman, Rothbart, & Posner, 1997; Higgins & Turnure, 1984; Humphrey, 1982; Lansink & Richards, 1997; Oakes, Kannass, & Shaddy, 2002; Oakes, Tellinghuisen, & Tjebkes, 2000; Richards & Turner, 2001; Ruff & Capozzoli, 2003; Tellinghuisen, Oakes, & Tjebkes, 1999; Turnure, 1970), no researchers have attempted to manipulate children’s attention allocation in the context of word-learning.

In infancy, manifest attention allocation seems to be a product of complex interactions between endogenous and exogenous attentional resources (Oakes, et al., 2002). In one of a series of important attention manipulation studies, Oakes et al. varied target stimulus familiarity, as well as distraction stimulus saliency, to show that infants’ allocation of attention depends on both endogenous and exogenous factors.
They found that in the presence of environmental distractions, 9- and 10-month-olds allocated greater attention to novel target stimuli than to familiar target stimuli, whereas 6.5-month-olds allocated attention to novel and familiar targets equally. The authors suggested that this pattern of results indexed greater endogenous control of attention by older infants than by younger ones because the older infants were capable of inhibiting attention to peripheral distracters in the service of processing novel target stimuli. Oakes et al. also found that latency to attend to peripheral distractions depended on attentional state at distraction onset. In particular, they observed longer latencies to attend to distracters when infants were engaged in focused attention to target stimuli than when they were engaged in casual attention. This finding replicated the authors' own earlier work (e.g., Oakes, et al., 2000; Tellinghuisen, et al., 1999) and corresponds with findings from other researchers (e.g., Lansink & Richards, 1997).

Our purpose in the present investigation was to extend the attention manipulation paradigm to a word-learning context to explore whether manipulating children's attention would affect word learning. We hypothesized that if environmental distractions could be arranged to co-occur with novel word learning, not only would novel word learning performance be compromised generally, but the extent of the compromise would vary as a function of the amount of attention allocated to the word-learning episode. Thus, we addressed two primary questions. The results of this study have implications for the role of attention allocation in word learning and provide one explanation for why temperamentally difficult children have smaller vocabularies than do children with easy-going temperaments. The first question we addressed was whether the presence of environmental distracters would impede vocabulary acquisition. In school-aged children (Higgins & Turnure, 1984; Turnure, 1970;) and in preschoolers and infants (Ruff & Capozzoli, 2003), environmental distracters adversely affect basic problem-solving ability. Environmental distracters compete with focal problem-solving tasks for children's attention and probably even disrupt their perceptual processing or cognitive appraisals of the target problem-solving task (Lansink & Richards, 1997; Richards & Turner, 2001). The present study adds to this literature by examining the effects of environmental distractions on linguistic problem solving. In this regard, word learning is viewed as a type of problem-solving task in which adequate attentional resources for successful problem resolution (i.e., learning a word) are required. Thus, when environmental distracters are presented during bouts of word learning, and there is a consequent reduction in endogenous attentional resources for word learning (i.e., for detecting word–referent associations), word learning should be just as negatively impacted as performance in any other problem-solving task.

The second question addressed by the present study was whether individual differences in the allocation of endogenous attention during a word-learning trial would predict word-learning performance during that trial. In particular, we expected that children who engaged in greater focused attention would perform
better than children who engaged in less focused attention. As in other studies (e.g., Oakes et al., 2002), we assumed that focused attention toward target stimuli would be a function of endogenous attention allocation. We further assumed that individual differences in children's abilities to maintain attentional focus, despite the presentation of peripheral distracters, was a function of individual differences in the attentional aspects of children's temperament.

**Integration of the Attention Manipulation and Fast-Mapping Paradigms**

**Fast Mapping**

To test for the effects of environmental distractions on word learning, we created a hybrid paradigm in which an attention manipulation protocol was crossed with a fast-mapping (word-learning) protocol. We assessed novel word learning by using the general procedures of the fast-mapping task described by Mervis and Bertrand (1994), which is a well-accepted paradigm for implementing fast mapping. The procedure for this task consisted of three phases. During the initial, **familiarization** phase, children were familiarized with a group of objects presented on a tray, consisting of one novel and four known exemplars. After about 1 min of familiarization, the second, or **comprehension**, phase began when children were asked for first a known and then a novel (or first a novel and then a known) object. Only one known object was requested per tray (selected randomly at the onset of the study).

To illustrate, a child might have been presented a tray containing a ball, a hairbrush, a cup, a shoe, and the novel object (e.g., a pastry blend). After being allowed to explore the objects for 1 min, the child might have heard “Jimmy, can you give me the ball? Where's the ball?” Subsequently, the child might have heard, “Jimmy, can you find the Dax? Where’s the Dax?” Novel labels consisted of nonsense, single-syllable words, such as “Dax,” “Noop,” or “Tuz,” and were identical to those employed by Mervis and Bertrand (1994). If a child was successful in selecting the novel object, the experimenter labeled the object three more times with the same novel label while the child continued to explore the object. If a child failed to select the novel object, the experimenter handed it to the child and applied the novel label three more times, again allowing the child to explore the object while the labels were applied.

During the third and final, **generalization** phase, children were once again presented with the same four known objects, but this time two new novel objects were presented. One was a new but taxonomically related version of the previous novel object (i.e., a categorical extension) and one was an altogether unrelated novel object serving as a foil. For example, if a pastry blend served as the novel object during the exposure and comprehension phases, then a new pastry blend was presented alongside an unrelated novel foil (e.g., a turkey baster) during generalization. This new pastry blend, then, served as a novel version of the novel...
object, but it maintained a taxonomic relationship to the original pastry blend because they were both pastry blends. During this generalization phase, children were asked one last time for the novel object (e.g., “Jimmy, can you find the Dax? Where’s the Dax?”). To successfully generalize, children had to apply the recently learned novel label to the new novel object.

Each learning trial consisted of a familiarization phase, a comprehension phase, and a generalization phase. Two complete word-learning trials were presented in each of the attention manipulation conditions. Both the known and novel exemplars varied from trial to trial, with a completely unique set of exemplars designated for every tray.

Attention Manipulation

Children’s attention during fast mapping was manipulated in two general ways. First, integral to the fast mapping task itself was a manipulation that was presumed to increase the endogenous attentional burden without drawing on exogenous attentional resources. In this manipulation, which was labeled the cognitive distraction condition, the number of known objects was increased by 50% (raising to six the number of known objects placed alongside the novel object). We expected that children’s allocation of attention to the stimulus objects in this task would increase, relative to baseline, by virtue of the fact that there were simply more objects to which children could attend. We expected word-learning performance in this task to decrease, relative to baseline, because the increased complexity of the stimulus array made identification of the novel object more difficult.

Second were two forms of distraction that were grouped together under the rubric of sudden onset distractions. In both cases, a salient environmental event took place suddenly and without warning. As Oakes et al. (2002) noted, sudden onset distractions tend to elicit automatic attention allocation, but we expected the speed of attention allocation to vary as a function of children’s temperament. These sudden onset distractions were expected to draw on exogenous attention, and consequently to reduce resources available for children’s endogenous attention to target stimuli. We expected children who performed well under these conditions to be those particularly high in endogenous attention, because such children should theoretically be better able to tune out distractions and maintain better focus on the target task than should children low in endogenous attention (again, reflecting an aspect of children’s temperament). We selected two types of sudden onset distracters to represent two different kinds of distractions children encounter in their day-to-day social and physical environments.

A social distraction condition was identical to the baseline condition except that at the onset of the first comprehension phase, a “stranger” (i.e., a female confederate) walked into the experimental room, addressed the child by name, and informed the child that she would be reading Green Eggs and Ham by Dr. Seuss.
She then walked past the child, sat down on a small sofa behind the child, and read the book aloud, ostensibly to herself. This procedure was designed to provide socially relevant background noise of the sort children might normally encounter in waiting rooms, childcare centers, or crowded homes, but not to provide direct interference between the child and experimenter.

A mechanical distraction condition roughly paralleled the social distraction condition, except that rather than a stranger suddenly walking into the room, a mechanical dancing Jar-Jar toy (from the Star Wars movie) suddenly turned on. The toy was behind a two-way mirror, directly across from the experimental table and in full view of the child when looking straight ahead. Despite being behind the mirror, the toy was clearly visible and audible when turned on.

Method

Participants

Forty-nine infants (24 boys and 25 girls) and their mothers visited the laboratory in a rural, northwest Ohio town when the infants were aged 22 months ($M = 22.00, SD = .87$). Names of babies were pulled from newspaper birth announcements, and the addresses and phone numbers of their parents were determined from the local telephone directory. Parents were contacted first by letter and then by phone. All children were European American, with the exception of one girl identified by her mother as multiracial. Families were generally of lower-middle class status and from a fairly homogeneous White, rural, working class population. Mothers remained with their babies throughout the visit, with most infants seated in their mothers’ laps. All sessions were videotaped.

Fast-Mapping Task

Distraction conditions. We implemented two fast-mapping trials (i.e., two different novel words were taught) under each of the four conditions of distraction. Each trial lasted about 2 min, including the 1-min familiarization period. We implemented the social and mechanical distraction conditions as a between-subjects manipulation, so only half of the children participated in each of these conditions. We treated the social versus mechanical distraction conditions as a between-subjects manipulation because it was not possible to anticipate the extent that the suddenness of onset of these distracters might generate anxiety, which might then carry over into subsequent conditions. Preliminary testing revealed that 2 of 5 pilot children appeared anxious in response to the mechanical distracter, but as it turned out, these were the only children in the entire sample to show signs of apprehension during any part of the experimental procedure. However, all children experienced the baseline and cognitive distraction conditions prior to experiencing either sudden onset distraction condition.
During the no-distraction baseline condition, as in all other distraction conditions, children underwent two fast-mapping trials. Performance in this condition functioned as a control and served as the point of comparison for performance in all other distraction conditions. The cognitive distraction condition was identical to baseline, except that six known objects were presented alongside the novel object instead of four.

The procedure in the sudden onset distraction conditions differed from the baseline and cognitive distraction conditions because the sudden onset distracters needed to be timed with the events of the fast-mapping task. Thus, in the social distraction sudden onset condition, the stranger entered the room at the onset of the comprehension phase of the first word-learning trial. While the stranger was reading *Green Eggs and Ham*, the experimenter proceeded through the rest of the comprehension phase and the generalization phase of the first word-learning trial, as if the stranger were not there. The stranger left the room upon completion of the generalization phase of Trial 1 and returned once again at the onset of the comprehension phase of Trial 2. Similarly, the onset of the mechanical toy was timed to coincide with the onset of the comprehension phase of Trial 1. There were, however, three structural differences between the social and mechanical distraction conditions that resulted from the fact that the mechanical toy was not self-propelled and could not walk into the room: (a) the toy was not in the same room as the child at the onset of the distraction, (b) the toy appeared in front of the child (whereas the stranger sat behind the child), and (c) the toy turned itself off automatically after Jar-Jar completed his dancing routine (roughly 1 min) and remained off until the beginning of the comprehension phase of the second word-learning trial.

**Novel objects and labels.** We used the same novel exemplars and labels as those used by Mervis and Bertrand (1994). Mervis and Bertrand classified objects as novel based on the criterion that no more than one 5-year-old child in a 10-child panel could generate the name of the object. Target novel objects (i.e., those to which we applied novel labels in both the comprehension and generalization conditions) included honey dippers, toothbrush holders, pastry blends, bottle stoppers, hand-held strainers, and garlic presses. Foil objects, respectively, included a stick-up hook, a soap dish, a closet hook, a hose connector, a bottle opener, and a turkey baster. Novel labels included *dax*, *noop*, *bem*, *tiv*, *gip*, and *tuz*, respectively. Like Mervis and Bertrand, we selected known objects based on the basis of MacArthur Communicative Development Inventory norms (Fenson, Dale, Reznick, Bates, & Thal, 1994) and included a flower, a block, a brush, a banana, a ball, and keys, among others.

**Procedural differences.** It should be noted that although we generally followed Mervis and Bertrand's (1994) fast-mapping procedure, we increased the difficulty of our protocol because our participants were several months older than were Mervis and Bertrand's participants. Specifically, we enhanced task difficulty by teaching the novel label only once per word-learning trial. In their
study, Mervis and Bertrand taught the novel label during both the exposure phase and the comprehension phase. In our study, we taught the novel label only during the comprehension phase. The practical result of this procedural change was that during our generalization phase, we asked children to generalize after only one word-referent mapping, whereas in Mervis and Bertrand’s generalization phase, children were asked to generalize after two word-referent mappings. Examination of the mean performances on this task revealed that children generally performed in the middle to low-middle range (Table 1), suggesting that our task was neither too hard nor too easy.

**Scoring.** Two independent coders (trained to 90% reliability on roughly 25% of the sample) scored children’s novel word performance during both the comprehension and generalization phases, using a 5-point scale indexing children’s success in responding to the request for an object. We defined reliability as the ratio of the number of agreements over the total agreements plus disagreements. Post-scoring reliability on 10% of the sample remained above 90%. We used a 5-point scale, as opposed to a yes–no scale, because children did not always clearly select the requested object. For example, children sometimes touched other objects on their way to a requested object, even though they ultimately may have handed the requested object to the experimenter. In this case, a child might have been given a score of “4,” rather than a “5,” because his or her behavior did not unambiguously indicate selection of the requested object. The rating scale was anchored by a score of 5 (child clearly and unambiguously demonstrated knowledge of the requested object and selected the requested object without hesitation), and a score of 1 (child did not respond to the object request).

**Attention Allocation Measures**

We extracted measures of attention allocation from children’s attentional behaviors exhibited during the comprehension phase of the fast mapping task. The measures of attention allocation were adapted from procedures described in the Laboratory Temperament Assessment Battery (LabTAB; Goldsmith & Rothbart, 1996), a lab-based measure of multiple dimensions of children’s temperament. Scoring of attention began during the comprehension phase at the moment the experimenter requested either the known or the unknown object, whichever came first, and ended at the completion of the comprehension phase. As derived from the LabTAB, our measures of attention included: (a) intensity of facially displayed interest upon presentation of the stimuli (as judged on a 3-point scale; 0 = no facial region shows codable facial interest, 1 = codable low-intensity interest, 2 = definite codable interest), (b) duration of looking at the stimuli upon presentation (measured in intervals; 0 = does not look at all, 1 = 1–4 s, 2 = 5–8 s, 3 = 9–10 s, 4 = more than 10 s), (c) latency to disengage visually from the objects after presentation (in actual seconds), and (d) length of object manipulation (including touching, holding, or mouthing), measured in intervals as in duration.
of looking. For facial interest, which was not a discrete variable, we recorded the highest level exhibited during the trial.

Two independent coders were trained to 90% reliability on each attention allocation measure across roughly 25% of the sample. We determined interobserver reliability for all measures except latency to disengage by calculating the ratio of the number of agreements over the number of agreements plus disagreements. We calculated reliability for latency to disengage in the same way, except that we permitted a window of ± 1 sec. Posttest reliability on 10% of the sample showed that the coders maintained at or above 90% agreement.

Results and Preliminary Discussion

Table 1 shows the means and standard deviations of the fast-mapping scores; Table 2 shows descriptive statistics for the attention measures.

Collapsing Across Sudden Onset Distraction Conditions

A first question of interest was whether our two sudden onset environmental distracters differentially impacted novel word acquisition or attention allocation. A test for differences in word learning as a function of type of sudden onset distracter revealed no main or interaction effects of these two distraction conditions on novel word learning. A test for differential impacts of the sudden onset distractions on attention allocation revealed that attention allocation also was not differentially associated with the social versus mechanical sudden onset distracter. Because the two sudden onset distraction conditions appeared not to impact children differentially, we collapsed performance across the social and mechani-

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<th>TABLE 1. Mean Fast-Mapping Performance as a Function of Distraction Condition and Word Learning Phase</th>
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Note. $N = 48$. 

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collapsing of variables resulted in a complete within-subjects design, consisting of a 3 (distraction condition: baseline versus cognitive distraction versus sudden onset distraction) × 2 (phase: comprehension versus generalization) repeated measures design with 6 cells. For the sake of brevity, data were collapsed across the two word learning trials.

**Fast Mapping**

One of our primary goals in the present study was to explore whether environmental distractions would impact novel word learning. Although we expected that environmental distractions would impede word learning, the extent of such an effect was not known, and neither was the extent that any distractions might interact with the word learning phases or trials. We expected that sudden onset distraction would negatively impact word learning in the comprehension phase more so than in the generalization phase, simply because the distracter was presented during the former and not the latter. To explore the effect of distracters on word learning, we conducted a 3 (distraction condition) × 2 (phase) repeated measures analysis of variance (ANOVA), with fast-mapping performance as the dependent variable (see Table 1). Results revealed significant main effects for both distraction condition, $F(2, 46) = 4.85$, $p = .012$, $\eta^2 = .17$, and phase, $F(1, 47) = 33.52$, $p < .000$, $\eta^2 = .42$. Evaluation of the marginal means for distraction condition indicated that, as expected, children learned the novel words significantly more poorly under conditions of distraction than in baseline. Sidak-adjusted (Sidak,
post hoc comparisons further revealed that performance in the cognitive distraction ($p = .055$) and sudden onset distraction ($p = .017$) conditions was significantly lower than in baseline. Word learning did not differ between the two distraction conditions.

Evaluation of the marginal means for phase indicated that word learning was significantly better during generalization than during comprehension. This finding was commensurate with the results of Mervis and Bertrand (1994), whose most developmentally advanced children performed better during generalization than during comprehension. It was reasonable to expect children in the present sample to display a pattern of performance similar to Mervis and Bertrand’s most developmentally advanced children, given that the children in our study were older than were the children in Mervis and Bertrand’s study.

However, as can be seen in Table 1, a significant interaction effect qualified the two main effects. In particular, the effect of environmental distraction depended on the fast mapping phase of the fast-mapping task, $F(2, 46) = 3.63$, $p = .034$, $\eta^2 = .14$. Surprisingly, the effects of distraction were limited to novel word generalization (see Figure 1). Presentation of the distracters did not seem to adversely impact word learning during initial comprehension. Sidak-adjusted post hoc analyses revealed that during generalization, children performed significantly more poorly in the sudden onset distraction condition ($p = .008$) than they did in baseline, although cognitive distraction performance did not differ from baseline. This finding suggests that any deleterious effects of environmental distractions on word learning may not appear immediately, but may instead exhibit a “sleeper effect” in which generalization to new exemplars is most affected.

This pattern of findings in which the poorest performance occurred in the last condition raises the possibility that the interaction effect of distraction condition by fast mapping phase was confounded with fatigue. However, recent modifications of this procedure in which order of distraction conditions were reversed, failed to eliminate the effect of distraction condition (Dixon, Salley, & Clements, 2006), thus eliminating fatigue as a possible explanation.

Attention

Coherence among the attention allocation measures. As already described, there were four measures of attention allocation assessed within each of the 3 environmental distraction (baseline, cognitive, sudden onset) x 2 fast mapping phase (comprehension and generalization) cells. Correlational analyses revealed that the attention measures clustered together quite tightly within each cell. Intraclass correlations (i.e., between the four attention allocation measures within each of the six cells) were all highly significant, with $rs$ ranging from .46 to .98, and all $ps < .001$. For purposes of parsimony, we combined the four measures into a
single multivariate attention allocation measure, which served as the basis for all of the following attention allocation analyses.

*Environmental distraction and attention allocation.* The primary question of interest pertaining to the attention measures was the extent to which attention allocation would be impacted by environmental distractions. We expected that the distracters would impact attention allocation in a manner that paralleled word learning. Multivariate analyses of variance (MANOVAs) revealed that although the environmental distractions impacted attention allocation, the pattern of impact differed from that of word learning. A 3 (distraction condition) \( \times \) 2 (phase) repeated measures MANOVA revealed that there was indeed a significant main effect of distraction condition on attention allocation, \( \Lambda = .61, F(8, 36) = 2.94, p = .012, \eta^2 = .40 \). However, evaluation of the marginal means revealed that this effect was contrary to the predicted direction (see Figure 2 and Table 2). We expected that attention allocation in the cognitive distraction condition would be
higher than in baseline because of the additional stimuli children were expected to process, but attention allocation in this condition was significantly lower than in baseline. Follow-up Sidak-adjusted post hoc comparisons revealed higher scores in baseline than in cognitive distraction for two of the attention measures: facial interest ($p = .062$) and duration of manipulation ($p = .001$).

The finding that attention allocation to the word learning stimuli during sudden onset distraction did not show a decline relative to baseline was particularly surprising. A tentative explanation for this finding was that experimenters actively implored children to attend to the objects during the sudden onset distractions, which may have compensated for the distracting effects of the distracters. We evaluated this possibility by quantifying the number of times children looked at the experimenter during baseline versus sudden onset distraction. We reasoned that if experimenters more actively recruited children’s attention during sudden onset distraction than in baseline, they would be successful in gaining it, and this effect would be evidenced by children looking at experimenters more frequently during sudden onset distraction.
Children's eye contact to the experimenters was scored by two coders who were trained to 90% reliability across 10% of the sample, and who maintained 90% reliability on a different 10% of the sample upon scoring completion. A 2 (distraction condition) x 2 (phase) repeated measures ANOVA revealed that children actually made fewer looks to the experimenters during sudden onset distraction than during baseline, $F(1,43) = 29.99, p = .000; M_{\text{baseline}} = 1.83, SD = .21$ versus $M_{\text{sudden onset}} = .92, SD = .13$. Although these data do not show that experimenters did not more actively recruit children's attention during sudden onset distraction, they do suggest that children paid less visual attention to experimenters during sudden onset distraction than during baseline. In any case, it appears that the relatively high level of attention allocation during sudden onset distraction did not result in group-level word-learning advantages compared with baseline, and calls into question the simple assumption that environmental distractions adversely impact word learning by virtue of their effects on attention allocation.

As shown in Table 2, there was also a significant main effect of fast-mapping phase on attention allocation, $\Lambda = .38, F(4, 40) = 16.61, p = .000, \eta^2 = .62$. Evaluation of the marginal means revealed that attention allocation was significantly higher during generalization than during comprehension. Children tended to pay more attention to the stimulus objects when they were asked to map a recently learned novel label to a new novel object than when they were asked to map a novel label to a novel object in the first place. This pattern of attention allocation corresponds with fast-mapping performance in that word learning was also higher during generalization than comprehension. There were no Distraction Condition x Word-Learning Phase interaction effects for attention allocation.

**Attention Allocation as a Predictor of Word Learning**

The fact that the pattern of results for the attention data did not map neatly onto the pattern of results for the word-learning data raises questions about the assumption that environmental distractions negatively impact word learning by way of their negative impact on attention. Indeed, it seems striking that children's attention was not adversely affected in the sudden onset distraction conditions. Still, the fact that as a group, children's patterns of attention allocation did not match their patterns of word learning does not mean that individual differences in attention allocation do not predict individual differences in word learning. To test for this latter possibility, we conducted correlations between attention allocation and word learning performance. For ease of presentation, we collapsed data across fast-mapping phase (see Table 3).

The pattern of correlations presented in Table 3 reveals that the strongest correlations between attention allocation and novel word learning were obtained in the cognitive distraction condition. That is to say, attention to the objects during the cognitive distraction condition was correlated with word
learning in the cognitive distraction condition, whereas attention allocation during the baseline and sudden onset conditions was not robustly associated with word learning during those same conditions, respectively. (Note, however, that attention during cognitive distraction was predictive of word-learning performance during the sudden onset distraction conditions.) Thus, it appears that attention allocation is a significant predictor of word learning in some circumstances. To be predictive, attention allocation may need to be assessed under conditions of attentional burden such as is found in the cognitive distraction condition, but not when the attentional burden comes in the form of a sudden onset distracter. Sudden onset distracters may tap into emotion-regulating aspects of attention that are not particularly relevant for predicting word learning in the presence of those distracters. In contrast, attention allocation in the presence of nonsudden onset attentional burdens may predict word learning, even carrying over to predict word learning during sudden onset environmental distractions. This finding is consistent with Rothbart and Bates' (1998) suggestion that attention allocation indexes an overarching executive control system that regulates emotional expression, because children who were highly focused in the cognitive distraction condi-

<table>
<thead>
<tr>
<th>Attention measure distraction</th>
<th>Baseline</th>
<th>Cognitive distraction</th>
<th>Sudden onset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facial interest</td>
<td>.37**</td>
<td>.30*</td>
<td></td>
</tr>
<tr>
<td>Duration of orientation</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Latency to respond</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration of manipulation</td>
<td>.26+</td>
<td>.39**</td>
<td>.52+</td>
</tr>
<tr>
<td>Cognitive distraction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facial interest</td>
<td>.35*</td>
<td>.49**</td>
<td></td>
</tr>
<tr>
<td>Duration of orientation</td>
<td>.43**</td>
<td>.50**</td>
<td></td>
</tr>
<tr>
<td>Latency to respond</td>
<td>.28*</td>
<td>.42**</td>
<td></td>
</tr>
<tr>
<td>Duration of manipulation</td>
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<tr>
<td>Sudden onset distraction</td>
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<td>Facial interest</td>
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<td>Duration of orientation</td>
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<td>Duration of manipulation</td>
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</tbody>
</table>

Note. Empty cells represent nonsignificant correlations.

*p < .10. *p < .05. **p < .01.
tion were able to learn words in the presence of sudden onset distracters better than were other less focused children.

Nevertheless, the amount of attention children allocated to word-learning stimuli during baseline was also not predictive of their ability to acquire novel words in that context. One possible explanation for this finding is that under minimal conditions of distraction, minimal attention suffices. All that might be required to learn and generalize a novel label under nondistracting conditions is minimal attention allocation, beyond which any further attention allocation fails to further enhance novel word-learning performance. In this case, individual differences in endogenous attention allocation due to temperamental variability may add statistical noise and mask underlying attention-vocabulary relations.

**Analysis of the Known Words**

As a check on our procedure, we conducted the same general analyses as just described on children's comprehension of the known words. We expected that children's comprehension of known words would surpass their comprehension of novel words. This was indeed the case. A 3 (distraction condition: baseline, cognitive, versus sudden onset) x 2 (word level: known versus unknown) repeated measures ANOVA revealed a significant and very large main effect for word level, $F(1, 47) = 205.99, p = .000, \eta^2 = .81$, which was qualified by a significant Distraction Condition x Word Level interaction effect, $F(2, 94) = 7.04, p = .001, \eta^2 = .13$. The locus of this interaction can be traced to the simple main effect of distraction condition on known words, which we did not obtain among novel words. Specifically, Sidak-adjusted post hoc analyses revealed significant differences in known word performance between the baseline and sudden onset distraction conditions ($M_{\text{baseline}} = 3.95, SD = .18$ vs. $M_{\text{sudden onset}} = 2.91, SD = .24, p = .002$), and between the cognitive and sudden onset distraction conditions ($M_{\text{cognitive}} = 3.56, SD = .23$ vs. $M_{\text{sudden onset}} = 2.91, SD = .24, p = .040$), but not between the baseline and cognitive distraction conditions. There were no effects of distraction condition on novel word performance during the comprehension phase.

To explore whether individual differences in attention allocation were predictive of known-word comprehension, we conducted correlational analyses within each of the six cells. Children's attention allocation during a particular word learning trial was unrelated to their known-word comprehension during that trial, or any other trial. A lack of association is consistent with what one might expect if attention allocation is taken as particularly important during initial word learning. That is, when words are being learned for the first time, attention allocation to word-learning stimuli is a significant predictor of word-learning success. However, when words are already known, attention allocation to word-learning stimuli is less predictive, or, in the present case, unpredictable.
General Discussion

In an effort to better understand the nature of the temperament–vocabulary relations reported in the literature, we focused our investigation on individual differences in endogenous attention allocation as an underlying mechanism for word learning. We viewed attention allocation as a central construct of interest not only because of its role as a temperament dimension, but because of its potential role as a regulator of many other temperament dimensions. Specifically examined were the relations between environmental distractions, attention allocation, and online, real-time novel word acquisition. We hypothesized that environmental distractions would inhibit novel word learning generally, but also that the amount of attention allocated during a given word learning trial would covary directly with success in learning the word. We found evidence in support of both hypotheses.

First, the environmental distractions employed in the procedure were found to reduce novel word learning significantly as compared with performance under nondistraction conditions. When children were required to process additional environmental stimuli, such as during the cognitive distraction condition, or when they were required to reckon with the sudden appearance of a stranger or a mechanical toy, novel word learning was adversely affected. However, this finding was tied to novel word generalization, and not initial comprehension. Environmental distractions impeded the generalization of recently acquired novel labels, but not initial comprehension of them.

This pattern of influence is especially interesting because the distractions had little impact during initial comprehension. One possible explanation for this sleeper effect may be that any word–referent mappings taking place during the comprehension phase of fast mapping, while environmental distractions are presented, are insufficiently incorporated into long-term memory. If children could not consolidate their word–referent mappings into memory upon initial exposure, their subsequent efforts to generalize novel words may have failed simply because of inadequate retrieval cues. This possibility is consistent with the further finding that children who allocated the greatest amounts of attention in the presence of distractions both learned and generalized novel words better than did children who allocated less attention.

Our manipulation of children’s attention across the distraction conditions did not confirm expectations: Children failed to exhibit a drop in attention allocation to target stimuli when they were exposed to sudden onset environmental distractions. This was surprising. Considerable literature attests to the attentional disruptiveness of environmental distractions (Higgins & Turnure, 1984; Lansink & Richards, 1997; Oakes, et al. 2002; Oakes, et al. 2000; Richards & Turner, 2001; Ruff & Capozzoli, 2003; Turnure, 1970), especially sudden onset ones. We expected our sudden onset distractions to be similarly disruptive to children’s attention.
However, a number of factors attenuating the disruptiveness of environmental distractions have also been identified in this same literature. For example, Oakes et al. have pointed out that the distractiveness of a distracter can depend on the attentional state of the child (Oakes et al., 2000), the child's familiarity with target stimuli (Oakes et al., 2002), and the relative saliency of the distracter stimulus vis-à-vis the target stimulus (Tellinghuesen et al., 1999). Generally speaking, children are less distractible when they are engaged in focused attention, when they are engaged with novel stimuli, and when environmental distractions are relatively simple or relatively persistent. In the present study, children may also have been less distractible by virtue of the attention-getting efforts put forth by the experimenter in the sudden onset condition, but if so, they did not validate the attention-getting efforts of the experimenter by looking in the experimenter's direction.

Several researchers have also described an attention-mobilizing phenomenon in which the presentation of environmental distractions can have the paradoxical effect of increasing children's attention to focal target stimuli (Higgins & Turnure, 1984; Ruff & Capozzoli, 2003; Turnure, 1970). This seems to be a poorly understood finding. The extent to which a form of attention mobilizing might have taken place in the present data is unclear. Although our word-learning stimuli were relatively novel and afforded focused attention overall, an attention-mobilizing effect should have resulted in heightened attention to the word-learning stimuli during the cognitive distraction condition in which the complexity of the stimulus was increased by adding two more objects, but this did not occur. Nevertheless, attention mobilization may have taken place during sudden onset distraction, which may explain why children's attention allocation appeared to be unaffected in this condition, as well as why children's eye contact to the experimenter was relatively low.

If attention mobilization did take place, then one possible source of the mobilization may have been general autonomic arousal. The rapid appearance of the sudden onset distracters may have aroused children not only to the point of mobilizing their attention to the stimulus objects, but also to the point of preventing them from establishing word-referent relations in long-term memory—perhaps an infant version of the Yerkes-Dodson law (Yerkes & Dodson, 1908). This autonomic arousal hypothesis is further supported by the fact that even children's known-word performance dropped significantly during sudden onset distraction, which would be expected if children were aroused by the distracters. Further research using the attention-manipulation paradigm should attempt to identify the extent that complex, real-life, sudden onset distracters mobilize the attention of toddlers to focal target stimuli, as well as the conditions in which they fail to do so.

Given that temperamentally difficult children tend to have shorter attention spans (Gartstein & Rothbart, 2003; Putnam et al., 2004), these data support the general contention that one reason temperamentally difficult infants tend to have smaller vocabularies is that they have fewer attentional resources to allocate to...
word-referent mappings. Although children in the present study were not classified as temperamentally difficult per se, analysis of the individual differences in their patterns of attention allocation showed that children who allocated the least attention during the cognitive distraction condition learned words most poorly in that condition as well as in the sudden onset condition. To the extent that difficult children have shorter attention spans, it stands to reason that they would be disadvantaged in acquiring novel words, particularly when such acquisition takes place in the presence of environmental distractions.

The present findings also add to the literature linking crowded home environments to negative developmental outcomes (Evans, Maxwell, & Hart, 1999; Matheny, Wachs, Ludwig, & Phillips, 1995). Evans et al. reported that parental speech to children in crowded homes was relatively impoverished compared with that in less crowded homes, and suggested that this impoverished language may play an important role in linguistic and cognitive developmental outcomes. Our findings introduce the additional possibility that the presence of environmental distractions, typical of overcrowded and chaotic environments, may themselves negatively impact language outcomes. Accordingly, children with the highest levels of endogenous attention may be most strongly buffered from the distracting conditions of overcrowded and chaotic homes.

**AUTHOR NOTES**

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