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# Temperament, Distraction, and Learning in Toddlerhood

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## Abstract

The word and non-word learning abilities of toddlers were tested under various conditions of environmental distraction, and evaluated with respect to children's temperamental attentional focus. Thirty-nine children and their mothers visited the lab at child age 21-months, where children were exposed to fast-mapping word learning trials and nonlinguistic sequential learning trials. It was found that both word and nonword-learning was adversely affected by the presentation of environmental distractions. But it was also found that the effect of the distractions sometimes depended on children's level of attentional focus. Specifically, children high in attentional focus were less affected by environmental distractions than children low in attentional focus when attempting to learn from a model, whereas children low in attentional focus demonstrated little learning from the model. Translationally, these results may be of use to child health-care providers investigating possible sources of cognitive and language delay.

## Temperament, Distraction, and Learning in Toddlerhood

The fields of temperament and cognitive development have followed long and productive paths, even though they seem to have done so in relative isolation from one another. Temperament researchers have made strides in identifying the nature of early temperament and its potential biological underpinnings, and they have identified a host of social-emotional sequelae of early individual differences in temperament (e.g., Guerin, Gottfried, Oliver, & Thomas, 2003; Molfese & Molfese, 2000). Cognitive development researchers have also made significant strides toward understanding basic mechanisms underlying attention (e.g., Colombo, 2004; Richards, 2004; Rose, Feldman, & Jankowski, 2004; Ruff & Rothbart, 1996) and memory (e.g., Bauer, 2004; Hayne, 2004), among other cognitive domains. Unfortunately, few researchers have undertaken empirical efforts to document interrelations between temperament and basic cognition (e.g., Wolfe & Bell, 2004); although Fagen and colleagues have amply demonstrated that aspects of temperamental fussiness (i.e., affective distress) negatively impact children's performance on cognitive tasks (Fagen, Ohr, Fleckenstein, & Ribner, 1985; Fagen, Ohr, Singer, & Fleckenstein, 1987; Fleckenstein & Fagen, 1994). Much would be gained were researchers able to link individual differences in cognitive function to individual differences in any of a number of domains of temperament, because such an effort would likely inform a better understanding of *intra* domain individual differences.

To the extent that temperament-cognitive relationships have been examined, a major focus seems to have been on temperament-language relationships (specifically vocabulary, e.g.,

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Dixon & Shore, 1997; Dixon & Smith, 2000; Kubicek, Emde, & Schmitz, 2001; Morales, et al., 2000). The general finding in this literature is that infants and toddlers who enjoy receptive and productive vocabulary advantages over others are those who are temperamentally more positive in mood, more adaptable, more soothable, and longer in attention span than others. Although it is not clear why these specific dimensions of temperament are correlated with vocabulary size, it stands to reason that individual differences in attention allocation may at least partially account for the overlap. Attention allocation is often presumed to reflect an overarching *executive control system* which theoretically has implications for both vocabulary and temperament development (cf. Rothbart & Bates, 1998). Specifically, children high in executive control would be better able to both focus attention in the service of learning environmental contingencies, such as happens in making word-referent associations, and in allocating attention in the service of regulating distress or negative emotion more generally, such as happens in various affective subsystems.

Smith and colleagues have underscored the necessity of taking basic attentional principles into account when explaining vocabulary acquisition (Jones & Smith, 2002; Jones, Smith, & Landau, 1991; Kersten & Smith, 2002; Samuelson & Smith, 1998; Smith, 1999; Smith, Jones, & Landau, 1992; Smith, Jones, Landau, Gershkoff-Stowe, & Samuelson, 2002). They argued that in most cases “dumb attentional mechanisms” are sufficient to enable the acquisition of vocabulary because they allow children to detect word-referent correspondences. Consequently, Smith and colleagues have argued that assumptions regarding underlying cognitive or social constraints for word learning (cf. Hollich et al., 2000) are unnecessary, at least early on. But even “smart” constraint theorists (e.g., Carpenter, Nagell, & Tomasello, 1998; Golinkoff, Hirsh-Pasek, & Hollich, 1999) require that children allocate attention to people, sounds, and objects in the environment in order to learn words. So regardless of theoretical perspective, it stands to reason that infants and toddlers who are better able to allocate their attention would be better able to both detect and respond to parental attention-directing efforts during bouts of word learning, as well as to detect and acquire the word-referent mappings their parents expose them to. For these reasons, children with temperamentally long attention spans, would be advantaged in terms of vocabulary.

From a control systems perspective, children high in attention allocation would also score high on dimensions of temperament reflecting positive mood, adaptability, and soothability (Kochanska, Murray, & Harlan, 2000; Rothbart & Bates, 1998), because they would be better able to manage transitions to new environments (adaptability) and to soothe themselves in times of distress (soothability) than children low in executive control. Executive control would also be linked to the regulation of mood to the extent that emotional expression in high executive control children is more easily subordinated to cognitive function than in low executive control children (Chang & Burns, 2005; Derryberry & Rothbart, 1988). Longitudinally, children high in aspects of executive control generally enjoy greater anger control (Kochanska, et al., 2000), coupled with heightened internalization of parental standards and conscience development (Kochanska, Murray, & Coy, 1997; Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996; Kochanska & Knaack, 2003) than children low in executive control. Miceli, Whitman, Borkowski, Braungart-Rieker, and Mitchell (1998) summarized this sentiment in their claim that “Infants who are better organized in terms of the way they react to stimulation and who can modulate their arousal appropriately are likely to have better control of their state changes and their attention. In contrast, poorly organized infants may be forced to use their attentional capacities for regulatory purposes” (p. 121).

By virtue of its ability to regulate emotion in the service of attention allocation, executive control also enables word learning — in at least two ways. First, it regulates the distribution of attention toward the word-learning event, as compared with other events taking place in the environment. Second, it regulates the distribution of attention among elements within the word-learning event, including the target word, the target referent, and any social or intentional cues provided by the social partner. In uncertain or distracting environments in which attentional priorities may be distributed more widely, word learning would be compromised. Word learning would suffer either because attention was not allocated to the word-learning event, or because elements within the word-learning event, though minimally attended to, were not sufficiently processed. This perspective can be understood within the context of Allport's (1989) attention allocation model.

In his model, Allport (1989) argues that the "primary *purpose* of an attentional system must be to ensure the *coherence* of behavior under ... often conflicting constraints" (p. 652). He argues further that "coherent, goal-directed behavior requires processes of selective *priority assignment* and *coordination* at many different levels (motivational, cognitive, motor, sensory)" [and that] "together this set of selective and coordinative processes can be said to make up the effective *attentional engagement* (or attentional *set*) of an organism at any moment" (p. 652, emphases in original). Thus, although it is the goal of an organism to maintain attentional engagement with some object or event of interest, such as is found during word learning, humans and other species have evolved systems that allow attention to be "diverted or overridden by changing external - or internal-events" (p. 652).

In the presence of a word-learning task, then, children who are temperamentally high in approach and/or inhibition, to the extent that they are simultaneously monitoring their surrounding environment for sources of reward or threat, may place low attentional priority on the goal of word learning, and thus fail to learn words under those conditions, or learn them more poorly. Children high in executive control, in contrast, may be better positioned to prioritize attention toward word learning events, and place lower attentional priority on the processing of environmental distractions which might otherwise appeal to the approach or inhibition subsystems, at least compared with children low in executive control. It follows that the extent to which attention gets allocated for the purpose of word learning should, all else being equal, vary as a function of the temperamental profile of the child. Children high in executive control should be able to rapidly attend to and judge the threat potential of environmental disturbances, and more quickly return to a word-learning task at hand. Children low in executive control should be more subject to the attractive or aversive, but nevertheless attention-grabbing features of ambient environmental activity, and less likely to return to the word-learning task at hand. This line of reasoning leads to the empirical expectation that children high in executive control should be relatively resistant to environmental distractions during word learning and should, over developmental time, enjoy a word-learning advantage over children low in executive control.

Correlational findings have been consistent with this hypothesis (Dixon & Shore, 1997; Dixon & Smith, 2000; Kubicek, et al., 2001; Morales, et al., 2000). Temperamentally long-attending children have been found to have larger vocabularies. However, to our knowledge only one published study has subjected this hypothesis to an experimental test (but see also Rashad & Hollich, 2004). Xxxx and Xx (in submission) presented 22-month-olds with two fast-mapping word-learning trials (cf. Mervis & Bertrand, 1994) in each of three conditions of environmental distraction: a no-distraction baseline condition and two distraction conditions. In their "sudden onset distraction" condition, in which an environmental distracter suddenly appeared at the onset of a word learning trial, either a noise-making mechanical toy suddenly turned on or a stranger suddenly walked into the room and read *Green Eggs and Ham* to the child aloud. In their "cognitive distraction" condition, children had to parse through seven potential novel label targets in order to successfully map a novel label to a target novel object, as compared to baseline in which there were only five potential novel label targets.

Consistent with Allport's (1989) model, Xxxx and Xx (in submission) found that novel word learning was significantly poorer under conditions of distraction than during baseline. But importantly, they found that word learning could be predicted by attention allocation in certain circumstances. In contrast, attention allocation was not predictive of word learning in the no-distraction, baseline condition. The authors surmised that children high in executive control were better able to overcome the environmental distractions, and to distribute their attention in ways that maximized word learning during the presentation of the distractions. Although it is unclear why attention allocation was not predictive of word learning in the no-distraction, baseline condition, Xxxx and Xx offered the possibility that word learning in the no-distraction condition may have required minimal attention such that the amount of attention allocated lost its predictive value in accounting for word learning.

An important next step would be to explore whether the learning of nonlinguistic contingencies is impacted by environmental distractions in the second year. Research involving older children has amply demonstrated the adverse impacts of environmental distractions on learning. For example, Turnure (1970) showed that the presence of a distracter inhibited the performance of 5.5 year-olds on a simple pattern-recognition task, relative to a control group of age-matched children. Higgins and Turnure (1984) reported a similar finding in preschoolers. However, environmental distractions do not always compromise performance. Both Turnure and Higgins and Turnure also found that the same distracter actually enhanced focal attention among slightly older children, resulting in enhanced performance on the pattern-recognition task. Ruff and Capozzoli (2003) reported a similar "mobilization of attention" in the presence of environmental distracters in children as young as 3.5 years of age. Turnure hypothesized that for some children under some conditions, the presentation of an environmental distraction might actually funnel children's attention to a target task, resulting in improved task performance. Data from these and other studies (e.g., Gemenyuk, Korzyukov, Alho, Escera, & Naatanen, 2004;Humphrey, 1982) support the intuitive expectation that distractions impede performance on some occasions, but also raise the curious possibility that distractions might enhance performance on others.

To test for the effects of environmental distractions on nonlinguistic learning, we employed the learning/memory tasks developed by Bauer. Bauer and her colleagues have employed a variety of tasks that require the learning of nonlinguistic environmental contingencies, and that very young children appear to learn quickly and retain for extended periods of time (Bauer, 1996; Bauer, Hertsgaard, & Dow, 1994; Bauer, Hertsgaard, & Wewerka, 1995; Wenner & Bauer, 1999). Among the environmental contingency action sequences these authors have employed are those that contain enabling-relation action sequences and those that contain conventional-relation action sequences.

Enabling-relation action sequences require a particular order of actions in order to achieve a desired goal. In the "Make-a-Rattle" task, for example, a ball is placed into a small plastic nesting cup, and then a larger plastic nesting cup is placed over the opening of the smaller one. When the device is shaken, a rattling sound results. Note that the ball must be placed into the nesting cup *before* covering it up with the other nesting cup, else the rattling effect is not enabled. In this case, order of actions is necessary and required.

Conventional-relation action sequences do not entail necessarily ordered actions. In the "Feed-Self" task, for example, the infant or toddler learns a series of conventional actions associated with pretending to eat breakfast. With this action sequence, there is no specific outcome goal that necessitates a singular order of actions, other than reproducing the conventional order of actions modeled by the experimenter; although enabling contingencies tend to be recalled more accurately over longer periods of time (Bauer, 1996). Both of these tasks may be regarded as analogous to word learning in that they require children to attend to environmental contingencies in order to learn them. Indeed, Elizabeth Bates and colleagues (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979; Bates, Bretherton, & Snyder, 1988) have long argued that word learning need not be granted any special status relative to other cognitive tasks, and have produced evidence that both linguistic and nonlinguistic problem solving draw from a common underlying cognitive facility. However, learning a conventional contingency sequence might be more analogous to the arbitrary word-referent associations that children learn, because in neither case is a causal contingency required for learning to occur. Bauer, Hertsgaard, Dropik, and Daly (1998) found accurate reproductions of nonenabling event sequences to be predictive of subsequent language development, and Shore (1986) found conventional contingencies incorporating counterconventional objects to be correlated with both semantic and morphological development.

A second question of even more importance for present purposes has to do with whether individual differences in executive control moderate the impact of environmental distractions on the learning of linguistic and nonlinguistic contingencies. As argued above, not only should environmental distractions impede the learning of environmental contingencies, but executive control, particularly as pertaining to attention allocation, should moderate the impact of environmental distractions on learning performance.

Thus, the purpose of the present investigation was twofold. First, we sought to test whether environmental distractions would negatively impact the learning of nonlinguistic environmental contingencies. Second, we sought to determine whether individual differences in executive control would moderate the effects of environmental distractions on the learning of linguistic and nonlinguistic environmental contingencies.

## Methods

### Participants

The sample of thirty-nine 21-month-olds was drawn from a population of full-term, non-high-risk babies in the local community. However the surrounding population throughout East Tennessee differs from others in that the community is predominantly rural, with an Appalachian heritage. All children (21 boys, 18 girls) who participated in the study came from two-parent homes, with all but one of the parents sharing a full biological relationship with the child. Average age of the mother at the time of the study was 32.00 (SD = 5.90), with fathers averaging about a year and a half older (M = 33.34, SD = 5.72). Median annual household income was $66,000. Children were recruited through newspaper birth announcements, advertisements on educational access cable television, postings in local physicians' waiting rooms, and through word of mouth. Only one father participated in this study, with the remaining 38 informants being children's mothers.

### Measures

**Early Childhood Behavior Questionnaire—**The Early Childhood Behavior Questionnaire (ECBQ; Putnam, Gartstein, & Rothbart, 2006) was used to assess attention allocation as a trait-based index of executive control. The ECBQ consists of 201 items involving toddlers' day-to-day behaviors determined by parents to have taken place in the previous two weeks. Although the ECBQ assesses 18 fine-grained subdimensions of temperament, including such dimensions as activity level, attentional focusing, fear, sociability, and shyness; the attentional focusing measure was of primary interest in the present study because its predecessor, duration of orientation, was found to correlate with productive and receptive vocabulary in previous research (Dixon & Shore, 1997; Dixon & Smith, 2000; Morales et al., 2001), and is presumed to reflect the central attentional component of executive control. Among the 12 items included on this scale are, "When engaged in play with his/her favorite toy, how often did your child play for more than 10 minutes?", "When playing alone, how often did your child move from one task or activity to another without completing any?", "While looking at picture books on his/her own, how often did your child stay interested in the book for 5 minutes or less?", and "When engaged in an activity requiring attention, such as building with blocks, how often did your child tire of the activity relatively quickly?" For each item, the response scale ranges from 1 ("never") to 7 ("always"). Cronbach's alpha for the attentional focusing scale for children in the 18- to 24-month age range is in the .81 to .86 range (Putnam et al., 2006).

**Novel Word Learning—**The word-learning task was derived from a procedure employed by Mervis and Bertrand (1994). Their original procedure was designed to assess the extent that toddlers are capable of fast-mapping novel names to novel objects, given as few as one exposure. Although their goal was to assess children's acquisition of a "Novel Name-Nameless Category" principle, which is often viewed as a "smart" language learning constraint, the goal here was only to utilize a robust, replicable word-learning paradigm through which toddlers could be taught new words.

Following Mervis and Bertrand's (1994) procedure, our baseline, no distraction condition was composed of a comprehension and a generalization phase. In the comprehension phase, children were initially presented with four known objects and one novel object. After a one-minute familiarization period, the five objects were aligned in a row, and children were asked for either an object with a familiar label or the novel object. Familiar objects were always requested first. With respect to the novel object, children were asked "Can you find the X," where X was a novel word such as "tuz" or "noop." If children failed to respond, the question was rephrased. If they failed to respond a second time, they were handed the correct object and allowed to examine it more closely. During this exploration period, the object was labeled three more times. Children who responded correctly to the requests were also allowed to explore the object, during which they heard the label applied three more times. All stimulus items were then put away, and a new word-learning trial, consisting of a second novel object and four new familiar objects, was introduced. Thus, within each condition, children learned two novel words. Generalization phases for both of the novel labels took place only after children experienced comprehension phases for both novel words.

During generalization, children were presented with the four familiar objects as before, but they received a new exemplar of the novel object category (e.g., a new tuz) accompanied by a novel foil. For example, if during a comprehension trial children were initially exposed to a fork, an airplane, a brush, and a doggie as familiar objects, and a pastry blend as the novel object, then during generalization they would have been exposed to the fork, the plane, the brush, and the doggie again. But new to the tray would be a new pastry blend, coupled with a door stopper serving as the foil. Children would then be asked, "Where is the tuz? Can you find the tuz?" The six objects (4 familiar, 1 new novel, 1 foil) would then be aligned in a row, and children would be asked for the X in the same manner as during comprehension. A response was considered correct if children selected the new version of the target novel object. Mervis and Bertrand (1994) argued that "Such responses provided evidence that the child not only fast mapped the new word to the initial unknown object, but also extended the new word to a new member of the same category" (p. 1652).

The procedure for the cognitive distraction condition was identical to the baseline condition, with the exception that instead of 4 known objects there were 5 known objects. The rationale for increasing the number of known objects was that an increase would place greater attentional demands on the executive control system than was present during baseline, and should serve to reduce word learning performance relative to baseline. Xxxx and Xx's (in submission) cognitive distraction condition used 6 known objects and found that increasing the number of known objects by 50% significantly decreased word learning. In an effort to hone the procedure further, we tested whether a 25% increase in the number of known objects would also significantly reduce word learning relative to baseline.

The procedure for the social distraction condition was identical to that of the baseline condition, except that during the two comprehension trials, an unfamiliar woman (female undergraduate lab assistant) entered the lab. In Version 1 of this condition, the stranger greeted the child by name, stood near the far end of the experimental table, and begin reading aloud either the Spanish or the French version (depending on the linguistic facility of the stranger) of *Goodnight Moon*. In this version, the stranger provided auditory and social distraction; but we reasoned that reading in the child's nonnative language would provide less of a verbal distraction than were the child to have been read a book in her native language. In Version 2 of the condition, the stranger entered the lab, stood at the far end of the experimental table, and simply smiled and looked at the child. However, the stranger did not attempt to converse with the child. In this version, the stranger provided social, but not auditory distraction. Upon completion of the first comprehension trial, the stranger left the room, and returned a few moments later at the onset of the second comprehension trial. This manipulation builds on Xxxx and Xx (in submission), who found that reading in children's native language during word learning significantly impeded word learning.

The procedure for the mechanical distraction condition was also identical to that of the baseline condition, except that during each of the two comprehension trials a mechanical "Mr. Monkey" toy suddenly turned on at the onset of the comprehension trial. Mr. Monkey was located atop a cabinet at the far end of the experimental table, in plain view of the child throughout the procedure. When turned on, Mr. Monkey began clanging cymbals while simultaneously bobbing his head up and down. The effect was created when a lab assistant inside an adjacent control room activated the toy.

The list of familiar and novel objects for each of the eight word-learning trials can be found in Table 1. Novel words were assigned randomly to distraction conditions across children, so that no novel word was consistently associated with one distraction condition. However, the familiar and foil objects listed with each novel label in Table 1, were always associated with that novel label, regardless of distraction condition. Two independent coders trained to 90% reliability on 10% of the sample, and who maintained 90% reliability on 10% of the sample at posttest, 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 object request. Reliability was defined as the ratio of the number of agreements over the number of agreements plus disagreements. A 5-point scale, as opposed to a yes-no scale, was used 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 her behavior did not unambiguously indicate selection of the requested object. The rating scale was anchored by a score of "5," which meant that a child clearly and unambiguously demonstrated knowledge of the requested object and selected the requested object without hesitation, and a score of "1" which indicated that a child did not respond to the object request. Performance was averaged across the two word-learning trials within each of the 4 distraction condition (baseline, cognitive, social, and mechanical) x 2 word learning phase (comprehension and generalization) cells.

**NonWord-Learning Tasks—**Nonword learning was assessed through two tasks, the "Make-a-Rattle" task and the "Feed-Self" task. The make-a-rattle task involved two nesting cups and a ball. The size of the nesting cups was such that the lip of a smaller cup fit within the lip of a larger cup. After an initial one-minute familiarization with the objects, children observed the experimenter place the ball in the smaller cup, cover the smaller cup with the larger cup, and shake the product (which produced a rattling effect). The experimenter accompanied the modeling sequence with a verbal narrative: “Watch what I can do. I’m going to put the ball into the cup. I’m going to cover it up. Shake it. Look, I made a rattle. Can you make a rattle?” Children were then given the opportunity to reproduce the action sequence. Although it is possible to derive a number of dependent measures from this task, for simplicity of presentation we focus on two measures: total number of target actions performed and pairs of target actions in sequence.

The feed-self task involved a bowl, a spoon, a napkin, a small box of cereal (empty), and a small carton of milk (also empty). After initial familiarization, children observed the experimenter model “eating breakfast.” The eating breakfast action sequence included pretending to pour the cereal into the bowl, pretending to pour the milk into the bowl, stirring the cereal with the spoon, putting the spoon to the mouth, and wiping the mouth with a napkin. As with the make-a-rattle task, the feed-self task was accompanied by a verbal narrative: “Watch what I can do. I’m so hungry I’m going to eat breakfast. I’m going to pour in the milk. I’m going to pour in the cereal. I’m going to stir it all up. Mmm, good cereal. Mmm, good cereal. All done, gotta wipe my mouth. Can you eat breakfast like I did?” Again, for purposes of brevity we focused on total number of target actions and pairs of actions in sequence as dependent measures.

The make-a-rattle and feed-self tasks differed structurally. Successful completion of the make-a-rattle task entailed sequencing three actions whereas successful completion of the feed-self task entailed sequencing five actions. In addition, the former represented an enabling relation action sequence, whereas the latter represented a conventional action sequence. However, the purpose of using these tasks was not to provide a comparison of performance across the two tasks, but to sample children’s performance on nonlinguistic tasks in the presence of environmental distraction. The questions of interest were whether environmental distractions impacted on both children’s linguistic and nonlinguistic learning, and particularly whether attentional focus moderated this effect.

Although all children received both tasks, type of distraction was counterbalanced across tasks and across children. Distraction came in the form of the Sesame Street *Elmo’s World: Head to Toe with Elmo* videotape. The videotape portrayed the Sesame Street character Elmo engaging in various activities related to clothing, such as shopping at a shoe store, and chatting with a fuzzy pink jacket. The videotaped program provided both auditory-verbal and visual forms of distraction, and was selected to mimic the effects of a television playing in the background. In the baseline condition, the nonword-learning tasks took place in the absence of either form of distraction.

In the auditory-verbal distraction condition, children were asked to perform the nonword-learning tasks in the presence of only the auditory track of the Sesame Street videotape. The soundtrack of the videotape was presented via a speaker centrally located at the opposite end of the experimental table from the child’s perspective (positioned next to Mr. Monkey).

In the visual distraction condition, children were asked to perform the nonword-learning tasks in the presence of only the video track of the Sesame Street videotape. In this case, the video signal was projected onto the blank wall at the far end of the experimental table, using a Sony VPL-CS5 projector suspended from the ceiling of the lab.

Finally, in the auditory-verbal + visual distraction condition, children were asked to perform the nonword-learning tasks in the presence of both the video and the audio tracks of the Sesame Street videotape. In all three distraction conditions, distraction onset took place immediately after a one-minute familiarization period with the props, commensurate with the onset of experimenter's modeling of the action sequences.

As in the word-learning tasks, scoring of the make-a-rattle and feed-self tasks were completed by pairs of coders trained to 90% reliability on 10% of the sample. Reliability of at least 90% was obtained throughout the scoring period, as determined when coders rescored a different 10% of the sample at posttest.

### Procedure

Two weeks prior to their arrival, parents were sent the ECBQ and a demographic instrument assessing the number of caregivers and siblings in the home, the gender of any siblings in the home, the income and age of the caregivers, family ethnicity and race, and the caregivers' employment status. Upon arriving at the lab, the toddlers and their parents were greeted by the experimenter in an outdoor parking lot and escorted to the lab, and the previously completed instruments were collected. After reaching the lab, and during the consenting process, children acclimated to the lab and the experimenter, the latter of which informally engaged children using Bert & Ernie soft characters. After the parents were consented, children sat on their laps at the far end of a 6′ x 3′ experimental table, and the experimental procedure began.

In Xxxx and Xx (in submission), order of presentation of distraction condition was potentially confounded with child fatigue. We tested whether drops in performance would still occur when distractions took place early on in the procedure; that is, before baselin. Therefore, the word-learning tasks were presented in two different orders of distraction presentation. In Order 1, the mechanical distraction condition occurred first, followed half the time by the no-distraction, baseline condition and half the time by the cognitive distraction condition, and always ended with the social distraction condition. In Order 2, the social distraction condition was presented first and the mechanical distraction condition was presented last, with order of the no-distraction and cognitive distraction conditions counterbalanced in between. In Order 2 we were also interested in testing whether the type of social distracter differentially influenced children's word learning performance. Thus, half the children in Order 2 received the "silent stranger" condition, and half received the "reading in a nonnative language" condition.

The two nonword-learning tasks were always interspersed between the social and the mechanical distraction conditions of the word-learning task. However, order of presentation of the make-a-rattle task and the feed-self task was also counterbalanced. For half the children the make-a-rattle task occurred first, whereas for the remaining children the feed-self task occurred first. As well, half the children experienced a distraction when learning the make-a-rattle task, and half the children experienced a distraction when learning the feed-self task.

## Results

Children were divided into groups of "low focused" and "high focused" children using a median split applied to the focused attention scale of the ECBQ, which is referred to below as *attentional focus*. The result was that 19 children were classified as low focused, and 20 were classified as high focused. Means and standard deviations of children's performance on the word learning and nonword learning tasks, in the low and high focused groups, as a function of distraction condition, are presented in Tables 2-4.

### Word Learning Performance

A preliminary analysis of variance involving order of distraction condition, revealed no significant main or interaction effects involving the order factor. Hence, word learning was collapsed across distraction orders. There was also no difference between the two types of social distracter, so these conditions were also collapsed. In order to test the effects of environmental distractions on word learning performance, and to explore whether level of child attentional focus moderated any distraction effects, a 4 (distraction condition) x 2 (word learning phase) x 2 (level of attentional focus) mixed design analysis of variance was conducted on children's word learning performance, with distraction condition and word learning phase serving as within-subjects measures. Because two children did not have complete scores across all of the 8 word-learning conditions along with completed ECBQs, analyses involving the word learning task were based on 37 children. These two children were missing data in one or more of the word-learning conditions, generally as a result of experimenter error, and included cases where a tray failed to be presented or the wrong tray was presented.

**Effects of Distracters on Word Learning—**As in Xxxx and Xx (in submission), results revealed significant main effects for distraction condition [$F(3, 33) = 5.31$, $p = .004$, $\eta^2 = .33$] and word learning phase [$F(1, 35) = 17.51$, $p = .000$, $\eta^2 = .33$]. Both of these effects are discussed in more detail in the next paragraph. However, unlike in Xxxx and Xx, a distraction condition x word learning phase interaction effect was not found in the present study. Xxxx and Xx found that improved performance during generalization, as compared to initial comprehension, was limited to the no distraction condition. In the present study, however, performance during generalization was higher than during comprehension, without regard to distraction condition.

To break down the distraction condition main effect reported above, planned comparisons (see Figure 1) revealed that overall word learning performance in the no distraction condition, collapsed across word learning phase, was significantly higher than performance in either the social distraction condition (LSD adjusted $p = .040$) or the mechanical distraction condition (LSD adjusted $p = .015$). Performance in the cognitive distraction condition was also higher than in the mechanical distraction condition ($p = .006$), and trended toward being higher than in the social distraction condition ($p = .087$). However, there was no difference in word learning performance between the baseline and cognitive distraction conditions. Thus, it appears that a 25% increase in the stimulus array in the cognitive distraction condition is not sufficiently attention-burdening so as to impede novel word learning. Consistent with Xxxx and Xx (in submission), there was also no difference in word learning between the social and mechanical distraction conditions.

**Attentional Focus—**Of primary interest in the present study was whether children's level of attentional focus would moderate the effects of environmental distractions on word learning. Interestingly, the omnibus distraction condition x level of focus interaction effect failed to reach significance [$F(3, 33) = 1.72$, $p = .182$, $\eta^2 = .14$]; however, consideration of planned comparisons revealed that there were differences. Specifically, as depicted in Figure 1, low focus children showed a significant decline in word learning in the social distraction condition ($p = .008$) and a nearly significant decline in the mechanical distraction condition ($p = .063$), relative to baseline. Low focus children also showed significant drops in performance in both the social ($p = .045$) and the mechanical ($p = .055$) conditions relative to the cognitive condition. In contrast, high focus children showed a drop in performance only in the mechanical distraction condition, and then only relative to the cognitive distraction condition ($p = .036$). This pattern of finding seems to suggest that to the extent that attentional focus may have moderated the influence of environmental distractions on word learning, it did so primarily in the social distraction condition.

**Summary—**These findings support the general contention that environmental distractions can inhibit word learning. Results from the present study suggest further that at least a portion of the variance in word learning performance can be attributed to children's attentional focus. In particular, the word learning of children high in attentional focus appears to be less adversely impacted by the presence of a social environmental distraction than children low in attentional focus. This finding is consistent with past literature reporting relationships between attention and language development (e.g., Dixon & Shore, 1997; Dixon & Smith, 2000). However, these results fail to replicate previous findings (Xxxx & Xx, in submission) that children learning novel words in the absence of environmental distractions are better able to generalize those words than children learning them in the presence of sudden onset distractions.

## NonWord-Learning Tasks

**Make-a-Rattle Task—**In order to test for the effects of environmental distractions on children's abilities to learn an enabling relations sequence, and to observe whether children's level of attentional focus would moderate such an effect, two 2 (modeling: preversus post-model) x 2 (distraction condition: presence versus absence) x 2 (level of attentional focus: low versus high) mixed design analyses of variance were conducted on children's make-a-rattle performance, with distraction condition and level of focus serving as between subjects factors. Two dependent measures of interest were: number of target actions performed and number of pairs of target action performed in sequence.

For pairs of target action performed in sequence, performance was significantly higher after the model than before it, as evidenced by a significant main effect of modeling [$F(1, 36) = 9.45$, $p = .004$, $\eta^2 = .21$]. Total number of target actions was not significantly affected by the model.

Pairs of target actions in sequence was involved in two additional effects. First, a significant modeling x distraction condition interaction effect [$F(1, 36) = 5.48$, $p = .025$, $\eta^2 = .13$], revealed that viewing the model only improved performance in the no distraction condition (see Figure 2). Thus, although the presence of a distraction did not adversely influence make-a-rattle performance overall, it did eliminate the facilitating effect of the model.

The second effect of interest was a modeling x attentional focus interaction effect which approached statistical significance [$F(1, 36) = 3.43$, $p = .072$, $\eta^2 = .09$]. This interaction hinted that the effect of the model might also be dependent on children's level of attentional focus. Specifically, high focused children trended toward benefiting from the model more than did low focused children (see Figure 2).

**Feed-Self Task—**In order to test for the effects of environmental distractions on children's abilities to learn a conventional, noncausal sequence, and to observe whether children's level of attentional focus would moderate the effect of environmental distracters in this nonword-learning task, two 2 (modeling: pre- versus post-model) x 2 (distraction condition: presence versus absence) x 2 (level of focus: low versus high) mixed design analyses of variance were conducted on children's feed-self performance; again, with distraction condition and level of focus serving as between subjects factors. As with the make-a-rattle task, the two dependent measures included in the analyses were number of target actions performed and number of pairs of target action performed in sequence.

However, unlike in the make-a-rattle task, modeling significantly increased both number of pairs of target actions in sequence [$F(1, 36) = 15.95$, $p = .000$, $\eta^2 = .31$] and total target actions [$F(1, 36) = 29.47$, $p = .000$, $\eta^2 = .45$], compared to premodel performance.

Two other significant effects were of interest. First, a significant modeling x attentional focus interaction effect [$F(1, 36) = 4.31$, $p = .045$, $\eta^2 = .21$] revealed that modeling effected more total target actions for children high in attentional focus than for children low in attentional focus. Moreover, and second, this interaction effect itself interacted with distraction condition [$F(1, 36) = 3.62$, $p = .065$, $\eta^2 = .09$], resulting in a 3-way interaction effect. Though complicated, this three-way interaction revealed that the effect of the model on feed-self performance was weakest in the distraction condition for children low in attentional focus. Figure 3 illustrates these effects for total number of target actions. Interestingly, post-hoc analyses revealed that children high in attentional focus had significantly lower performance before exposure to the model than children low in attentional focus (Sidak adjusted $p = .046$). That is to say, when children low in attentional focus were initially given the feed-self stimuli, they seemed more inclined to begin performing target actions with those items than children high in attentional focus. This finding raises the possibility that our attentionally focused children were more inclined to wait for adult direction in an otherwise ambiguous situation than were children low in attentional focus. But further research is needed to evaluate this possibility.

Finally, it should be noted that a cursory review of Figure 3 seems to indicate *premodel* differences in feed-self performance across the two distraction conditions, for children both high and low in attentional focus. However, post hoc analyses revealed that children low in attentional focus in the distraction condition did not differ significantly in premodel performance from children low in attentional focus in the nondistraction condition. The same was true for high focus children. On the other hand, high focus children differed from low focus children in terms of premodel performance in the distraction condition (LSD adjusted $p = .019$), whereas no corresponding difference in the nondistraction condition was detected. This finding suggests that our high focus children differed in some way from our low focus children in the distraction condition, in a way that was not mirrored in the nondistraction condition. The source of such a difference is not possible to determine because all children were assigned randomly to condition. It is interesting, nevertheless, that children whose premodel performance was so low demonstrated a 14-fold postmodel increase. This increase suggests that their initially low performance was not a disadvantage once the modeled behavior was presented to them.

**Summary—**Data from the nonword-learning tasks revealed that environmental distractions impacted the extent that children were able to acquire and reproduce environmental contingencies, in a manner that generally mirrored word-learning performance. Furthermore, as in the word-learning tasks, it appears that attentional focus may have moderated the adverse impacts of environmental distractions on children's learning of nonlinguistic contingencies, such that children high in attentional focus were less affected by environmental distractions when learning either linguistic or nonlinguistic contingencies. Because attentional focus seemed to play a similar moderating role across both nonword-learning tasks, it does not appear that either causally or arbitrarily linked event sequences are particularly associated with the moderating role of attentional focus. It also does not appear that vocabulary acquisition is an any privileged position when it comes to learning environmental contingencies in the presence of environmental distractions.

## Discussion

It was proposed at the outset that executive control, often regarded as a fundamental component of temperament that may play an overarching regulative role, would impact children's abilities to learn environmental contingencies. In that regard, it was expected that not only would environmental distractions negatively impact the learning of both linguistic and nonlinguistic environmental contingencies, but that the effect of the environmental distractions on the learning of those contingencies would be moderated by children's attentional focus.

Generally speaking, both hypotheses were supported. First, environmental distractions were found to negatively impact both word-based and non-word based learning of environmental contingencies. In word learning, children's performance was significantly lower during the sudden onset distractions, such as when a stranger suddenly entered the room or when a mechanical toy suddenly turned on, than during the no-distraction baseline condition. In nonword-learning, environmental distractions also had an impact. In the make-a-rattle task, a behavioral model did not facilitate the performance of children who were simultaneously being exposed to environmental distractions. Children only benefited from the behavioral model when they did not have to contend with environmental distraction. Similarly, the presentation of a distraction in the feed-self task prevented children from benefiting from the presence of a behavioral model, but in this case, only for children low in attentional focus. The feed-self performance of children high in attentional focus was not adversely impacted by the presentation of an environmental distraction.

Second, in two of the tasks the effects of the distractions depended in some way on children's levels of attentional focus. During word learning, children high in attentional focus did not exhibit a decrement in word learning when the stranger walked into the room, unlike children low in attentional focus. And the 3-way interaction that obtained for the feed-self task indicated that the effect of the environmental distractions on the facilitating effects of the model was different for high focus children than for low focus children. High attentional focus may serve as a sort of buffering agent to prevent environmental distractions from interfering with children's learning of environmental contingencies.

It was noted at the outset that a major reason for child development researchers to begin exploring temperament-cognition relationships generally, and temperament-language relationships more specifically, was the possibility that interdomain correspondences may shed light on intradomain functioning. In the present case, we may be able to draw on the interrelations between temperamental attentional focus and the learning of linguistic and nonlinguistic contingencies as an indication of the importance of individual differences in attentional focus for associational learning generally, and word learning specifically. Previous correlational research has revealed that children high in duration of orientation/attention span enjoyed receptive and productive vocabulary advantages over children low on those same temperamental dimensions. The present study suggests that one possible reason for this vocabulary advantage is that children high in duration of orientation/attention span are less susceptible to the adverse impacts of environmental distractions. Indeed, the negative impacts of environmental chaos and noise on vocabulary development have long been known (DeJoy, 1983; Richardson & McLaughlin, 1981; Wachs, 1979). It is promising to consider that at least some children, by virtue of their temperamental disposition, may enjoy partial cognitive or linguistic protection against such adversity.

Limitations of the present study may serve as goals for future research. It was beyond the scope of the present study, for example, to evaluate which specific aspects of learning were moderated by attentional focus. For children to demonstrate that they had acquired an environmental contingency, they not only had to be able to recall the event after they had learned it, they also had to encode it in the first place. So although children high in attentional focus were generally buffered from environmental distractions in learning from the model, it is not clear whether attentional focus facilitated children's recall of the learned contingencies, their initial encoding of them, some form of post-encoding memory consolidation, or any of the three. We suspect that attentional focus had its greatest impact during encoding because it was during initial word-referent encoding that environmental distractions were presented. Nevertheless, it remains an empirical question just how environmental distractions and attentional focus combine to impact learning processes associated with encoding, memory consolidation, and recall.

A second goal of future research should be to explore the impact of different types of environmental events on different subcomponents of executive control. Our focus in the present study was on the moderating role of attentional focus with respect to environmental distractions. However, other forms of ambient environmental events are likely to impact word or nonword learning, and they may do so by virtue of their interaction with less attentionally central components of executive control. For example, a number of researchers have employed the “risk room” methodology, in which children enter a room containing any number of risky stimuli designed to arouse children’s inhibitive or fear responses (Aksan & Kochanska, 2004; Kagan, Reznick, & Gibbons, 1989). If children were asked to learn environmental contingencies while in the risk room, that is, under conditions of fearful arousal but without the advent of sudden onset distractions, components of executive control responsible for regulating fearful arousal may predict children’s abilities to learn contingencies. Conversely, highly attractive stimuli may produce affectively positive arousal in children, which might draw on still other subdimensions of executive control, but which might nevertheless redirect children’s attentional priorities and compromise their learning of environmental contingencies.

We regard stimuli employed in the present study to be relatively neutral, with, if anything, a slight tendency toward being affectively positive. Except for one boy, who became upset and discontinued participation in our study after the onset of the Mr. Monkey distracter, we obtained very few fear responses to any of our distracters- too few even to train coders to reliably score negative affect. We had slightly more affectively positive responses, but again, these were relatively few, and far fewer than responses indicating attentional interest. Accordingly, our stimuli seem unlikely to have tapped into aspects of executive control involving the regulation of negative or positive affect in any significant way. Nevertheless, we recognize that our stimuli, having been selected so as to represent the kinds of distracters naturally occurring in children’s environments, are relatively complex; so it is not possible to determine from our data, precisely which aspect or dimension of our stimuli bears the brunt of responsibility for impeding children’s learning. One goal of future research would be to vary stimulus dimensions continuously so as to narrow in on the most cognitively and temperamentally relevant features of environmental distractions.

These results begin to shed light on how temperament might be linked and may even contribute to cognitive and language development. First, the fact that parent-reported measures of attentional focus were consistently associated with children’s observed behaviors across a variety of word and nonword learning situations lends construct validity to the attentional focusing scale of the ECBQ. Second, as experimentally induced results, they support expectations that were previously based on correlational findings, namely that aspects of children’s temperament appear to interact with social and environmental input to determine what and how children learn. These results also extend previous findings beyond the domain of lexical acquisition to the acquisition of environmental contingencies more generally, which further supports Bates and colleagues contention that language learning is simply a subtype of contingency learning more generally (Bates et al., 1979). Translationally, these results may be useful for informing educators, physicians, and other child health-care providers that learning need not simply be a manifestation of children’s innate cognitive function, but that children’s cognitive function interacts with their temperament in complex ways so as to produce learning.

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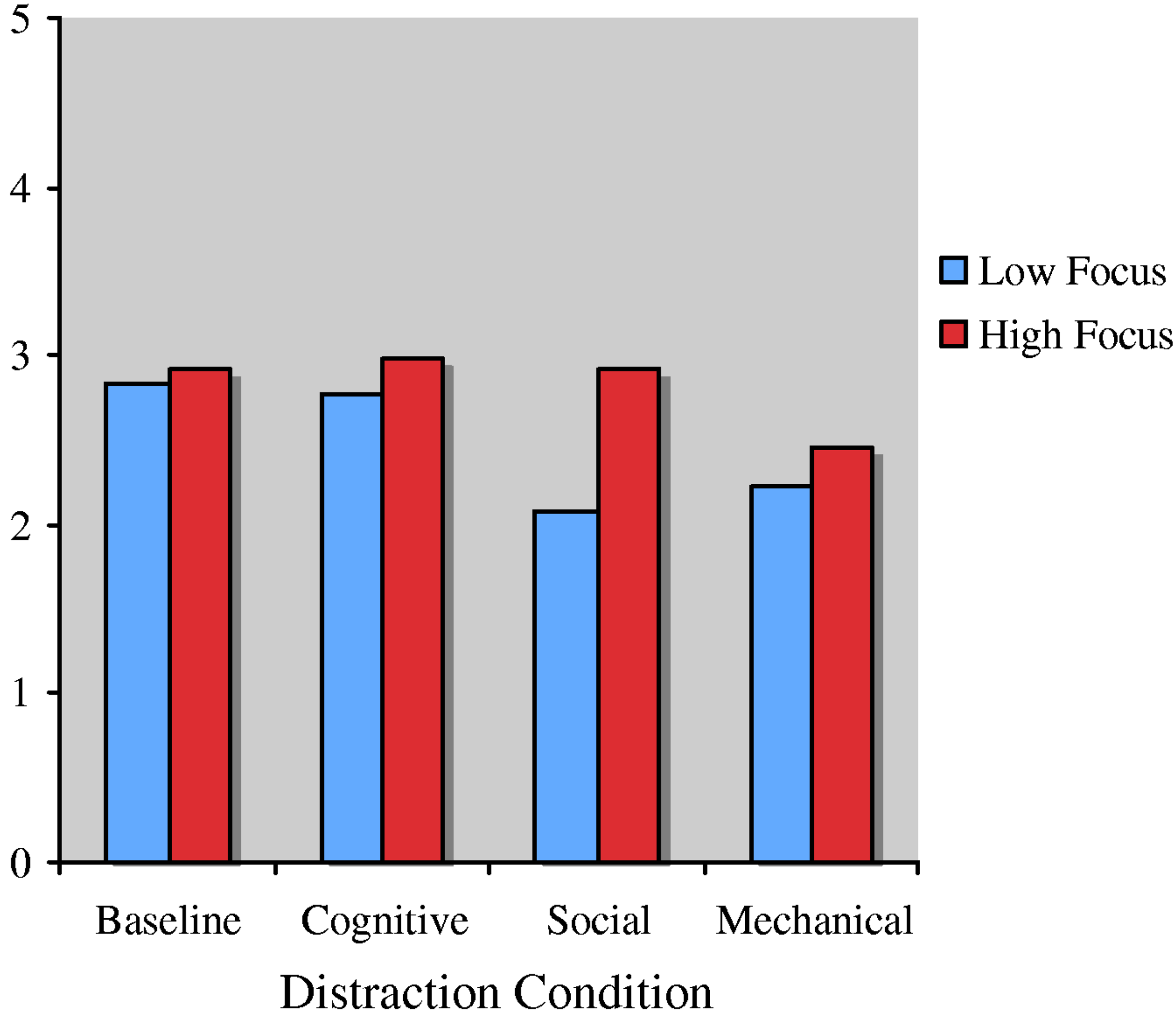


**Figure 1.**
Word Learning Performance by Level of Focus and Distraction Condition

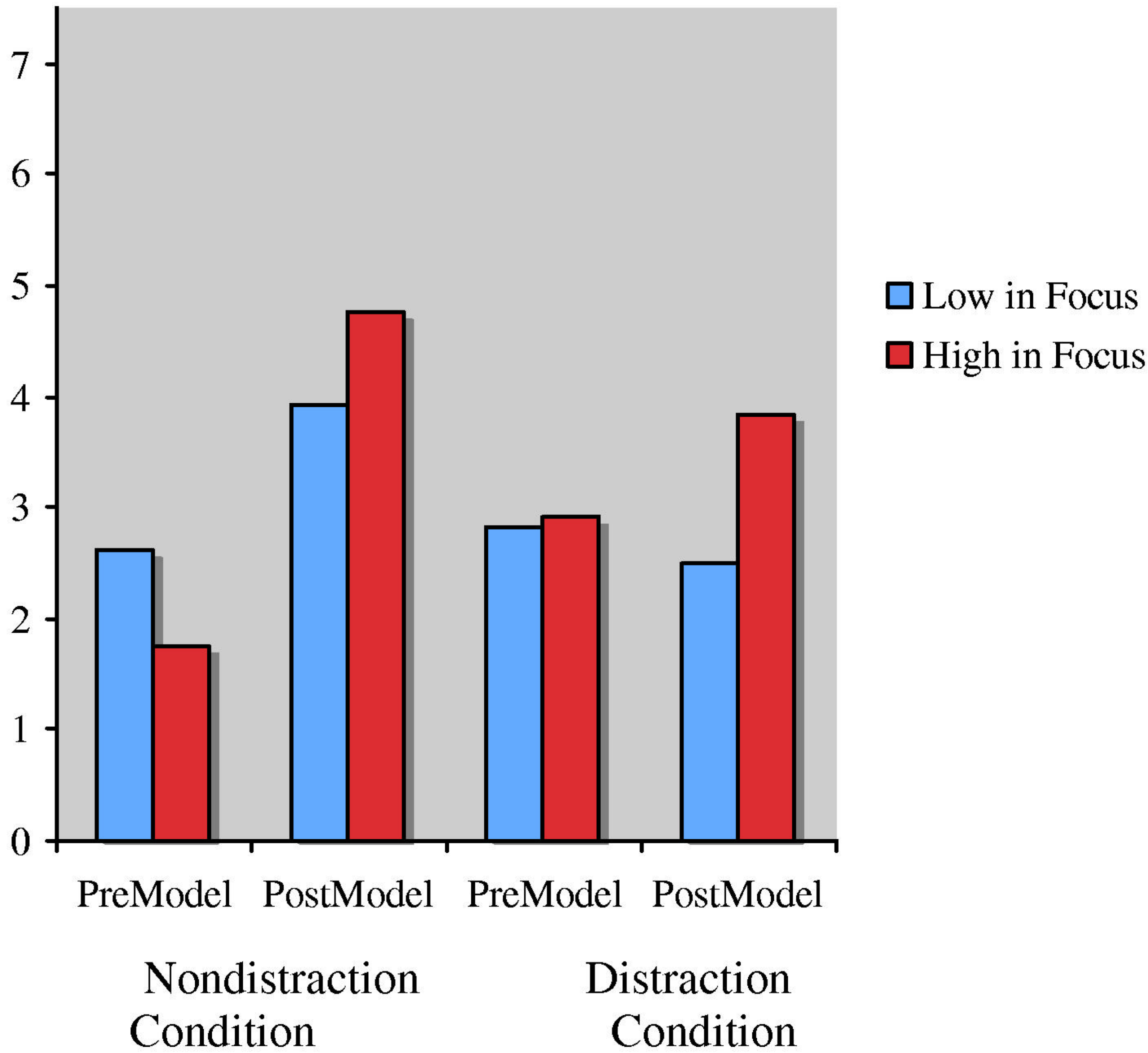


**Figure 2.**
Performance in the Make-a-Rattle Task Pre- and PostModel by Level of Attentional Focus and Distraction Condition

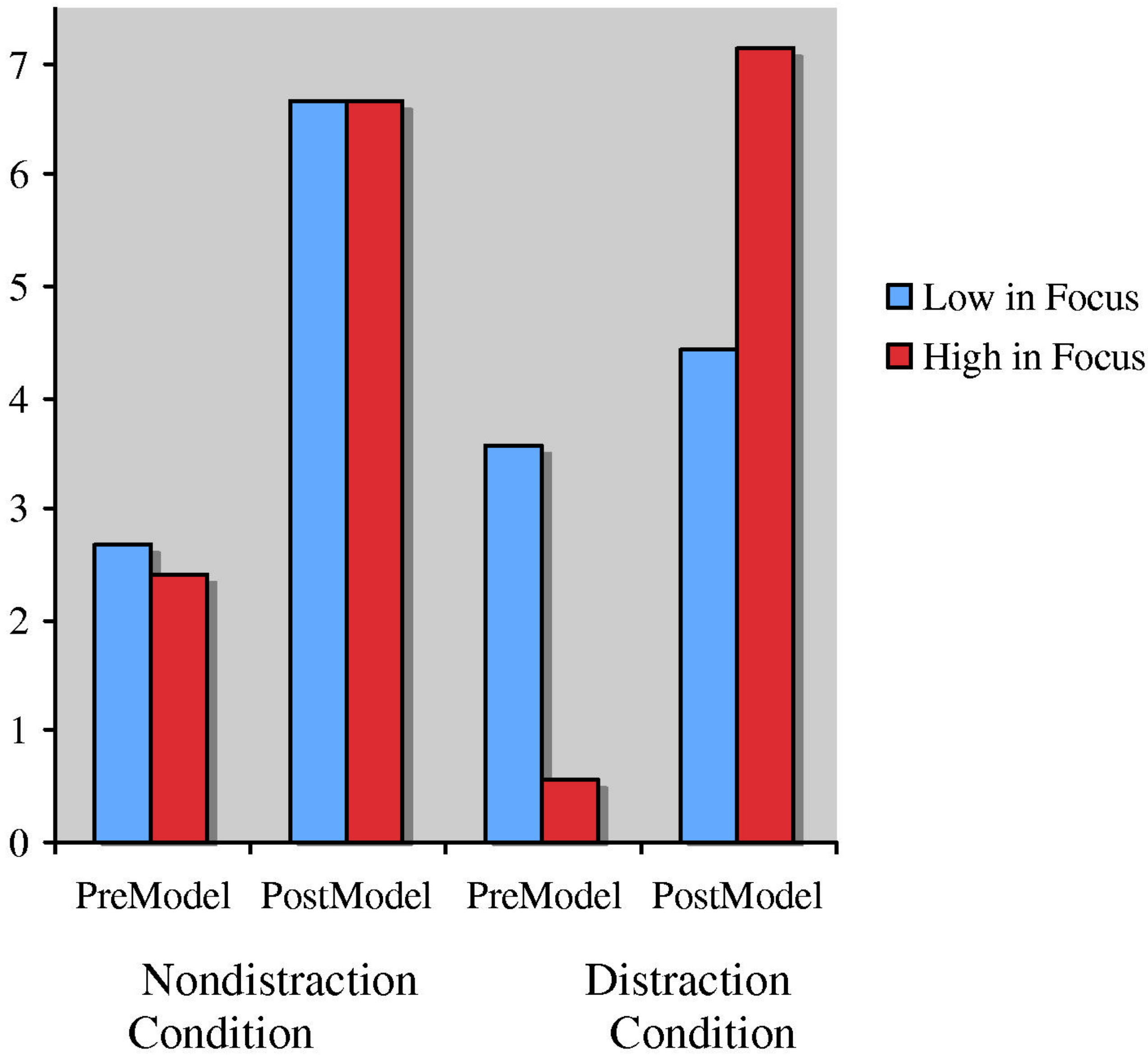


**Figure 3.**
Performance in the Feed-Self Task Pre- and PostModel by Level of Attentional Focus and Distraction Condition

**Table 1**

Stimulus Items Used in the Fast-Mapping Word Learning Task

| Novel Label | Novel Object | Familiar Objects | Foil |
|---|---|---|---|
| gip | bottle opener | car, kitty, pen, cheese | sink strainer |
| tiv | honey dipper | French fries, keys, block, little people girl | door hook |
| hod | hand-held strainer | book, flower, pig,egg (over easy) | egg piercer |
| tuz | toothbrush holder | truck, cup, banana, bird | soap dish |
| dax * | garlic press | shoe, bug #, bear, boat,orange juice | chicken baster |
| lep | tire gauge | bottle, glasses, comb, pizza | coat hook |
| noop * | pastry blend | fork, plane, arm #, brush, dog, | door stopper |
| bem | bottle stopper | apple, hat, spoon, horse | hose connector |

* In the pairing depicted, dax and noop would have been words associated with the cognitive distraction condition, in which 5 rather than 4 familiar objects were on the tray with the novel object.

# The bug and the arm were “cognitive distraction” objects and moved to whatever tray was assigned to the cognitive distraction condition.

**Table 2**

Means and Standard Deviations of Word Learning Performance on Fast-Mapping Task by Distraction Condition and Level of Focus

| Distraction Condition | Level of Focus: Low | | High | |
|---|---|---|---|---|
| | **M** | **SD** | **M** | **SD** |
| Baseline (No Distraction) | | | | |
| Comprehension | 2.75 | 1.32 | 2.71 | 1.28 |
| Generalization | 2.91 | 1.50 | 3.12 | 1.26 |
| Cognitive Distraction | | | | |
| Comprehension | 2.63 | 1.48 | 2.69 | 1.25 |
| Generalization | 2.94 | 1.35 | 3.29 | .87 |
| Social Distraction | | | | |
| Comprehension | 1.88 | 1.22 | 2.62 | 1.22 |
| Generalization | 2.31 | 1.20 | 3.19 | 1.20 |
| Mechanical Distraction | | | | |
| Comprehension | 1.66 | .93 | 2.05 | 1.54 |
| Generalization | 2.81 | 1.36 | 2.88 | 1.40 |

**Table 3**

Means and Standard Deviations of Make-a-Rattle Sequence Learning Task Performance by Distraction Condition and Level of Focus

| Condition | Level of Focus | | | |
|---|---|---|---|---|
| | Low | | High | |
| | M | SD | M | SD |
| No Distraction | | | | |
| Pre-Model | | | | |
| Number of Actions | 4.85 | 3.21 | 4.50 | 4.04 |
| Ordered Pairs of Actions | 2.62 | 1.66 | 1.75 | 1.91 |
| Post Model | | | | |
| Number of Actions | 6.15 | 3.02 | 7.25 | 3.99 |
| Ordered Pairs of Actions | 3.92 | 2.33 | 4.75 | 2.61 |
| Distraction | | | | |
| Pre-Model | | | | |
| Number of Actions | 5.17 | 3.31 | 5.23 | 3.44 |
| Ordered Pairs of Actions | 2.83 | 2.14 | 2.92 | 1.89 |
| Post Model | | | | |
| Number of Actions | 4.50 | 1.76 | 6.23 | 4.15 |
| Ordered Pairs of Actions | 2.50 | .55 | 3.85 | 1.91 |

**Table 4**

Means and Standard Deviations of Feed-Self Sequence Learning Task Performance by Distraction Condition and Level of Focus

| Condition | Level of Focus | | | |
|---|---|---|---|---|
| | Low | | High | |
| | M | SD | M | SD |
| No Distraction | | | | |
| Pre-Model | | | | |
| Number of Actions | 2.67 | 2.29 | 2.42 | 2.47 |
| Ordered Pairs of Actions | 1.56 | 1.94 | 1.58 | 2.68 |
| Post Model | | | | |
| Number of Actions | 6.67 | 5.94 | 6.67 | 3.34 |
| Ordered Pairs of Actions | 5.33 | 5.39 | 5.08 | 3.20 |
| Distraction | | | | |
| Pre-Model | | | | |
| Number of Actions | 3.58 | 2.97 | .57 | 1.13 |
| Ordered Pairs of Actions | 2.58 | 3.03 | 1.00 | 1.53 |
| Post Model | | | | |
| Number of Actions | 4.42 | 4.70 | 7.14 | 3.98 |
| Ordered Pairs of Actions | 3.25 | 4.27 | 4.29 | 4.03 |