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Toddlers' Word Learning from Contingent and Non-Contingent Video on Touchscreens

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Abstract

Researchers examined whether contingent experience using a touchscreen increased toddlers' ability to learn a word from video. One-hundred-sixteen children (24-36 mos) watched an on-screen actress label an object: (1) without interacting, (2) with instructions to touch *anywhere* on the screen, or (3) with instructions to touch *a specific spot* (location of labeled object). The youngest children learned from contingent video in the absence of reciprocal interactions with a live social partner, but only when contingent video required specific responses that emphasized important information on the screen. Conversely, this condition appeared to disrupt learning by slightly older children who were otherwise able to learn words by passively viewing non-interactive video. Results are interpreted with respect to selective attention and encoding.

Toddlers' Word Learning from Contingent and Non-Contingent Video on Touchscreens

Toddlers' access to mobile technology in the US has surged, with young families who own a tablet computer rising from 8% in 2011 to 40% in 2013; 38% of infants (0-2 years) and 80% of preschoolers (2-4 years) used such a device in 2013, compared to just 10% of infants and 39% of preschoolers two years earlier (Rideout, 2013). As toddlers increasingly use interactive media, researchers must understand whether and how children learn from different experiences with screens. The purpose of the current project was to determine the extent to which toddlers learn from interactive and non-interactive video using tablet computers.

Despite claims that videos (Garrison & Christakis, 2005) and mobile applications (Shuler, Levine, & Ree, 2012) are educational, toddlers exhibit difficulty transferring information from one medium (e.g., 2-dimensional screen) to another (e.g., 3-dimensional object; Zack, Barr, Gerhardstein, Dickerson, & Meltzoff, 2009). This *transfer deficit* has been demonstrated for many media and tasks (Barr, 2010; 2013). To understand mechanisms underlying this phenomenon, researchers have manipulated social contingency of an on-screen actress using video chat. For instance, Roseberry, Hirsh-Pasek, and Golinkoff (2014) showed 24- and 30-month-olds actions accompanied by novel verbs either in person, through live video chat, or via yoked video from a previous session; the yoked actress maintained the appearance of social interaction (e.g., paused following questions) but lacked reciprocity (e.g., advanced regardless of the viewer's response). Children who experienced live interactions – either in person or via video chat – learned more than those who watched yoked video. Others reported similar results using object-retrieval (Troseth, Saylor, & Archer, 2006) and imitation tasks (Nielsen, Simcock, & Jenkins, 2008). The ineffectiveness of yoked video suggests that interactivity must be authentic to aid learning.

While social-contingency studies provide insight into the transfer deficit, these studies confound contingency (responding in sync with the child's own behavior) with adaptive, personally relevant, accurate social reciprocity. That is, these studies do not separate the contingency of a response from the true social nature of a response. Do toddlers fail to learn from yoked video because it lacks contingency or because it provides inaccurate information (e.g., hearing another's name rather than one's own)?

Further research is needed to establish whether contingency alone will enable toddlers to overcome the transfer deficit (Kuhl, 2007). Lauricella, Pempek, Barr, and Calvert (2010) examined contingency apart from true social interactions. They showed 30- and 36-month-olds videos of puppets hiding in an adjacent room, and then asked children to enter the room and find the hidden puppets. Some children watched the puppets hide via non-interactive video whereas others played a computer game in which they pressed a button to view a video of each puppet's hiding spot. During the search task, children who pressed a button outperformed those who passively watched the video, suggesting that contingency provided by computer interaction (viewing hiding spots only after a response from the child) is sufficient to ameliorate the transfer deficit, even in the absence of true social interactions with a live social partner via video chat. Nonetheless, adjustments required for toddlers to use the computer keyboard (e.g., covering irrelevant keys) threaten the ecological validity of findings. Moreover, researchers did not test younger participants who are most likely to exhibit a transfer deficit in this task (e.g., Schmitt & Anderson, 2002; Troseth & DeLoache, 1998). Finally, the mechanism underlying this contingency effect is unclear. Kuhl (2007) proposed two mechanisms that may underlie the benefit of social interaction: (1) increased arousal or engagement and (2) increased encoding of critical information because of social cues (e.g., partner's eye gaze). Lauricella et al.'s study does not allow for a test of these accounts.

In the current study, we assessed the effect of contingency using a touchscreen tablet, which toddlers (24-36 months) could operate with minimal training. Three conditions were designed to explore the relative impact of generalized arousal or engagement (via any interaction) versus interactions that draw attention to critical information (via deliberate responses to target objects; Kuhl, 2007). A novel label was presented while children watched a video: (1) without interacting, (2) with instructions to touch *anywhere* on the screen, or (3) with instructions to touch *a specific spot* on the screen. Consistent with previous research, we expected word learning to increase with age in the non-contingent condition. Whether younger children were successful in the contingent-video conditions was expected to depend on the mechanism(s) underlying the transfer deficit and the facilitative effect of contingency that has been observed in previous studies. For instance, if the benefit of contingency requires true social interactions with a live social partner (responds reciprocally; supplies accurate, personally relevant information), then we would expect performance to be similar in all three conditions, given that all conditions used pre-recorded video that lacked real social interactions with a live partner. However, if contingency serves to increase engagement or arousal during learning, both interactive conditions should be equally successful in teaching new words. Conversely, if contingency serves to draw attention to the most important elements of the scene, then only the third condition that required children to touch a specific location should improve word learning.

Method

Participants and Design

Participants were 116 toddlers between 23.5 and 36.0 months of age (58 females, 58 males). The ability to transfer information from screens to real objects develops across this age range (Barr, 2010). Children were primarily from White or Caucasian families (82.11%) who attended preschool and lived in middle- and upper-class homes in a university town in Wisconsin. Parent education averaged 19.23 years (*SD* = 3.06, range 13-28). Children were randomly assigned to one of three conditions: Non-Contingent (*n* = 38, mean age = 29.76 mos), General-Contingent (*n* = 38, mean age = 29.72 mos), and Specific-Contingent (*n* = 40, mean age = 29.92 mos). Data were collected from August 2012 through March 2015.

Parent Survey

Parents were asked to complete an online survey including demographic information and child media use. Parents reported whether and how often they allowed their child to use touchscreen devices at home. They also estimated the number of minutes that their child used different types of media on the previous day. Categories included viewing non-interactive video content (television program, DVD) on a television, computer, or mobile device; playing a game on a computer, videogame console, handheld gaming device, or mobile touchscreen device; using a digital reading device (Nook, LeapFrog); and video-chatting (Skype on a computer or mobile device). Parents also completed the MacArthur Communicative Development Inventories Checklist to assess productive vocabulary (Level II for children <30 months, Level III for children >30 months; Fenson et al., 2000).

Stimuli

Videos were presented on a 10.1" Samsung Galaxy Tab using an application that was developed for this project. The script was adapted from O'Doherty et al. (2011). In the videos, a model sat at a table facing the camera with four boxes in front of her. Each box contained either a familiar object (plastic animal figurine, for training) or an unfamiliar object (item from a hardware store, for testing). See Figure 1.

The actress displayed one object at a time, moving from the viewer's left to the viewer's right, according to the following script: She placed her hand on a box and gave a verbal instruction, such as, "I'm going to show you this one. Let's see this one. Watch the screen and I'll show you this one." She opened the box, smiled, and removed the object. She displayed the object for 5 sec by rotating it (familiar objects) or demonstrating a novel action (novel objects), returned it to the box, and replaced the lid.

The three experimental conditions differed in (1) the type of verbal instruction given by the actress and (2) the manner by which each program advanced to the next video:

1. *Non-Contingent*: The actress instructed children to "watch the screen" to see the object. The video paused briefly (~500 ms) and then resumed automatically.
2. *General-Contingent*: The actress instructed children to "touch the screen" to see the object. The video paused until children touched any part of the screen, then resumed to show the actress opening the box.
3. *Specific-Contingent*: The actress instructed children to "touch the box" to see the object. The video paused until children touched the box that was indicated by the actress (Figure 1); touching anywhere else on the screen had no effect.

Critically, the actress referred to all objects with a generic label ("this one") except for the final novel object, which she called "the *toma*". To ensure that findings could be generalized, two different objects were used as the t*oma*; children were randomly assigned to one or the other. After showing all four objects, the video was presented twice more. Thus children saw each object three times, and heard the word *toma* nine times (three times per presentation). The contingent stimuli required children to touch the screen before each of the boxes was opened, such that children touched the screen 12 times during training and 12 times during test (once per box per presentation).

Procedure

Each child was tested in an empty classroom in the preschool. Two research assistants were present: The experimenter interacted with the child, presented stimuli, and conducted word-learning tests; the observer recorded the child's behavior.

Training. Children were asked to sit on a bench in front of a table. The experimenter explained that she was going to play some games with the child. She placed the tablet computer on a stand and started the training video for the assigned experimental condition. If the child was assigned to a contingent-video condition but was hesitant to follow the instruction to touch the screen, the experimenter encouraged the child (e.g., "What did she say? She said to touch the box/screen!").

After three presentations of the training video, the experimenter occluded the tablet and produced the four boxes, arranging them in the same order as they appeared in the video. The experimenter opened each box, removed the familiar object, and placed it in a tray. She asked the child to identify objects by name (e.g., "Which one is the dog?"). A successful response was coded if the child pointed to or picked up the correct object. This continued until the child identified two objects consecutively.

Word-Learning Task and Testing. After training, the experimenter removed the boxes, tray, and familiar objects. Then she played the next set of videos. After viewing three presentations of the test video, the experimenter occluded the tablet computer, produced the boxes again, and placed each of the novel objects in the tray. During the simple test of word learning, the experimenter asked the child, "Which one is the *toma*?"

After the child completed the simple test by selecting one of the four objects, the experimenter conducted a stringent test of word learning that was adapted from a disambiguation procedure used by Roseberry and colleagues (Roseberry et al., 2009; Roseberry et al., 2014). The experimenter removed two of the objects, leaving the target object and one distracter in the tray. She then asked the child to identify the *modi*. Once the child selected an object, she asked them to identify the *toma* a second time. This stringent test provides a stronger test of word learning by determining whether toddlers will accept any new label for the target object or whether they have truly mapped the word *toma* to the target. Toddlers tend to operate with a mutual exclusivity constraint whereby they assign only one label to a particular object (Markman, 1989), and this constraint is evident before 24 months of age (Liittschwager & Markman, 1994; Markman, Wasow, & Hansen, 2003). Thus a child who mapped the word *toma* to the target object should have selected the distracter object when given a different label (*modi*) and then selected the target again when asked for the *toma* a second time.

Results

Preliminary Analyses

Of the parents who completed the survey (81.90% of sample), 81.72% reported that they let their child use tablet computers. Total screen-media use the previous day averaged 39.69 min (range 0-215), of which 30.47 min were spent with TV (range 0-200) and 7.43 with interactive media (range 0-60). Preliminary analyses indicated that the probability of passing word-learning tests did not differ as a function of parent-reported media use variables, child sex, child race and ethnicity, vocabulary, parent education, or target object (which of two objects was the *toma*).

Moreover, the distribution of these variables did not differ by experimental condition. Thus these factors are not considered further.

Simple Word-Learning Test

The dependent measure was a dichotomous variable reflecting whether children selected the target object (coded as 1) or one of the three distracter objects (coded as 0). Given that age ranged from 24 to 36 months, we used logistic regression to determine the extent of developmental change in each condition. Because visual inspection of the data indicated that age effects were non-linear, we included both linear and quadratic terms for age. See Table 1 for results of this analysis. The probability of passing the simple test increased with age in the Non-Contingent condition (Wald = 4.79, $p = .029$); there was a marginally significant quadratic component for age, such that performance increased until an asymptote around 30 months (Wald = 3.16, $p = .075$). The General-Contingent group did not differ significantly from the Non-Interactive group (all *p*s > .300). Conversely, the results for the Specific-Interactive condition revealed a significant main effect of condition (Wald = 5.81, $p = .016$) as well as significant interactions with both the linear (Wald = 7.45, $p = .006$) and quadratic components for age (Wald = 6.54, $p = .011$). The pattern was such that performance was high for the youngest children, decreased with age until about 30 months, and then increased for older children. The predicted probability of passing the simple test is plotted in Figure 2 for the two groups that differed significantly (Non-Contingent and Specific-Contingent).

The interactions between age and condition were explored further with binomial-probability and chi-square tests. Of particular interest was whether toddlers' performance exceeded what would be expected by chance (probability of .25, given the likelihood of randomly selecting the target among four objects). One-tailed binomial probability tests were used to compare observed probabilities to chance. Thus we divided the sample into three age groups that were approximately equal in sample size and that roughly mapped on to the age groups observed in prior studies of the transfer deficit (e.g., O'Doherty et al., 2011; Schmitt & Anderson, 2002): 23.5-27.5 mos ($n = 38$), 27.5-32.0 mos ($n = 40$), and 32.0-36.0 mos ($n = 38$). Separate tests were conducted for each age group and condition.

Descriptive statistics and results of binomial probability tests are presented in Table 2. Among the youngest toddlers, only those in the Specific-Contingent group performed above chance. Chi-square tests confirmed that children in the Specific-Contingent group were marginally more likely to pass the simple test than were children in Non-Contingent [$\chi^2(1) = 3.23$, $p = .072$] and General-Contingent groups [$\chi^2(1) = 3.23$, $p = .072$]. This pattern was reversed for children in the middle age group, in which children in the Non-Contingent and General-Contingent (but not Specific-Contingent) groups performed above chance. Chi-square tests confirmed that children in the Specific-Contingent group were less likely to pass the simple test than those in the Non-Contingent group [$\chi^2(1) = 4.64$, $p = .031$]; however, the two contingent groups did not differ significantly at this age [$\chi^2(1) = 2.23$, $p = .136$]. Finally children in the oldest age group performed above chance in all three conditions, and chi-square tests revealed non-significant differences between conditions (*p*s > .500). Children in Non-Contingent and General-Contingent groups did not differ at any age (*p*s > .450).

Stringent Word-Learning Test

Of particular interest was the proportion of "simple word-learners" (children who passed the simple test) who also passed the stringent test (selected the distractor when asked for the *modi* and returned to the target when asked for the *toma* a second time). Figure 3 presents the percent of children in each sub-sample who passed both tests (simple and stringent), the simple test only, or neither test.

Given that children passed the simple test, they nearly always passed the stringent test; only a small percentage of children passed the simple test only. This was true in all sub-groups with one exception: While the youngest Specific-Contingent group were about twice as likely as children in the other two conditions to pass the simple test, only about half of these children went on to pass the stringent test as well. In other words, the rate at which younger children passed the stringent test was similar across conditions, despite different rates of passing the simple test. Chi-square tests revealed that children in the middle age group were more likely to pass the stringent test in the Non-Contingent group than in the Specific-Contingent Group [$\chi^2(1) = 4.32$, $p = .038$]; all other comparisons between conditions (within age groups) were non-significant (ps > .250).

Discussion

The purpose of this study was to determine whether toddlers would learn a word from video that incorporates contingency without a real-time social partner. Findings replicate prior research insofar as the likelihood of learning a word from Non-Contingent video increased between 24-30 months of age. The results extend prior research by demonstrating that the youngest 2-year-olds learned a word from video when the screen afforded contingency, even in the absence of socially relevant information from a reciprocally interactive, on-screen partner. However, learning increased only with contingency that required specific responses, and the effect was limited to a simple word-learning test. Moreover, results suggest that specific contingency disrupted learning by slightly older toddlers who otherwise learned words from video.

One potential explanation for the benefit of contingency is that it increases engagement and enables self-pacing. However, not all types of contingency supported learning in this study. Rather, only a program that required deliberate responses to the location of the target object increased fast-mapping. Perhaps specific contingency facilitates learning by directing attention to relevant information, thereby supporting limited attention skills that otherwise might rely on bottom-up, stimulus-driven features (Frank, Vul, & Johnson, 2009; Kirkorian, Anderson, & Keen, 2012). If so, perhaps non-interactive video could also support limited attention skills by emphasizing target content with perceptually salient features (movement, contrast; Wass & Smith, 2015). Future research should assess whether individual differences in visual attention (measured by eye movements) moderate toddlers' ability to learn from both interactive and non-interactive screens.

Although younger toddlers exhibited greater-than-chance performance on a simple word-learning test after using Specific-Contingent video, this did not extend to a stringent test. This is consistent with findings that young children fail to disambiguate when using non-interactive video (Scofield & Williams, 2009) and that they are able to pass a stringent word-learning test only when video incorporates a live social partner, either in person (Roseberry et al., 2009) or via video chat (Roseberry et al., 2014). Fast-mapping is only an initial process in word learning (see Carey, 2010). Perhaps toddlers require more than contingent experience with pre-recorded video in order to engage in more extended processes. This may be particularly true for the stringent word-learning test given that toddlers' ability to disambiguate and to retain new words continues to develop until at least 30 months of age (Bion, Borovsky, & Fernald, 2013).

While Specific-Contingency facilitated learning by the youngest 2-year-olds, this manipulation appears to have disrupted learning by slightly older toddlers who were able to learn in the other conditions (Non-Contingent, General-Contingent), passing both simple and stringent word-learning tests. The reversal in condition effects around 28-32 months of age was unexpected. Perhaps this phenomenon is due to some transition in typical language development, such as the extent to which word learning requires a realistic social context. However, research on the transfer deficit more generally suggests that the problem is not limited to word learning. Studies using other types of tasks also suggest that 30 months is a transition point for children with respect to learning from video (e.g., Schmitt & Anderson, 2002). Further research is needed to determine whether current findings reflect toddlers' ability to learn any information from video or to learn words specifically.

The non-linear age effect may be explained by differences in the amount of information encoded. Perhaps Specific-Contingency enabled the youngest toddlers to encode just enough information to pass the simple word-learning test, whereas this condition may have caused slightly older children (who were already capable of encoding this level of detail with Non-Contingent video) to encode too much detail, thereby rendering them less able to generalize beyond the screen context. Indeed, we observed several of these toddlers point in the direction of the occluded tablet computer (rather than one of the real-life objects) when asked to find the *toma,* suggesting that they mapped the word to the object but only in the context of the video. It is not the case that these children cannot appreciate the symbolic relation between the screen and the objects (indicated by better-than-chance transfer in the other conditions) but, rather, they may tightly bind that information to the tablet in the Specific-Contingent condition. Other researchers have reported that generalization may be impeded when young children encode too many details about an exemplar (Vlach & Sandhofer, 2012), and that generalization may increase after a delay, at which point children recall only the most central features of a given category (see

Vlach, 2014). Thus toddlers around 30 months of age may be more successful in the Specific-Contingent group after a delay. Future research should explore this possibility.

Conclusion

Findings from the current experiment build on the extant literature by demonstrating that toddlers may learn more from interactive media than from non-interactive video. However, the extent to which toddlers learn from interactive and non-interactive video varies across the third year of life, such that the type of video experience that produces the greatest rates of word learning at some ages may disrupt learning at other ages. Current findings emphasize the importance of exploring continuous developmental change: Had we only compared children at 24 and 36 months of age, we would have overlooked an important transition around 30 months. Further research is necessary to understand the specific conditions under which toddlers can learn from screen media at different ages and the cognitive mechanisms that moderate learning. Such studies, combined with current findings, will inform recommendations for parents and educators by establishing whether, how, and for whom screen media can be educationally valuable.

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Table 1

Logistic Regression Results for the Probability of Selecting the Target Object during the Simple Test of Word Learning as a Function of Age and Video Condition

	B	S.E.	Wald	df	Sig.	Exp(B)	95% CI
Constant	-2.60	1.20	4.66	1	.031	0.07	
Age	1.02	0.47	4.79	1	.029	2.78	[1.11, 6.92]
Age*Age	-0.07	0.04	3.16	1	.075	0.94	[0.87, 1.01]
General-Contingent	1.08	1.52	0.51	1	.477	2.94	[0.15, 57.49]
General*Age	-0.62	0.60	1.06	1	.303	0.54	[0.17, 1.75]
General*Age*Age	0.05	0.05	1.08	1	.300	1.05	[0.96, 1.16]
Specific-Contingent	3.70	1.53	5.81	1	.016	40.37	[2.00, 816.36]
Specific*Age	-1.64	0.60	7.45	1	.006	0.19	[0.06, 0.63]
Specific*Age*Age	0.12	0.05	6.54	1	.011	1.13	[1.03, 1.24]

Note. *Age is measured in months and is centered at 24 months. The reference group for condition is Non-Interactive. CI indicates 95% confidence interval for Exp(B).*

Table 2

Proportion of children who passed the simple test of word learning as a function of age and video condition

	Young (23.5-27.5 mos)			Middle (27.5-32.0 mos)			Old (32.0-36.0 mos)		
	n	*M (SD)*	95% CI	*n*	*M (SD)*	95% CI	*n*	*M (SD)*	95% CI
Non.	13	.23 (.12)	[.05, .54]	12	.75 (.13)***	[.43, .95]	13	.69 (.13)**	[.39, .91]
Gen.	13	.23 (.12)	[.05, .54]	13	.62 (.14)**	[.32, .86]	12	.75 (.13)***	[.43, .95]
Spec.	12	.58 (.15)*	[.28, .85]	15	.33 (.13)	[.12, .62]	13	.77 (.12)***	[.46, .95]

Note. *The dependent variable is the proportion of participants who selected the target object when asked for "the toma". Conditions are Non-Contingent, General-Contingent, and Specific-Contingent. Numbers in brackets indicate 95% confidence intervals for two-tailed binomial tests comparing whether observed probabilities differed from those expected by chance (.25). Significance levels are for one-tailed binomial tests comparing whether observed probabilities are greater than those expected by chance (.25). Binomial probability tests were conducted using the binom.test function in R. Asterisks indicate level of significance as follows:* * $p < .05$; ** $p < .01$; *** $p < .001$

FIGURE CAPTIONS

Figure 1. Familiar objects used during training (top left), novel objects used during testing (bottom left), and actress indicating the box that she will open next (right)

Figure 2. Predicted probability of passing the simple test of word learning. Age was centered at 24 months of age. Shading indicates 95% confidence intervals. For ease of interpretation, this figure depicts only the conditions that differed significantly in the model: Non-Contingent and Specific-Contingent. The fitted line for the General-Contingent group was intermediate and not significantly different from either of the other conditions.

Figure 3. Percent of children in each condition and age group who passed both simple and stringent tests, simple test only, or neither test.

FIGURE 1

FIGURE 2

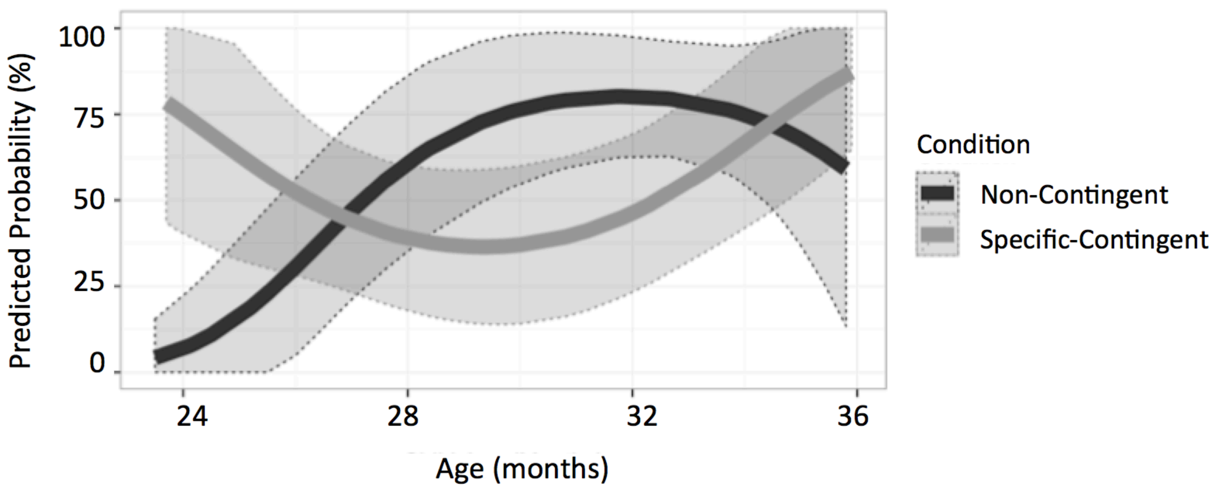
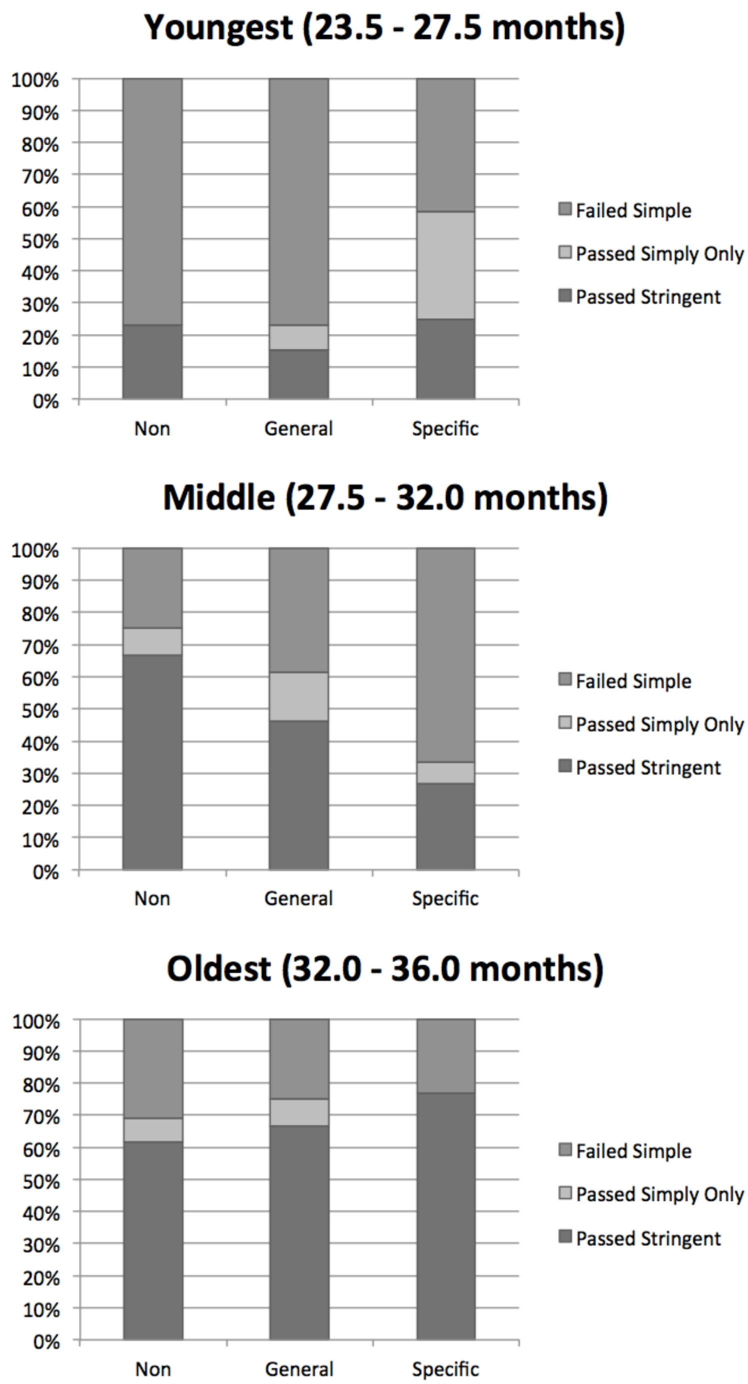

Predicted Probability (%)
100
75
50
25
0
24
28
32
36
Age (months)
Condition
Non-Contingent
Specific-Contingent

FIGURE 3


Youngest (23.5 - 27.5 months)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Non
General
Specific
Failed Simple
Passed Simply Only
Passed Stringent
Middle (27.5 - 32.0 months)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Non
General
Specific
Failed Simple
Passed Simply Only
Passed Stringent
Oldest (32.0 - 36.0 months)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Non
General
Specific
Failed Simple
Passed Simply Only
Passed Stringent