ATTENTIONAL BASIS OF DEONTIC REASONING ABOUT PERMISSION RULES IN 3-5 YEAR-OLD CHILDREN

by

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ABSTRACT

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Deontic reasoning is a domain of reasoning concerning permissions, obligations, and prohibitions often utilizing conditional logic (Wason, 1968). Correct identification of rule violations is bolstered by the addition of a social valence to the rule for both adults (Tooby & Cosmides, 1992) and children (Harris & Nunez, 1996). This "deontic advantage" for violation-detection is taken as evidence for evolved social-cognitive mechanisms for reasoning about cheaters in the context of social contracts (Fiddick, 2004), and the early development of this advantage supports an evolutionary account of such abilities (Cummins, 2013). The current research hypothesized that differential attention to rule elements underlies the early emergence of the deontic advantage.

Accuracy to a change-detection paradigm was used to assess implicit attention to various rule elements after children were told 4 different rules (2 social contracts, 2 epistemic statements). Thirteen 3-year-olds, twenty 4-year-olds, and sixteen 5-year-olds

completed the experiment. Each participant completed 64 change-detection trials embedded within a scene depicting adherence to or violation of the rule.

Results indicate that 4 and 5 year-olds consistently attend to the most relevant rule information for making decisions regarding violation ($F(6, 124)=3.86$, $p<.01$, $\eta_p^2 = .144$) and that they use observed compliance/non-compliance with the rule to further direct attention ($F(6, 138)=3.27$, $p<.01$, $\eta_p^2 = .125$). Furthermore, accuracy of change-detection to scenes of rule violation increases from ages 4 to 5, but not 3 to 4. However, a novel finding emerged suggesting that children use the absence of benefit to direct attention, suggesting possible "being-cheated" detection, rather than cheater-detection ($F(9, 345) = 21.855$, $p<.001$, $\eta_p^2 = .322$). This work is the first to investigate a deontic effect on attentional processes and opens a new avenue of inquiry to understanding the internal and external variables contributing to the development of deontic reasoning. Follow up studies are currently underway to clarify how children use these environmental cues and in/out group membership to direct attention to rule violations.

ATTENTENTIONAL BASIS OF DEONTIC REASONING ABOUT PERMISSION RULES IN 3-5 YEAR-OLD CHILDREN

TABLES

FIGURES

I. INTRODUCTION

Deontic reasoning is a domain of reasoning concerning personal requirements, permission, and obligations. In other words, deontic reasoning describes the actions in which one *must* engage, in which one *may* engage, and in which actions one *must not* participate. The ability to reason correctly in this fashion is not exclusively social in nature; people are also able to reason this way in the abstract using content-general *If-Then* statements, or propositional logic. But, deontic rules derive their practical meaning from the addition of a social valence not necessitated by purely propositional logic. The addition of social information to propositional logic allows for the broad transmission of social rules and proscriptions within groups of all sizes. Given human's intense dependence on social function, cognitions related to the acquisition of and adherence to such rules likely faced significant evolutionary pressures. Societies and cultures of all types, from industrialized to hunter-gatherer, are built upon both formal and informal deontic rules; furthermore, the ability for individuals to interpret and abide by these rules is critical to proper social functioning. Legal systems prescribe obligatory rules, in addition to specifying situations under which permission is granted for different action (e.g., killing another person is generally illegal, but is permissible in self-defense). Informal deontic rules often govern everyday social interactions (e.g., if you want dessert, you must first eat your broccoli). Given deontic reasoning's intimate relationship with social interaction, understanding how children's cognitive abilities develop in the domain

is of critical importance to overall social functioning in childhood and beyond Additionally, previous work in evolutionary psychology conceptualizes the detection of rule violators as one of many domain- specific cognitive tools acted upon by natural selection. Understanding the developmental or maturational course of these abilities is critical to both theory and applied social functioning. Furthermore, the current experiment holds methodological value, as no previous investigation of rule violations in children has assessed the attention to story elements in such a specific manner.

Three domains of deontic reasoning exist: moral, prudential, and social conventional rules (Beller, 2010). Moral rules are identified by universal, unalterable judgments of right and wrong. Adherence to moral rules is obligatory and independent of authoritative proscription. Prudential rules involve the self and concerns of safety. Social conventional rules are socially constructed and provide a structure for appropriate social behavior and interactions.

However, researchers from different sub-fields of experimental psychology have reached divergent conclusions regarding the nature of deontic reasoning and the separability of its three domains. Differences exist between the two groups in how to conceptualize and categorize deontic reasoning, namely, whether the division into three domains is psychologically relevant or necessary, in addition to differences regarding measurement tools and procedures. These competing theoretical accounts of deontic reasoning pit the cognitive reasoning literature against the moral reasoning literature and social contract theory.

Cognitive Reasoning

Cognitive reasoning advocates claim deontic reasoning need not be sub-divided into independent, distinctive domains (Fiddick, 2004). Individuals are purported to reason about obligation, permission, and prohibition as a cohesive group. All rules falling under the umbrella of deontic reasoning are considered equivalent conditional rules by cognitive reasoning researchers (Beller, 2010). Conditional rules are those that can be expressed using *If-Then* statements. Classification as a conditional rule leads to the application of classical logic in determining how such rules are represented psychologically. The subtle differences are glossed over in favor of uniting the domains through their shared membership as classical logical rules in the form of, *If* P, *then* Q.

Wason (1968) conducted the original research on the subject using his classic Wason Selection Task. Conditional rules, in the abstract form of, *If* P *then* Q, were presented to subjects who were then required to judge whether certain conditions should be investigated for violations of the rule. Participants were shown four cards with information about P on one side and Q on the other. Each card corresponded to one of the four possible combinations of results: P and Q*, not*-P and Q, P and *not*-Q*, not-P* and *not*-Q. Participants must choose, while looking at only one side of the card, which cards must have their other side checked for possible violations. The only violation of the rule *If* P, *then* Q, is P and *not*-Q; therefore a correct answer is to check the P card and the *not*-Q card. Checking any other cards is unnecessary and disobeys the rules of propositional logic.

It is widely accepted that people do not typically reason in accord to formal logic, and not surprisingly, correct performance on abstract propositional-logic tasks is quite

low, around 15% for adults, whereas performance is greatly improved when the abstract problem is made concrete (Cheng & Holyoak, 1985). Wason and Shapiro (1971) found that phrasing the conditional rule in concrete terms ("Every time I go to Manchester I travel by car") significantly improves correct selection of conditions that need to be checked for violations when compared to a traditional abstract form of the rule ("Every card which has a D on one side has a 3 on the other side"). Concrete formations of the rule lead participants to outperform even those who have been taught the proper propositional logic and been given practice trials with accuracy feedback when completing the abstract task (Wason & Shapiro, 1971).

The positive influence of context on selection task performance requires a content-dependent interpretation of performance on propositional logic problems and peoples' understanding of conditional rules. Cheng and Holyoak (1985, 1989) proposed a pragmatic reasoning schema that "consists of a set of generalized, context-sensitive rules which, unlike syntactic rules, are defined in terms of classes of goals and relationships to these goals" (p.395, 1985). Whether performance on a selection task conforms to formal logic is a function of the domain of information, as some classes and contexts of rules engage material and evoke schemas not bound by formal *If-Then* logic. However, deontic reasoning, reasoning about permission and obligation, is argued to yield responses in accordance to correct propositional logic across all three domains (moral, prudential, and social conventional). Furthermore, these different rule structures are treated as logically identical simply because they can be expressed using formal logical forms. Important to note is that performance on deontic conditionals is

characteristically evaluated using the same logical criteria as propositional logic problems.

More recently Beller (2008, 2010) argues that moral reasoning relies on the same independent emotional and cognitive evaluative systems as do the other two domains of deontic reasoning. Such a position holds that emotional and cognitive evaluations of rules and their violations operate independently, often in concert, but are nonetheless separable; but these systems of evaluation are applied to all deontic rules equivalently. Additionally, due to morality's inherent indefinability, Beller (2008) argues no dedicated cognitive system could exist; a rule imbibed with moral implications for one group may function as a social convention in another.

To be clear, cognitive reasoning researchers do not claim that logic is the explanation for participants' behavior, they correctly claim that people in fact do not answer logically (Wason, 1968). But the application of similar logical characterizations to deontic logic prohibits researchers from finding differences in sub-types of deontic rules by limiting both interpretation and theory formation (Fiddick, 2004). As such, deontic reasoning remains a unified phenomenon in the eyes of cognitive reasoning. For example, the rule "If Sally rakes the leaves then she is allowed to ride her bike" is treated as logically identical to *If* P, *then* Q, despite the deontic condition of permission, as opposed to obligation, being in effect. Sally is not *required* to ride her bike after raking the leaves, but she is *allowed* to if she chooses. However, the cognitive reasoning literature has shown the tendency to treat "*logically* identical reasoning as *psychologically* identical reasoning" (Fiddick, 2004, p. 448). This overgeneralization of identical logic and reliance upon a single task (Wason Card Selection) for experimental

investigation left the cognitive reasoning field unable to adapt their theory and methods to a more domain-specific approach to deontic reasoning. Theories of moral reasoning, bolstered by findings from evolutionary psychology, specifically *social contract theory* (Tooby and Cosmides, 1992) promote a domain-specific view of deontic reasoning in which types of rules are demarcated not by logical similarity, but by psychologically relevant content and application.

Moral Reasoning

The moral reasoning literature contends moral, prudential, and social conventional rules represent different domains of reasoning that, while logically equivalent, are not treated as uniform in our cognitive judgments about the rules. Evidence for the psychological separation of deontic domains comes from many sources, but tends to highlight the reparability of moral rules from social conventional and prudential rules in pragmatic reasoning. Both children and adults rank moral violations as more serious than violations of social convention, even in the absence of rules prescribing adherence to the moral rule (Nucci, 1981). Children justify moral transgressions by citing context independent reasons such as fairness and welfare, whereas they invoke concepts such as authority and social coordination when justifying conventional transgressions (Song, Smetana, & Kim, 1987). More generally, naturalistic mother-child interactions differ based upon the domain of rule involved in the interaction or discussion (Nucci & Weber, 1995). Children's inferences regarding contract violations differ based upon context and the nature of the relationship between the two parties involved in the contract (Keller, Gummernum, Wang,& Lindsey, 2004). For a more thorough review of evidence for the separability of domains see Fiddick (2004). Further

division of deontic domains is proposed from an evolutionary perspective; differences in psychological reasoning are proposed for rules of pure social conventions, or social contracts, as opposed to rules involving safety and precaution.

Social Contract Theory

Social contract theory proposes that social life, and the push for an evolutionary advantage through superior social functioning, is a prime determinant of human cognitive evolution (Cosmides & Tooby, 1992). Specific cognitive adaptations emerged and are present in humans to deal with the complex and varied world of human social systems**.** This view is in some sense similar to the pragmatic reasoning schemas of Cheng and Holyoak (1985) in that different contexts evoke the use of different schemas; however social contract theory affords special privilege to evolutionarily relevant contexts.

The *social-brain hypothesis* (Dunbar, 1992, 1998, 2010) explains expansive hominid brain growth relative to body size, particularly of the neo-cortex, in terms of the sophisticated cognitive mechanisms required for navigating and manipulating social interactions. Increases in group size, and thus number and complexity of social interactions, resulted in the evolution of adaptations for mind-reading (Theory of Mind) which enables numerous complex cognitive processes involving the anticipation and manipulation of another's mental states. Such abilities open an entirely new arena for competition and cooperation among conspecifics, requiring a host of specific perceptual, attentional, and processing capabilities. As Theory of Mind (ToM) abilities increased across phylogeny, individuals were better able to predict and anticipate the mental states of others. This has many implications, most notably the ability to deceive. Understanding that others can hold a false-belief, an ability which begins to emerge

around the age of 3 (Wellman, Cross, & Watson, 2001), allows one to manipulate that false belief surreptitiously for deceptive personal gain. However, hominids would not have benefited from blind-faith in others, particularly as group size increased and interactions with close, immediate kin decreased. Thus, an evolutionary arms race between the development of sophisticated deception abilities and specific adaptations for detecting and protecting against such deception should have emerged simultaneously. The social brain hypothesis provides the evolutionary foundation upon which social contract theory can make informed predictions regarding the existence of social-cognitive abilities. One such ability is cheater-detection (Cosmides and Tooby, 1992; Cosmides, Tooby, Fiddick, & Bryant, 2005). Cheater-detection is a specific cognitive propensity to check for and notice when an individual violates a social contract by reaping the benefit but not completing the required action.

Tooby and Cosmides (1992) present numerous experimental accounts of increased logical performance on selection tasks (choosing the logically correct *P* and *not-Q* cards) framed in a social contract format than when the rule is presented abstractly or descriptively. Findings are even presented which account for the possibility that social contracts simply elicit logical reasoning, rather than the existence of a dedicated processing mechanism that would search for rule violations independent of logical consideration. To show such abilities Tooby and Cosmides (1992) presented participants with a "switched" format social contract, the merit of which is found in the fact that purely logical abstract deontic accounts (If P then Q) are content independent, whereas social contracts and subsequent violations are meaningful only because of their content. By switching the format of a rule from "If you give me your watch, I'll give you $20" to

"If I give you $20, you give me your watch" researchers are able to pit logical against social contract violations and investigate which holds greater sway over responding. In the first rule, the logically correct answers for violation detection (P and not-Q) align with violations of the contract (Receiving a watch, and not giving $20). However, in the second example, while logically correct answers do not change (P and not-Q), answers that constitute checks of cheating or receiving benefit without paying the cost switches do (not-P and Q; not giving $20 and receiving a watch). Thus, by comparing rates of responses to rule 2 violation checks, researchers were able to directly compare the use of a dedicated cheater-detection mechanism independent of traditional logic. Results confirm that even when it violates logic, respondents more readily identify cards that correspond to social contract violations as needing to be checked for rule violations.

Hazard Management Theory

Additionally, evolutionary theory predicts a dedicated and separable cognitive mechanism, *hazard management theory*, focused on precautionary reasoning for the purpose of protecting individuals from harm (Cosmides & Tooby, 1997). Indeed, Fiddick, Cosmides, and Tooby (2000) found evidence that individuals reason in a domain-specific manner regarding violation detection when presented with a rule of protection that is not predicted by purely logical considerations. Evidence for the separability of social contract theory and hazard management theory is available through the creation of rules in which the two theories, through their differences in content emphasis, predict different violation-detection strategies for the identical rules, resulting in disparate response patterns that are best explained by the existence of specialized mechanisms regulating responses to either cheater-detection or hazard-management

(Fiddick et al., 2000). Further evidence for the separation of social contracts and precautions comes from a case study of an individual, R.M., who has bilateral limbic system damage. R.M. is able to correctly and consistently reason about precautionary rules: 'If you engage in P, then you must take precaution Q," but performs significantly worse on logically identical, but contently dissimilar, social contract rules: "If you take benefit P, then you must meet requirement Q" (Stone, Cosmides, Tooby, Kroll, & Knight, 2002). Such evidence necessitates a domain-specific explanation of conditional reasoning, based upon ecologically valid contextual differences, that accounts for divergent response patterns across logically identical circumstances.

Development, Social Contract Theory, and Hazard Management

Children obtain an understanding of deontic conditionals and rules by the age of 3, evidenced by their ability to use a violation-detection strategy when examining deontic rules but a confirmatory strategy when faced with indicative reasoning (statements whose factual basis can be disproven: "All children must wear coats") (Cummins, 1996). Children as young as 3 years old understand that permission rules are not violated simply by the actor not meeting the condition, but that the benefit must first be received to warrant a violation (Harris & Nunez, 1996). Harris and Nunez (1996) also present evidence and conclude that "children have a robust understanding of deontic conditionals, irrespective of whether they include a pragmatic rationale, irrespective of whether they are linked to a particular authority figure, and indeed irrespective whether they are familiar or novel" (p. 1584). Development of these capabilities understandably coincides with the emergence of ToM between 3 and 5 years of age, as both are necessary for navigation of adult-like social hierarchies and situations. However, a dearth of evidence

exists regarding the separation of social conventional and hazard management domains in children's reasoning. Song and colleagues (1987) report that children in kindergarten (~5 years old) are able to separate moral rules from social convention in their evaluation of transgressions. Cummins (1996) reports the ability for violation-detection in children as young as 3, but little work has been done to compare these abilities with children's hazard management responses in the same experiment.

No known work, with adults or children, has attempted to understand the fundamental cognitive abilities that may underlie or be required for deontic reasoning. In order to make judgments about violations, individuals must orient toward and attend to rule objects, actions, and actors. Thus, differences in attention may be one piece of the cognitive puzzle leading to the separability of cheater-detection or hazard-management. Additionally, a general investigation of differential attention to rule dimensions can provide information about how individuals attentionally interact with rule and observed behavior. For example, what rule elements capture attention when observing a rule being broken, adhered to, or ignored? In this way a fundamental pattern of attention to conditional rules may be established. Furthermore, the use of an implicit measure of attention can enable the assessment of rule interaction below conscious awareness. Participants may differentially report violations during certain rules or conditions, but may not have available for conscious referent the process working beneath this decision.

Thus, I sought to investigate the developmental course of cheater-detection in 3-5 year old children, the proximate attentional mechanisms of understanding permission rules, and the potential separability of social contract theory and hazard management theory. Children aged 3-5 years were selected for three reasons: 1. Evidence for an

evolved domain-specific mechanism is strongly supported by early maturational existence; 2. Previous work has confirmed preschool children's preferential violation detection for rules over descriptive norms, however no work has investigated precautionary rules with this age group; 3. The preschool years are a time of substantial social-cognitive development and might be a crucial time for any developmental change in deontic reasoning. Using stories of fictional children, participants were presented with four rules that vary on two dimensions: social-conventional vs. precautionary, and obligatory vs. habitual. The use of a *change-detection paradigm* will allow for the investigation of possible attentional differences attributable to differences in rules, immediate behavior, or conditional objects and actions.

A flicker change-detection paradigm was employed where the participants viewed a continual cycling of displays and must determine if a change occurred within a specific time limit (Resnick, 2002). In these tasks an original image is presented, followed by a fixation point, followed by an altered image containing the change, followed by a fixation point. Movement through these four presentations represents one cycle of the change, which can then be repeatedly looped for any desired amount of time. This results in the change appearing to "flicker." For example, a location change would appear as if the object were jumping across the screen, or a color change would appear as if the object were flashing different colors. Both accuracy and time to detection can be measured as dependent variables and are found to serve as a marker for the direction of focused attention (Resnick, 2002, Simons & Resnick, 2005). Those changes that are found more frequently can be assumed to have attention directed toward them. While the task of change-detection itself is explicitly instructed, the variation between accuracies for

different rules, scenes, or changes is implicit, as no specific instruction to incorporate this information was given to children during the task. Therefore, differences in accuracy are assumed to reflect differences in children's attentiveness to information in the observed environment given variation along the meaningful higher-order concepts of rule and scene. A reasonable basis for this conclusion exists as many experiments have found impact on change-detection of higher-order knowledge or representations (Archambault, O'Donnell, & Schyns, 1999; Simons & Levin, 1998; Werner & Thies, 2000).

Four change types were presented: Action, Object, Person, and Background. These categories serve to meaningfully define and group those items that are changing in the flicker task. Action changes relate to the benefit action, object changes to the conditional object, person changes to the physical nature of the fictional child, and background changes are irrelevant to the story. These four change types will allow assessment of which elements of the conditional logic children attend to most, and how this varies with rule type. Accuracy of change-detection to correctly identified changes will be measured. Additionally, these changes are nested within computer generated scenes that depict the fictional child differentially engaging with the rule. These scenes function as the original and changed image in the flicker paradigm. Scenes occur in four types: Follow Rule/Benefit, Follow Rule/No Benefit, Break Rule/Benefit, and Break Rule/No Benefit. Participants will detect changes while they observe the fictional child in each of these four behavioral situations, allowing for assessment of how immediate behavior may impact the attention of participants. For example, Break Rule/Benefit depicts the fictional child cheating, thus hypotheses regarding cheater-detection can be tested by assessing what children attend to when they view a fictional child cheating.

It is hypothesized that overall accuracy for rules (both precautionary and social-conventional) will be higher than descriptive norms, and that this difference will become greater with age. However, no hypothesis is made regarding a main effect of precautionary vs. social-conventional rules. No previous work has attempted to dissociate this rule dimension in children's cognitions, and it is unclear why one might be preferred over another. Children's change-detection accuracy is expected to be higher for Break Rule/Benefit and Follow Rule/No Benefit scenes, as these scenes depict situations where the fictional child is cheating or being cheated. This pattern is expected to emerge at the age of 4. Action and Object changes are expected to be detected more accurately than Person and Background as they provide information about the conditions of the rule. Four and five-year-olds are expected to show this pattern, whereas three-year-olds are not.

II. METHOD

Participants

Forty-nine participants (13 3-year-olds (8 male), 20 4-year-olds (12 male), and 16 5-year-olds (9 male)) were recruited from a university preschool in south Florida, which is required by law to mimic the socioeconomic and ethnic diversity of the surrounding community. Children who did not demonstrate appropriate understanding of the experiment and its requirments were excluded from participation. All participants gave verbal consent at the time of experimentation in addition to previous consent by a legal guardian.

Materials

The change-detection task was presented on an Acer Aspire 5517 laptop using the stimulus presentation software Superlab 4.0. Accuracies and demographic data were recorded by hand.

Stories. Four fictional story types were used to manipulate the deontic characteristics of the rule across both the social nature (Social Obligatory, prescribed by the fictional child's mother, or Social Descriptive, presented as habitual action) and the prudential nature (Precautionary Obligatory, prescribed action concerning an aspect of the child's well-being; or Precautionary Descriptive, habitual safety-relevant action) of the situation. The source of manipulation stems from whether or not the rule concerns safety and whether or not adherence to the rule is required by an authority figure, the

child's mother. Thus, the four story types were labeled Precautionary-Obligatory, Social-Obligatory, Precautionary-Descriptive, and Social-Descriptive. In Precautionary-Obligatory stories, the fictional child is given a conditional rule from his or her mother that involves safety (Precautionary) (e.g., "Ben's Mom says that *if* Ben plays videogames, *then* he must sit far away from the TV, in the big blue chair, so he doesn't hurt his eyes"). In Social-Obligatory stories, the conditional rule is prescribed by the mother but is not relevant to safety (e.g., "Ben's Mom says that *if* Ben plays videogames, *then* he must first put away his blocks into their box"). In Precautionary-Descriptive stories, the conditional rule is in the form of a habit (Descriptive) and involves safety (e.g., "Ben says that *if* he plays videogames, *then* he always sits far away from the TV so he doesn't hurt his eyes"). In Social-Descriptive stories, the conditional rule is in the form of a habit (Descriptive) and does not involve safety (e.g., "Ben says that *if* he plays videogames, *then* he always cleans up his blocks first").

Stories came in four different content types (i.e., playing videogames, painting, playing outside, and riding a bike) corresponding to four different fictional children about whom the participants hear: Ben, Carol, Sally, and Max. See Table 1 for a list of all stories told to children.

Images. Images presented for the change-detection paradigm were created specifically for this purpose (see Figure 1 for examples). Images were paired into 16 couples per each of the four stories (creating 2x16x4=256 images). Each pair of images was presented in a 1 second loop, alternating with a fixation point (Original, Fixation, Changed, Fixation) for 30 cycles (30 seconds). Thus, each screen shot was present for 250 milliseconds. The second image included a single change from the first image in one of four categories:

Background, Object, Action, and Person. Background changes were irrelevant to the story (e.g., windows or a plant); Object changes were relevant to the object of the condition (e.g., If Ben must sit in a chair when he plays videogames, the change would be about the chair); Action changes were relevant to the benefit obtained by adherence to the rule (e.g., If Ben must sit in a chair in order to play videogames, the change was about the videogames); and Person changes were about physical properties of the fictional child (e.g., clothing and hair). Changes occurred in color, location, or size of the changing object.

Scenes. These sets of images used for change-detection also correspond to unique scenes depicting the fictional child engaging in one of four possible actions relevant to the story: meeting the condition of the rule and receiving the benefit (Follows Rule/Benefit), not meeting the condition of the rule but receiving the benefit (Breaks Rule/Benefit), meeting the condition of the rule and not receiving the benefit (Follows Rule/No Benefit), and both not meeting the condition nor receiving the benefit (Breaks Rule/No Benefit). For example, in the story where "Ben's mom says that *if* Ben plays videogames *then* he must always picks up his blocks," a "Follows Rule/Benefit" scene depicted Ben both having picked up his blocks and playing videogames; a "Breaks Rule/Benefit" scene depicted Ben having not picked up his blocks, but playing videogames; a "Follows Rule/No Benefit" scene depicted Ben having picked up his blocks but not playing videogames; and a "Breaks Rule/No Benefit" scene depicted Ben engaging in neither action. Thus, Follows Rule/Benefit depicts adherence to the rule, Breaks Rule/Benefit depicts cheating or disobeying, Follows Rule/No Benefit depicts not receiving the benefit when it is deserved, and Breaks Rule/No Benefit depicts ignoring both the rule and benefit. Each

scene type occurred four times per story, with each change type occurring four times within each scene type, resulting in the 16 change-detection trials per story previously mentioned.

Design. For each age level (3, 4, and 5 years), each story type is presented once, such that each child received a Precautionary-Obligatory, Precautionary-Descriptive, Social-Obligatory, and Social-Descriptive story. Within each story type there are16 change-detection trials, four each of four different scenes (Follows Rule/Benefit, Follows Rule/No Benefit, Breaks Rule/Benefit, and Breaks Rule/No Benefit), with each of the four change types (Background, Action, Object, and Person) occurring once per scene type. Presentation of story type was Latin-square counterbalanced, while scene and change presentation order was randomized.

Procedure

Children were taken from their classroom to a private room for the experiment, which consisted of two sessions one week apart. Participants were assigned to one of the four counterbalanced conditions which determined the order in which they were presented the four story types. In the first session, participants were given the first two stories and the final two in their second session.

Children were told they would be playing a computer game with the experimenter in which they would be a detective and their help was needed to find things that are changing in order to help the experimenter. Practice trials with the change-detection task were completed until the participant understood the nature of the task.

To begin each story, children were read the explicit rule statement and asked to repeat it to the experimenter. This was repeated until the child showed an understanding

of the conditional relationship and whether this conditional relationship was prescribed by the fictional child's mother or whether it was simply a function of habit. Next, participants were told they would need to find things that were changing while looking at pictures of the fictional child and were reminded to do so as quickly as possible. Eight change-detection trials were then completed with the experimenter recording accuracy of the child's response when the child correctly pointed out or verbally acknowledged the change. After eight trials the participant was once again asked to report the conditional rule to the experimenter with accuracy recorded for being able to identify the benefit and condition. Following this story understanding check, the final eight trials were completed for the story.

This procedure was repeated for all four stories across both test days. At the beginning of the second test day each participant completed the practice trials as they did on the first test day.

III. RESULTS

Analyses were conducted on change-detection accuracies in a 3 (Age: 3, 4, and 5 year olds) X 4 (Story: Precautionary-Obligatory, Precautionary-Descriptive, Social-Obligatory, and Social-Descriptive) X 4 (Scene: Follows Rule/Benefit, Follows Rule/No Benefit, Breaks Rule/Benefit, and Breaks Rule/No Benefit X 4 (Change: Action, Object, Person, and Background) mixed ANOVA, with Age being the only between-subjects variable. A trial was judged as accurate if the participant correctly identified what was changing in the scene within 30 seconds. If children could not identify the change or surpassed 30 seconds then the trial was recorded as incorrect. For within-subjects variables, Story, the Story-Scene interaction, the Story-Change interaction, and the Story-Scene-Change interaction violated Mauchly's Test of Sphericity (W=.662, .162, .152, and .000 respectively), all p's <.05. As such, the Greenhouse-Geisser correction was used for analyses when appropriate. The Bonferroni p-value adjustment is used on all subsequent post-hoc multiple comparison analyses.

The analysis produced significant main effects of Age, $F(2,46) = 21.42$, $p < .001$, η_p^2=.48, (5-year-olds, 62.5% > 4-year-olds, 52.9% > 3-year-olds, 38.8%), Scene, $F(3,135) = 15.3$, $p < .001$, $\eta_p^2 = .25$ (Follows rule/No benefit, 56.5% = Breaks rule/No benefit, 55.5%) > Breaks rule/Benefit, 47.5% = Follows rule/Benefits, 45.5%) and Change, $F(3,124) = 81.3$, $p < .001$, $\eta_p^2 = .64$ (Action, 65.8% = Object, 63% > Person,

42.6% > Background, 35.1%). The main effect of Story was not significant, $F(3,111) = 1.20$. Main effects are depicted in Table 2. Also significant were the following interactions: Age X Scene, $F(6, 138)=3.27$, $p<.01$, $\eta_p^2 = .125$, Age X Change, $F(6, 124)=3.86$, $p<.01$, $\eta_p^2 = .144$, Story X Scene, $F(6, 283) = 2.41$, $p<.05$, $\eta_p^2 = .05$, Story X Change, $F(6, 293) = 2.67$, $p<.05$, $\eta_p^2 = .055$, and Scene X Change $F(9, 345) = 21.855$, $p<.001$, $\eta_p^2 = .322$.

Age X Scene

Means for the significant Age and Scene interaction significant are depicted in Figure 2. Post-hoc ($p < .05$) multiple comparisons across Age revealed that for 3-year-olds, accuracies during Follows Rule/Benefit (R+B+ in Figure 2) scenes (29.8%) were significantly lower than accuracies for all other scenes, which did not differ from one another except (Breaks Rule/Benefit [R-B+] = 39.9%, Breaks Rule/No Benefit [R-B-]= 41.8%, and Follows Rule/No Benefit [R+B-] = 43.7%, all *p*s < .05) For 4-year-olds, accuracies for the Breaks Rule/No Benefit scenes (62.8%) and Follows Rule/No Benefit scenes (57.8%) did not differ, and both were significantly greater than the Follows Rule/Benefit (46.9%) and Breaks Rule/Benefit (44.1%) which did not differ. The 5-year-olds' accuracies did not significantly differ across any Scene types (Follows Rule/No Benefit = 68%, Breaks Rule/No Benefit = 62.9%, Follows Rule/Benefit = 59.8%, Breaks Rule/Benefit = 58.6%).

Considering the interaction from the other direction, analyses of Scene across Age revealed similar developmental patterns for Follows Rule/Benefit and Follow Rule/No Benefit scenes. For both the Follows Rule/Benefit scenes and the Follows Rule/No Benefit scene, there were significant differences between each age group (i.e., 5 > 4 > 3).

However, for Breaks Rule/Benefit scenes, 5-year-olds were more accurate the 3- and 4-year olds who did not differ significantly from one another (i.e. 5 > 4 = 3); and for the Breaks Rule/No Benefit scenes, percentage accuracies were equivalent for the 4- and 5-year-olds and both were significantly greater than the 3-year olds (41.8%) (i.e. 5 = 4 > 3).

Age X Change

Means for the significant Age x Change interaction are depicted in Figure 3. Multiple comparisons across Age revealed that for 3-year-olds, Action changes (54.3%) did not differ from Object changes (44.7%), but were significantly greater than Background (22.6%) and Person (33.7%) changes, *p*s< .001. Object changes were not statistically different from Person changes, but both were significantly greater than Background changes, *p*s ≤ .01 (i.e., Action > Object = Person > Background). For 4-year-olds, Action (67.2%) and Object (68.4%) change accuracies were comparable, and both were significantly greater than Person (45.3%) which is also greater than Background (30.6%),(i.e., Object = Action > Person > Background). Five-year-olds followed a similar pattern to the 4-year olds, such that Action (75.8%) and Object (75.8%) change accuracies were comparable, and both were significantly greater than Person (45.7%) and Background (52%) that did not differ (i.e. Object = Action > Background = Person).

Story X Scene

Means for the significant Story and Scene interaction are presented in Figure 6. Multiple comparisons revealed for Precautionary-Obligatory stories, accuracy for Follows Rule/Benefit scenes (40.3%) was significantly lower than Breaks Rule/No Benefit (56.6%) and Follows Rule/No Benefit (53.6%), but was comparable to the Breaks Rule/Benefit scenes (50%). All other Scene comparisons did not vary significantly. For

Precautionary-Descriptive stories, accuracy for the Breaks Rule/No Benefit scenes (63.3%) was significantly greater than the Follows Rule/No Benefit scenes (52%), Breaks Rule/Benefit (48%), and Follows Rule/Benefit (42.3%) scenes. No other contrasts are significant. For Social-Obligatory stories, only one comparison achieved significance: accuracy for Follows Rule/No Benefit (63.8%) scenes was significantly greater than accuracies for the Breaks Rule/No Benefit scenes (48.5%). All other comparisons were nonsignificant. Likewise, in Social-Descriptive stories only Follows Rule/No Benefit (60.2%) was significantly greater than Breaks Rule/Benefit (44.4%), with all other contrasts being nonsignificant.

Story X Change

Means for the significant Story and Change interaction are depicted in Figure 4. For Precautionary-Obligatory stories, Action changes (68.4%) did not differ from Object changes (57.7%), and both were significantly higher than Person (39.8%) and Background (34.7%) changes (i.e., Action = Object > Person = Background). For Precautionary-Descriptive stories, Action change accuracies (67.9%) were significantly greater than Object (54.6%), Person (44.9%), and Background changes (38.3%). Object changes were significantly higher than Background changes and did not differ from Person changes. Background and Person changes did not differ. For Social-Obligatory stories, Action (66.8%) and Object (74.5%) changes did not differ, and both were significantly higher than Person (43.9%) and Background changes, which did not differ (i.e. Object = Action > Person = Background). For Social-Descriptive stories, Action (63.3%) and Object changes (71.4%) again did not differ, but both were significantly

more accurate than Person (40.8%) and Background (32.1%) changes, which did not differ from each other (i.e., Object = Action > Person = Background).

When considering this interaction from the direction of Change, only Object accuracies varied with Story, with Social-Obligatory (74.5%) and Social-Descriptive stories (71.4%) producing comparable accuracies, both of which were significantly greater than Precautionary-Obligatory (57.7%) and Precautionary-Descriptive (54.6%) stories. which did not differ (i.e. Social-Obligatory = Social-Descriptive > Precautionary-Obligatory = Precautionary-Descriptive).

Scene X Change

Means for the significant Scene x Change interaction are depicted in Figure 5. For Follows Rule/Benefit scenes, Object changes (67.9%) did not significantly differ from Action changes (59.2%), however both were significantly higher than Background (36.7%) and Person changes (22.4%), which did not differ from one another (i.e. Object = Action > Background = Person). For the Follows Rule/No Benefit scenes, all change comparisons were significant, except for the Object and Person changes, which did not differ (i.e. Action: 81.6% > Person: 60.2%, = Object: 55.6% > Background: 32.1%). For Breaks Rule/Benefit scenes, Object change accuracy (65.3%) was significantly higher than Action (41.8%), Person (46.4%), and Background changes (37.2%), with the latter three not differing from one another (i.e. Object > Person = Action = Background). For Breaks Rule/No Benefit scenes, accuracy for Action changes (83.7%) was significantly greater than for Object changes (69.4%), which was significant greater that for Person (40.3%), and Background (35.7%) changes, with the latter two no differing (i.e., Action > Object > Person = Background).

Considering this interaction from the other direction, for Action changes, Breaks Rule/No Benefit scenes (83.7%) did not differ from Follows Rule/No Benefit (81.6%), but both of these scenes were significantly higher than Follows Rule/Benefit (59.2%) and R-B+ (41.8%), which also differed (i.e. Break rule/No benefit = Follows rule/No benefit > Follows rule/Benefit > Break rule/Benefit). For Object changes, accuracies for Follows Rule/No Benefit (55.6%) was significantly less than for each of the other three types of changes that did not differ from one another (i.e. Breaks Rule/No Benefit = Follows Rule/Benefit = Breaks Rule/Benefit > Follows Rule/No Benefit). For Person changes, Follows Rule/No Benefit (60.2%) accuracy was significantly higher than for all other scenes, which did not differ from each other (i.e. Follows Rule/No Benefit > Breaks Rule/Benefit = Breaks Rule/no Benefit > Follows Rule/Benefit). Table 4 contains accuracy means broken for change X rule X age comparisons as well as marginal means.

IV. DISCUSSION

The pattern of results observed in this investigation provide evidence that preschool children readily attend to the Action and Object changes, those elements of a story most relevant for consideration of interactions with rule and benefit. This interacts with the way children deploy and direct attention toward social-conventional and prudential rules, in addition to evidencing some amount of domain-specificity between these two rule types. Evidence for specialization in attention for possible cheating situations was also observed. Additionally, the observed actions of individuals engaged with the rule and benefit are a significant determinant for the direction of attention, suggesting automaticity in consideration of propositional logic when observing the interaction of others with rules.

Age Effects

Age-related increases in overall change-detection accuracy, in the absence of considering any other variables or manipulation, confirms the expectation that as children age the attentional resources at their disposal increase, or are at least better directed toward the task at hand. Indeed, visual search and attention performance has been found to increase well into the school years (Klenberg, Korkman, & Lahti-Nuuttila, 2001). The interaction of Age and Scene illustrates that 4-year-olds exemplify the main effect of Scene such that scenes with no Benefit have the highest accuracies, representing an attentional focus on a potential cheater-detection shortcut directed toward the fictional

child being cheated. However, 3 and 5 year olds appear to be less discriminating a display change-detection accuracies that are more uniform across Scene. However, 3 year olds' overall accuracy rate was lower than those of the 4 year olds, while the 5 year olds was higher than 4 year olds, evidence that the relative scene invariance shared by 3 and 5 year oldsmay not represent similarity in the workings of attention. Three-year-olds are perhaps less discriminating because their overall attentional capacity is lower than 4 year olds, whereas 5 year olds might display the same pattern because their attentional capacity is higher than 4 year olds. Therefore, 4 year olds may represent a middle-ground of attentional capacity where the strategic value of Benefit absence is most clearly observed. Perhaps, 4 year olds find themselves in a developmental period in which the task of checking rule adherence is difficult enough to require strategic deployment attentional of resources, however unlike 5 year olds, they do not have the resources to complete this task invariantly well.

Perhaps the most robust finding from this experiment is children's preferential attention to Action and Object changes over and above Person and Background changes. Beginning at the age of 3, children are already focusing on the most relevant aspects of their environment in a way predicted by social-contract theory, and at ages 4 and 5 the distinction becomes dramatically clear. This clear pattern of 4- and 5-year-olds suggests more strategic attention to the actions and objects relevant to the logical conditionals as age increases. The exact mechanism behind this age-related change is at this point unclear. Possible factors for consideration include the achievement or elaboration of social-cognitive milestones such as perspective taking and Theory of Mind, which would provide the strategic basis for discrimination and deployment of maturational increases in

general attentional capacity. Whatever the mechanism behind this developmental change, the existence of a functioning discrimination system, a sub-component required for cheater-detection, as young as the age of 3 provides the first evidence for specifically dedicated neuro-cognitive architecture in preschool children.

Story Effects

Story interacted with scene in a way that suggests some dissociability between social-conventional and precautionary rules. Under precautionary rules, viewing a fictional child breaking the rule lead to greater attention, whereas in social-conventional rules following the rule garnered more attention. This could be evidence for a hazard-detection shortcut during precautionary rules, as breaking the rule creates a circumstance of potential danger. Likewise, increasing attention when the rule is being followed may underscore a cheater-detection mechanism. Following the rule means the fictional child *could* be cheated. This, along with other findings presented here, evidence a tendency for children to focus on the fictional child *being cheated* rather than the fictional child being a *cheater*.

Scene Effects (Cheater and Being-Cheated Detection)

Accuracy for scenes in which the fictional child is cheating (breaking rule/benefit) was equivalent from 3 to 4 years of age, but significantly increased in 5 year olds, and was the only scene to follow such a pattern. This suggests a somewhat delayed acquisition of attentional resources for detecting cheaters. Accuracy during scenes in which the child was being-cheated (follows rule/no benefit) significantly increased at each age. It appears that children attend more readily to circumstances in which the fictional child is being cheated, and that the scene associated with the traditional

interpretation of cheater-detection is delayed, at least attentionally. These findings support the conclusions from the above discussion that children focus more on being-cheated than detecting cheaters. This is possibly a result of the task, as children heard permission rules given by an authority figure (Mom) and perhaps engaged in perspective-taking in reference to the fictional child, resulting in checking for Mom's cheating more than the child's cheating. While this is certainly still cheater-detection, it is different from any observed in the previous child literature, as no previous experiments allowed for such an open-ended engagement with the rules. Children may be quite sensitive to the framing of the statements and authoritarian demands, therefore future work should attempt to understand what may prompt a child to switch between these two focuses. Numerous factors could be responsible for this unexpected finding. Children's egocentrism may be prompting perspective taking whereby children check for cheating as if they were the child in the story. Alternatively, children may not be taking the perspective of the fictional child, they may simply view the child as an in-group member, who needs to be protected, and the mother as an out-group member. Either perspective is likely to lead to the observed finding; therefore, future research should attempt to unpack the underlying reason behind children's propensity for attending to the fictional child being cheated.

Scene X Change

Evidence for cognitive specialization used by a cheater-detection mechanism in young children is apparent when considering the interaction between scene and change. During breaking rule/benefit scenes (fictional child is cheating), participant children attended significantly more to Object changes. This increase in attention is referenced

toward the conditional object, evidence that children see the child cheating, and this directs their attention to items relevant to meeting the condition. Viewing a cheater thus directs attention toward the very set of objects necessary for the observed individual becoming adherent to the rule. Additionally, viewing a fictional child *being cheated* (following rule/no benefit) increased children's attention to Action changes, precisely the relevant source of information for checking if the child will engage in the benefit action. Viewing someone being cheated prompts the direction of attention toward a check of their benefit-relevant actions.

Substantial increases in accuracy and attention to Action changes during scenes with no benefit likely is evidence that children are enacting a cheater-detection heuristic, which in this case is referenced toward the observed child being cheated. In the absence of a child receiving the benefit, children are attending to the benefit-relevant actions with high accuracy, displaying heightened attention in only those situations where the child could be cheated.

Conclusion

These results represent the first investigation of how viewing scenes of engagement with deontic rules impacts lower-order attentional mechanisms in preschool children. Such basic-level direction of attention is conceptually, and now experimentally, relevant for a domain-specific consideration of cheater-detection (Cosmides & Tooby, 1992). These data conclusively demonstrate that 3-5 year-old children are able to efficiently engage attention toward conditional objects and actions when told deontic permission rules. Additionally, children differentially recruit these resources when the behavior of a fictional child changes. This occurs in a manner consistent with and

predicted from social-contract-theory, suggesting the presence of attentional mechanisms that are an antecedent to cheater-detection in preschool children. While some differences between social-convention and precautionary rules is observed, they are less conclusive than findings regarding children's incorporation of immediate behavior. Future work should address this lack of conclusive findings and attempt to examine whether children do attentionally differentiate between these rule types. It is possible that simplified rules with a greater distinction would prompt greater differences; however it is also possible that children may simply attend to all conditional rules similarly.

Evidence for age related increases in both cheater-detection and detection of the fictional child being cheated represents another possible avenue of investigation. Are these processes distinct or combined in children's reasoning? Do they differentially depend on social-cognitive skills, like perspective taking? Answers to such questions are critical for constructing a complete understanding of how children conceptualize relevance of information for rule following and deontic conditionals.

Most critically, children were found to allocate attention to different conditional objects and actions based upon the behavior of the fictional child. This represents an integration of understanding logical conditions of permission rules with an analysis of current behavior within a relevant environmental context. Children are performing complex algorithmic analysis of these interactions and producing implicit attentional behavior directed toward solving the problem of whether or not a rule is being followed. This bodes well for the cheater-detection hypothesis as applied to development, however further work is needed to unpack the many complexities unearthed and numerous questions raised by these finding.

Table 1. Fictional Stories Used In Rule Manipulation

Precautionary Obligatory
Ben's mom says that if Ben wants to play videogames then he must sit far away from the TV, in the big blue chair,so that he dosen't hurt his eyes.
Carol's mom says that if Carol wants to paint, then she must put newspaper on the floor so she doesn't slip and fall.
Sally's mom says that if Sally wants to play outside with her toys, then she must sit under the umbrella so she doesn't get sunburnt.
Max's mom says that if Max wants to ride his bike then he must always put safety cones at the end of the driveway to block cars.
Social Obligatory
Ben's mom says that if Ben wants to play videogames then he must put away his blocks into their box first.
Carol's mom says that if Carol wants to paint then she must first wash the dishes.
Sally's mom says that if Sally wants to play outside with her toys then she must take the trash to the road.
Max's mom says that if Max wants to ride his bike then he must always rake up the leaves.

*Precautionary Descriptive and Social Descriptive stories simply removed the proscription from the child's mom while keeping the content equivalent.

Table 2. Change-Detection Percent Accurate Main Effects

Age				
	3	4	5	
	38.8	52.9	62.3	
Story				
	PO	PD	SO	SD
	49.5	50.4	54.8	50.8
Scene				
	R+B+	R+B-	R-B+	R-B-
	55.8	47.5	45.5	56.5
Change				
	Action	Object	Person	Background
	65.8	63	41.6	35.1

Table 3. Accuracy Means

3	PO	PD	SO	SD	Total
R+B+					
Action	46.2	46.2	53.8	30.8	44.2
Object	38.5	23.1	76.9	30.8	42.3
Person	0	23.1	7.7	23.1	13.5
Background	30.8	15.4	15.4	15.4	19.3
Total	28.8	26.9	38.5	25	29.8
	PO	PD	SO	SD	Total
R+B-					
Action	69.2	69.2	53.8	61.5	63.5
Object	23.1	0	61.5	46.2	32.7
Person	53.8	69.2	53.8	53.8	57.7
Background	30.8	15.4	15.4	23.1	21.2
Total	44.2	38.5	46.2	46.2	43.7
	PO	PD	SO	SD	Total
R-B+					
Action	53.8	23.1	38.5	23.1	34.6
Object	53.8	53.8	61.5	53.8	55.8
Person	38.5	46.2	53.8	23.1	40.4
Background	23.1	30.8	23.1	38.5	28.8
Total	42.3	38.5	44.2	34.6	39.9
	PO	PD	SO	SD	Total

R-B-					
Action	76.9	69.2	76.9	76.9	75
Object	53.8	46.2	53.8	38.5	48.1
Person	23.1	38.5	7.7	23.1	23.1
Background	30.8	7.7	38.5	7.7	21.2
Total	46.2	40.4	44.2	36.5	41.8
4	PO	PD	SO	SD	Total
R+B+					
Action	55	50	60	70	58.8
Object	65	75	90	85	78.8
Person	15	5	35	20	18.8
Background	30	35	30	30	31.3
Total	41.3	41.3	53.8	51.3	46.9
	PO	PD	SO	SD	Total
R+B-					
Action	90	85	85	85	86.3
Object	35	50	70	75	57.5
Person	80	65	50	60	63.8
Background	20	20	25	30	23.8
Total	56.3	55	57.5	62.5	57.8
	PO	PD	SO	SD	Total
R-B+					
Action	40	45	35	20	35

Object	70	50	60	75	63.8
Person	50	40	45	50	46.3
Background	15	35	45	30	31.3
Total	43.7	42.5	46.3	43.8	44.1
	PO	PD	SO	SD	Total
R-B-					
Action	95	95	80	85	88.8
Object	65	80	80	70	73.8
Person	40	75	55	40	52.5
Background	45	35	35	30	36.3
Total	61.2	71.3	62.5	56.3	62.8
5	PO	PD	SO	SD	Total
R+B+					
Action	50	81.2	68.7	87.5	71.9
Object	75	68.7	81.2	75	75
Person	12.5	18.7	37.5	68.7	34.4
Background	56.2	56.2	56.2	62.5	57.8
Total	48.4	56.2	60.9	73.4	59.8
	PO	PD	SO	SD	Total
R+B-					
Action	93.7	93.7	93.7	81.2	90.6
Object	50	37.5	100	100	71.9
Person	56.2	50	81.2	43.7	57.8

Background	31.2	56.2	68.7	50	51.6
Total	57.8	59.4	85.9	68.7	68
	PO	PD	SO	SD	Total
R-B+					
Action	68.7	50	56.2	50	56.2
Object	75	75	62.5	87.5	75
Person	56.2	56.2	56.2	37.5	51.6
Background	56.2	68.7	43.7	37.5	51.6
Total	64.1	62.5	54.7	53.1	58.6
	PO	PD	SO	SD	Total
R-B-					
Action	75	93.7	93.7	75	84.4
Object	75	68.7	87.5	93.7	81.2
Person	37.5	50	31.2	37.5	39.1
Background	50	75	37.5	25	46.9
Total	59.4	71.9	62.5	57.8	62.9

Figure 1. Screenshot of a Change-Detection Scene

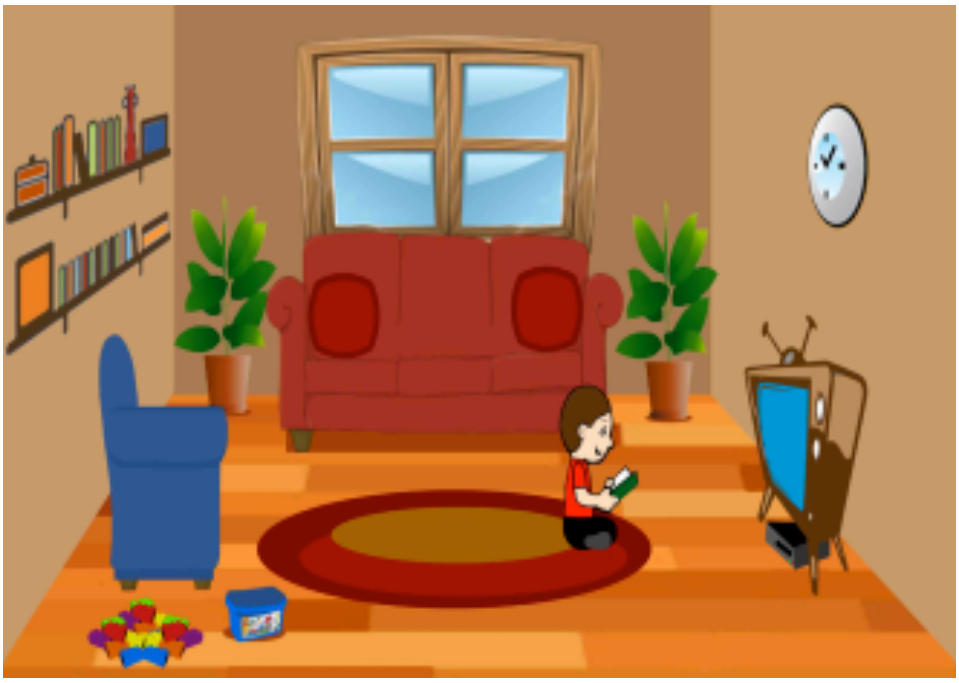


Figure 2. Change-Detection Accuracies Age X Scene

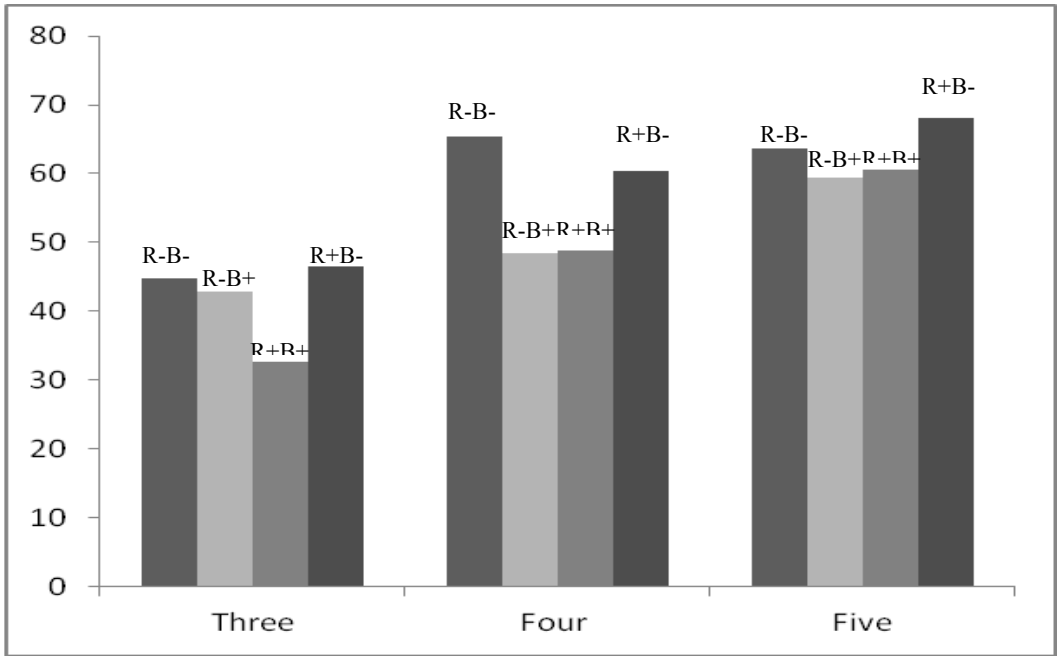


Figure 3. Change-Detection Accuracies Age X Change

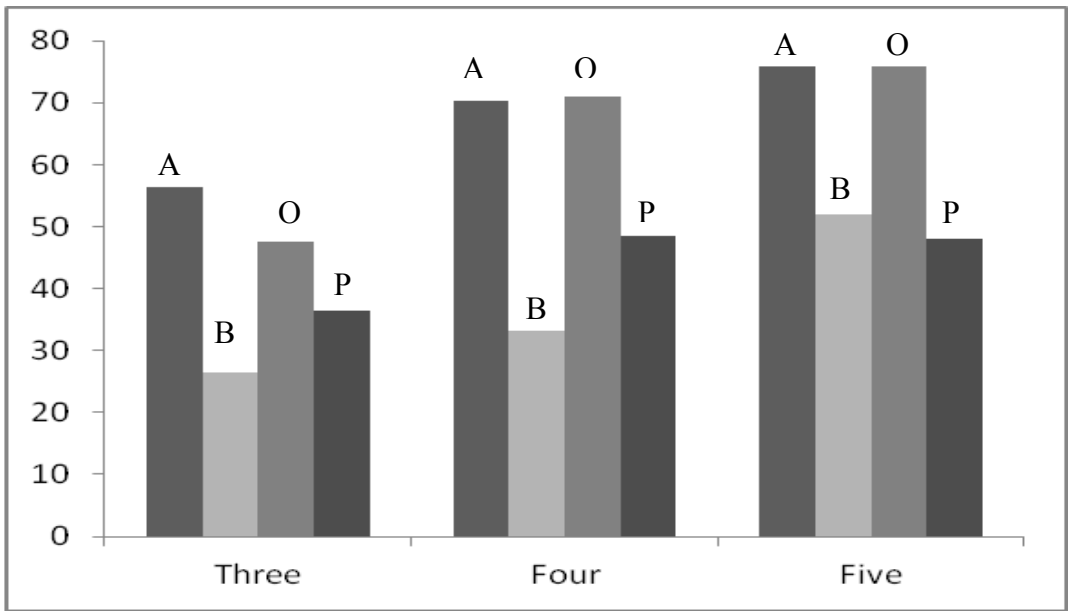


Figure 4. Change-Detection Accuracies Story X Change

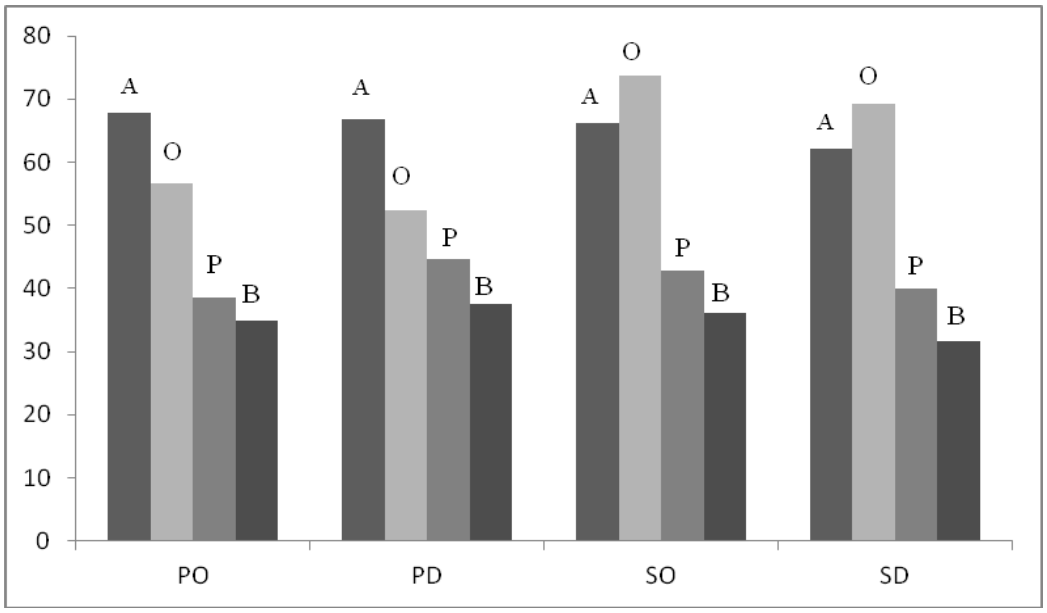


Figure 5. Change-Detection Accuracies Scene X Change

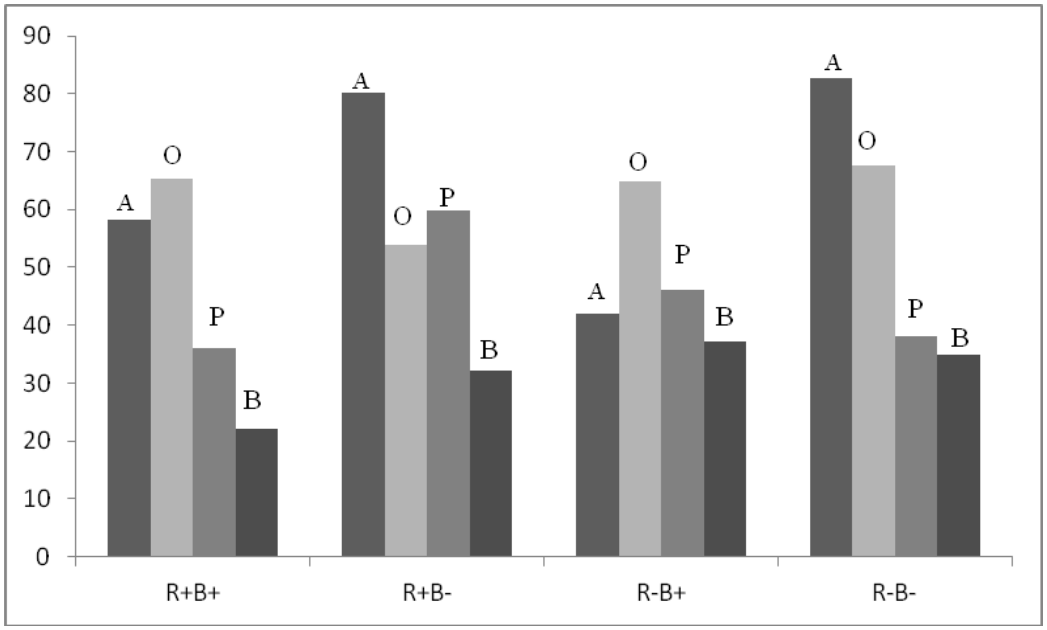
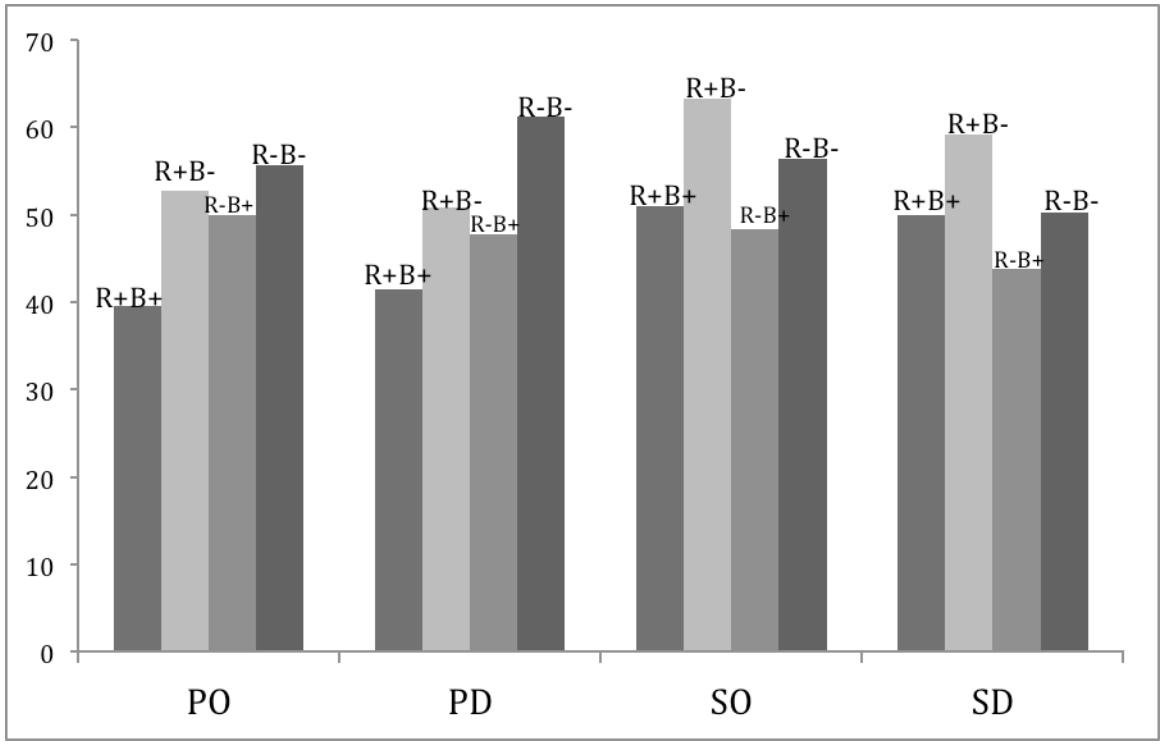


Figure 6. Change-Detection Percent Accurate Story X Scene



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