5-2024

The development of children's causal language

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Abstract

In order to talk about mechanical support (e.g., girl adheres a picture to a box), children must not only represent the relevant components (actor, action, figure, spatial relation, ground) but also map them onto linguistic structures (e.g., NP, VP, NP, PP). Although research has explored how children linguistically encode states of mechanical support (picture adhering to box), little research has explored how children encode mechanical support events - representations that involve knowledge of event causality as well as states (the picture adheres to a box because the girl used an adhesive mechanism). The current study tests whether children 3- to 5-years of age linguistically encode the cause of mechanical support events (and if so, how), by presenting children with mechanical support events in contexts of inconsistency (e.g., the toy previously adhered to a box, but now it falls). The findings revealed that although most children encoded the cause in their explanations, the likelihood of encoding the cause of support increased over age. Further, as children aged, they also tended to explain the events by referring to the object category that changed ('It's a not-a-toma now') - a type of causal explanation that the younger children did not use often. The results shed light on how children acquire the language of mechanical support events and raise questions for future research about why children's mechanical support event language changes from 3 to 5.

MONTCLAIR STATE UNIVERSITY

The Development of Children's Causal Language

By

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A Master's Thesis Submitted to the Faculty of

Montclair State University

In Partial Fulfillment of the Requirements

For the Degree of

Master of Psychological Sciences

May 2024

College of Humanities & Social Sciences

Department of Psychology

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Explanations of Mechanistic Support: The Development of Children's Causal Language

THESIS

Submitted in partial fulfillment of the requirements

For the degree of Master of Arts

By

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Montclair State University

Montclair, NJ

2024

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Introduction

We trust that our chairs will provide *support* as we take a seat, and our tables *support* our mugs. This trust is rooted in the concept of physical support. Physical support can be understood as a force-dynamic relationship where one object (ground object) prevents another object (figure object) from falling (Coventry, Carmichael, & Garrod, 1994; Landau, 2018). There are a multitude of force-dynamic relations, contingent upon the interplay of objects and the specific type of force facilitating the support. One domain of physical support is Support-From-Below (SFB). An illustration of a SFB relation is exemplified by a toy resting on top of a box; the ground object (box) provides support to the figure (toy) - preventing it from falling. In contrast, mechanical support can be understood as support that is not achieved by a figure object being supported from below, but instead through 'mechanical means' such as embedded support (tattoos), support via adhesion (sticker on wall), support via hanging (bag on hook), and support via point attachment (clothespin holding shirt) (Landau, Johannes, Skordos, & Papafragou, 2016).

To talk about mechanical support, children must not only represent the relevant components involved but also map them onto linguistic structures. These mappings can vary, particularly when considering whether the mechanical support relation is portrayed as a static state or as an event. Consider, for instance, the state of a figure object adhering to a box. In order to encode this state in language, the child must represent the toy (figure), the box (ground), and the static relation of the toy *on* the box. Then, the child must map it to the linguistic structure, such as 'The toy is *sticking on* the box', where the figure and ground map to noun phrases (subject and object, respectively), the state maps to the verb (is sticking), and the relation of support maps to a preposition (on).

However, the mapping may vary when the mechanical support relation is portrayed as an event; imagine a scenario where a girl adheres a figure object to a box. In order to encode this *event* in language, the child must represent the same components as before (figure, ground, support relation), in addition to the agent (the girl) and the dynamic action (sticking). Having represented the event in this way, the child may then map it to a different linguistic structure, such as "the girl sticks the toy on the box". Here, the linguistic structure encodes not only the state (the toy sticking on the box) but also the *causal explanation* of how it got there (*the girl sticks it* to the box).

Considering first how children describe mechanical support states (e.g., toy sticking to box), research suggests that there may be a 'division of labor' in the semantic space of support that may serve as an initial framework for children acquiring the language of support. According to this hypothesis, the Basic Locative Construction (BLC) (e.g., 'BE on' in English) is used mostly to encode SFB, while other linguistic devices, such as lexical verbs in English (e.g., stick, glue, tape), map to various types of mechanical support. English-speaking children show this 'division of labor' by 2.5 years in production (Lakusta et al., 2024), and as early as 20 months in comprehension. This suggests that from an early age, children linguistically encode mechanical support in the early stages of linguistic development.

Although prior research has delved into how children articulate mechanical support states (Lakusta, Wefferling, Elgamal, & Landau, 2024; Landau, et al., 2016), a substantial gap exists in our understanding of how children encode mechanical support within events—instances where an agent's action causes a figure object to be supported by a ground object. This study aims to address this gap by exploring how children conceptualize and express mechanical support events. Rather than focusing solely on static states, we aim to examine the language children use to talk about events involving an agent's active role in establishing mechanical support.

As described above, events not only include the static state of the figure and ground, and often also include the agent that causes the state. But how do young children linguistically encode such causal events? Do they encode the agent and/or mechanism as causing the support (e.g., the girl sticks the toy on the box with tape) or do they simply encode the static state (e.g., the toy sticks on the box)? In order to test this question the current study presents young children with support events in the contexts of inconsistency and measures whether and how children linguistically encode the cause of the mechanical support event.

We chose to present mechanical support events in inconsistent contexts because research has shown that children explain events that deviate from their expectations (Legare, Gelman, & Wellman, 2010). Further, support mechanisms themselves often exhibit inconsistency. Consider the scenario of a sticker adhering to a wall. While the expectation is for it to remain in place, it is not uncommon for the sticker to defy this expectation and fall, challenging our preconceived notions of its adhesive properties. Thus, understanding how children map inconsistent mechanistic support events into language may be more generalizable to the contexts in which children typically acquire and produce this kind of language.

Given children's tendency to explain inconsistent events, and given that support mechanisms may not always be consistent in the real world, we ask, when presented with mechanical support events, where an object may or may not be supported, do young children map the cause of support to the linguistic structure? Or do they only encode the state of the support, either because they do not yet represent the event as causal and/or they do not map it into language? We test these possibilities by presenting 3- to 5-year-old children (an age range where previous studies have shown children to offer explanations of hidden causes; Legare, et al., 2010) with mechanical support events that behave inconsistently.

Method

Participants

A total of 72 3- to 5-year-old children were tested; there were 30 boys and 42 girls (M age = 54 months 1 day, range = 36 months 26 days to 72 months 6 days; race: 51 White, 16 Asian, 2 Black, 1 American Indian/Alaska Native, 1 Other, 1 not reported; ethnicity: 8 Hispanic or Latino, 63 not Hispanic or Latino, 1 not reported). Participants were recruited through community fairs, lab research postings on social media groups, as well as the Children Helping Science platform. All children were learning English as their first language, and none were reported to have any developmental delays. Parents of all participants signed informed consent before beginning the study for the 3- to 4-year-olds. Participants who were 5 years old completed assent before beginning the study. An additional 10 participants were excluded due to failure to complete more than 50% of the test trials.

Stimuli and Design

The study took place online via Zoom. The parent was asked to wear headphones and to look away from the computer screen for the duration of the experiment. The experiment proper then began. As shown in Figure 1, and following Legare, et al. (2010), children were first presented with two separate training trials that labeled the objects with a novel name and presented the objects' affordances, then a confirmation trial demonstrating the affordances of the objects (without labeling), followed by two test trials demonstrating the objects acting inconsistent with prior demonstration. Each participant viewed three blocks, each block had the same design, but different figure and ground objects.

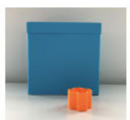
In block A, participants were shown a star shaped block labeled a 'toma' and an x shaped block labeled 'not-a-toma'. They first viewed the training trials, where they saw the star shaped block and heard 'This is a toma' and then saw a video of the object placed in contact with a blue box and then adhered to it. The child then viewed the x shaped block and heard 'This is not-a-toma', then was shown a video of the object placed in contact with the side of the box, but then fell. Next during the confirmation trial, they simultaneously viewed the same videos played prior but with no sound, and then asked 'Why did that happen?'. In the first test trial they simultaneously viewed the 'toma' and the 'not-a-toma' both sticking onto the side of the box and then asked 'Why did that happen?'. They were asked follow-up questions with 'Can you tell me more?' or 'Do you have any other ideas?'. During the second test trial, children simultaneously viewed both objects placed in contact with the side of the box, but now both fell. They are asked 'Why did that happen?' and probed with follow-up questions such as 'Can you tell me more?' or 'Do you have any other ideas?'.

Blocks B and C mirrored the procedural structure of block A, with variations in objects and their designated novel names. Block B introduced black and yellow sand objects, termed 'twaz' and 'not-twaz,' demonstrating adhesion or non-adhesion to the inside of a bowl when flipped over. In block C, paper cut-out shapes demonstrated adhesion or non-adhesion to a string with the novel labels 'blicket' and 'not-a-blicket.' Note that none of the support events in any of the blocks exhibited observable adhesion; instead, adhesion had to be inferred. Furthermore, the stimuli was counterbalanced for the order of block presentation and the positioning of events on the screen during the confirmation and test trials. The stimuli and procedure are depicted in Figure 1(a-c).

We deliberately incorporated diverse types of adhesion across all three blocks. This was motivated by the aim to capture a range of support scenarios encountered in children's everyday experiences. The variations in adhesion mechanisms, such as surface adhesion demonstrated in Block A and B (with blocks adhering to the side of a box or to the inside of a bowl) versus point attachment depicted in Block C (with objects adhering to a string), were intended to provide a comprehensive understanding of how children reason about different forms of support. By systematically manipulating these variables, the study aimed to elucidate the factors contributing to children's reasoning about support events and to identify potential differences in their interpretations based on object material and attachment type. This approach aligns with theoretical frameworks emphasizing the importance of considering both object properties (encoded with mass nouns) and attachment mechanisms in children's conceptual and language development.

Figure 1:

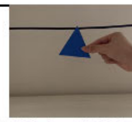
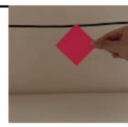
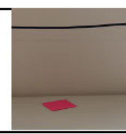
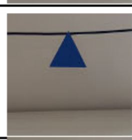
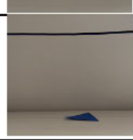
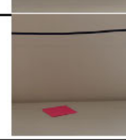
a)

	Left side of Screen	Center of screen/speaker	Right side of screen
Training Trial		 "This is a toma" (hand places figure object on box and it stays on) 	
Training Trial		 "This is not a toma" (hand places figure object on box and it falls off) 	
Confirmation Trial		"Why did that happen?" (hand places figure objects on box; one stays, and the other falls)	
Test trial:		"Why did that happen?" (hand places figure objects on box; both objects stay on)	
Test trial:		"Why did that happen?" (hand places figure objects on box; both objects fall off)	

b)

	Left side of Screen	Center of screen/speaker	Right side of screen
Training Trial		 "In here is twaz" (hand picks up bowl, flips it upside down and it stays in) 	
Training Trial		 "In here is not-a-twaz" (hand picks up bowl, flips it upside down and it falls out) 	
Confirmation Trial		"Why did that happen?" (hand flips the bowls; one stays, and the other falls out)	
Test trial:		"Why did that happen?" (hand flips the bowls; both say in)	
Test trial:		"Why did that happen?" (hand flips the bowls; both fall out)	

c)

	Left side of Screen	Center of screen/speaker	Right side of screen
Training Trial		 "This is a blicket" (hand picks up object, places it on the string and it stays) 	
Training Trial		 "This is a not a blicket" (hand picks up object, places it on the string and it falls) 	
Confirmation Trial		"Why did that happen?" (hand picks up the objects; one stays, and the other falls)	
Test trial:		"Why did that happen?" (hand picks up the objects; both objects stay on)	
Test trial:		"Why did that happen?" (hand picks up the objects; both objects fall off)	

The figures depict the stimuli used in each block and general block design. It is organized by trial, presentation slide, as well as location of the videos per slide. The language used is also included and is the same for each block, except for the objects' novel labels.

Data Coding

Prior to coding, all videos underwent transcription. A trained research assistant transcribed the children's responses. The data was initially binary-coded, with '1' denoting a causal explanation from the child and '0' indicating otherwise. Explanations were coded as causal if the language encoded *why* the figure object was either supported or not, as exemplified by statements like 'The toy is *glued* to the box.', 'The toma is *sticking* to the box.', and 'They switched the not-a-toma for a toma.'. In all these responses the cause of the support (or lack of support) is encoded (e.g., glue causes the support). All other responses were coded as non-causal (e.g., 'It *is on* the box'; this response only encodes the state of the figure without any reference to why it is supported or not). In addition, following Legare, et al. (2010), causal explanations were sub-coded into distinct categories: 'causal function explanations', which referenced properties of how the object worked (e.g., 'The toy is sticking to the box because there is glue.'), 'category label explanations', which referenced the category of the objects changing (e.g., 'They change the toma for a not-a-toma, and that's why it fell.'), 'causal action', which referred to experimenter-induced variations, such as incorrectly placing the object (e.g., 'The girl put the toy on wrong, that's why it fell.'), or 'other explanations', which included content that did not fall into the above categories (e.g., 'It's magic').

Results

Causal Explanations: Confirmation Trials

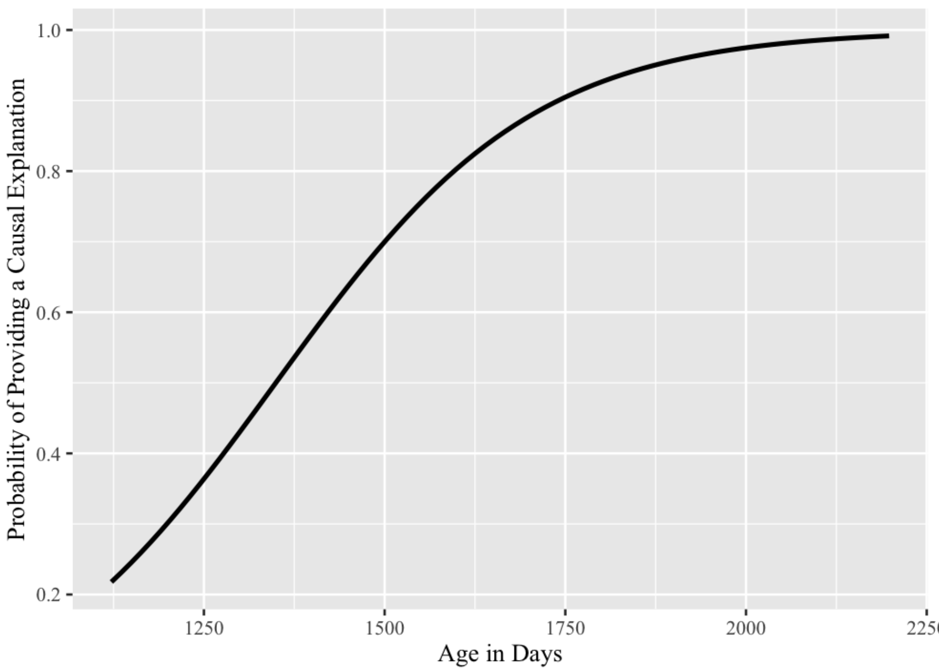
First, we examined the usage of causal language during confirmation trials (i.e., the trials demonstrating the affordances of the objects without labeling), A binary logistic regression was employed on the binary coded data (1 = causal, 0 = non-causal; see above), with age (in days) included as a covariate, which revealed that by 4 years, children used causal language to explain what occurred and this competency increases as age increases ($\beta = 0.00830$, 95% CI = 0.00476 - 0.0118, $p < .001$) (Figure 2a). Further analysis of the confirmation trials included block type, order of block presentation, as well as gender in the model but no effect was found. These results indicate that usage of causal language during confirmation trials increases with age, and block type, presentation order, and gender have no impact on this competency in using causal language.

Causal Explanations: Test Trials

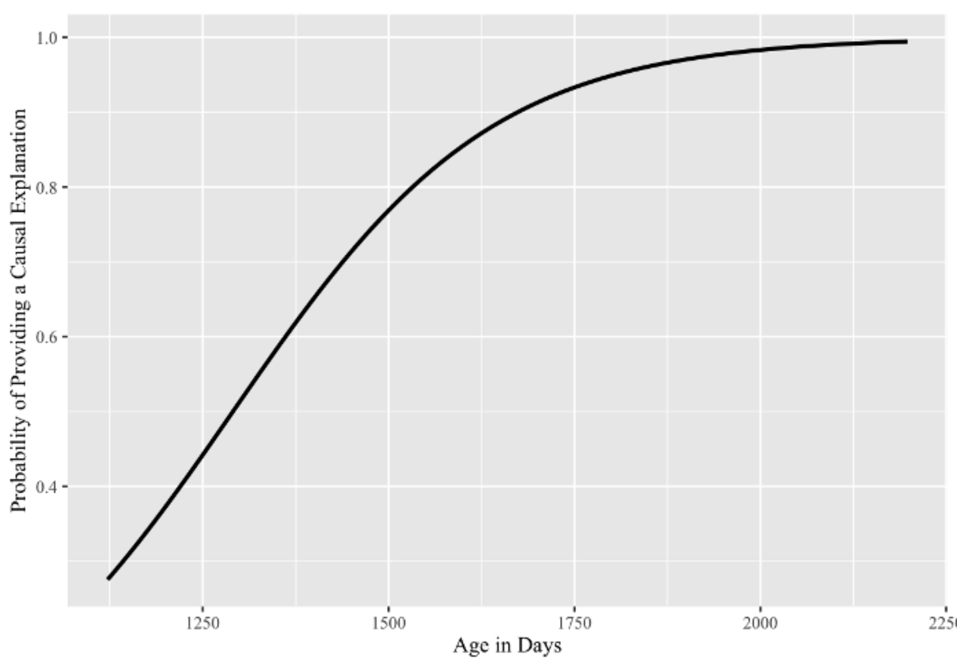
A second binary logistic regression on the explanations provided during the test trials was run. Our findings were consistent and found that by 4 years children's explanations incorporated causal language and the likelihood of providing causal explanations increases as children become older ($\beta = 0.00947$, 95% CI = 0.00594 – 0.0130, $p < .001$) (Figure 2b). Within the test trials, we ran further analysis to test if there was an effect of block type, block presentation order, or gender, but no significant differences were found, thus they were removed from the model. Our findings suggest that young children use causal language to encode mechanical support, and this competence undergoes development from 3 to 5 years. Further interpretation of the results and possible explanations for these findings are discussed in the subsequent General Discussion.

Figure 2: Do Children Use Causal Language to Explain Mechanical Support Events?

a) Usage of Causal Explanations Within Confirmation Trials



b) Usage of Causal Explanations Within Test Trials



Results from a binary logistic regression predicting children's likelihood to provide a causal explanation as a function of age. Ages 3-5 years (plotted in days) are shown as a continuous variable. 1500 days is approximately equal to 4 years.

Types of Causal Explanations: Confirmation Trials

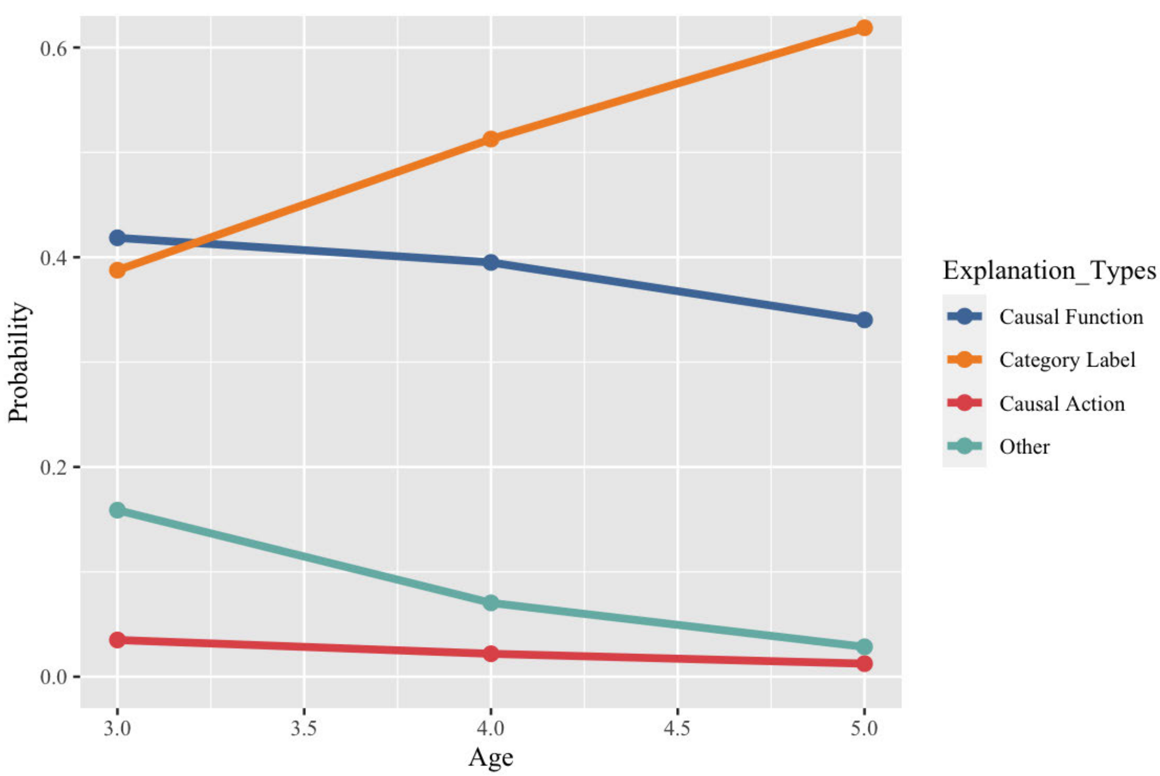
The subsequent analysis explores the types of causal explanations used by children (i.e., causal function, category label, or causal action; and others see above). That is, when the children provided a causal explanation, what type did they provide? Examination of the confirmation trials data revealed that category label explanations were the predominant choice, but to further explore the interplay between age and different explanation types for confirmation trial explanations, a multinomial logistic regression was used. Using causal explanation type as the dependent variable, age as a covariate, and category label as the reference category, the regression analysis revealed the following trend: as age progressed, there was a decrease in causal function explanations ($\beta = -0.497$, 95% CI = -0.836 – (-0.159), $p = 0.004$). Causal action explanations were used the least by all age groups and the usage of other types of explanations were low and significantly decreased as children became older ($\beta = -1.175$, 95% CI = -1.814 – (-0.536), $p < .001$). The relationship between age and explanation type in the confirmation trials is visually depicted in Figure 3.

Types of Causal Explanations: Test Trials

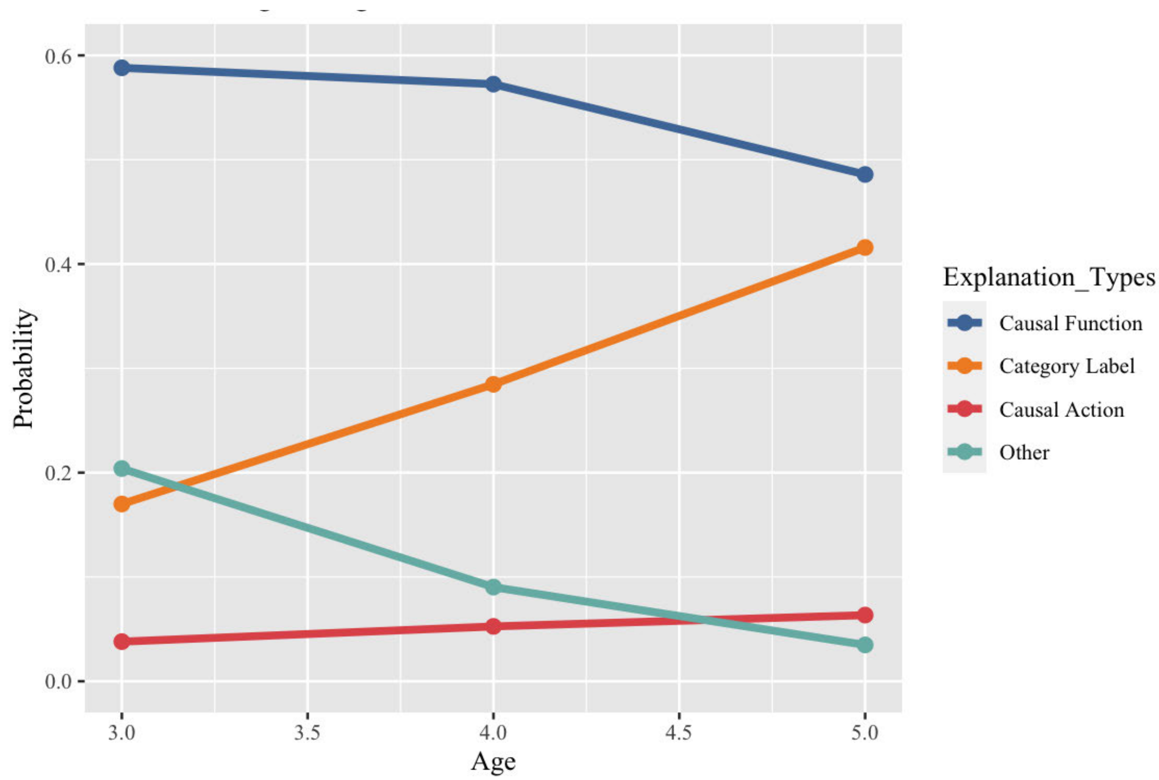
The same analysis on the explanations given during the test trials was run. For test trials, children predominately used causal function explanations. A multinomial logistic regression was used, using causal explanation type as the dependent variable, age as a covariate, and causal function as the reference category. The regression analysis revealed that as age progressed, there was an increase in category label explanations (β = 0.626, 95% CI = 0.271 – 0.981, $p < .001$). Causal action explanations were used the least by all age groups and the usage of other types of explanations were again low and decreased as age increased (β = -0.824, 95% CI = -1.363 – (-0.284), p = .003). This is depicted in Figure 3. The findings not only affirm the prevalence of causal function explanations, but also sheds light on the developmental trajectory, showcasing how children, with increasing age, expand their repertoire to include more category label explanations and use less of the explanations categorized as 'other'.

Figure 3: What Types of Causal Explanations do Children Provide?

a) Causal Explanation Types Within Confirmation Trials



b) Causal Explanation Types Within Test Trials

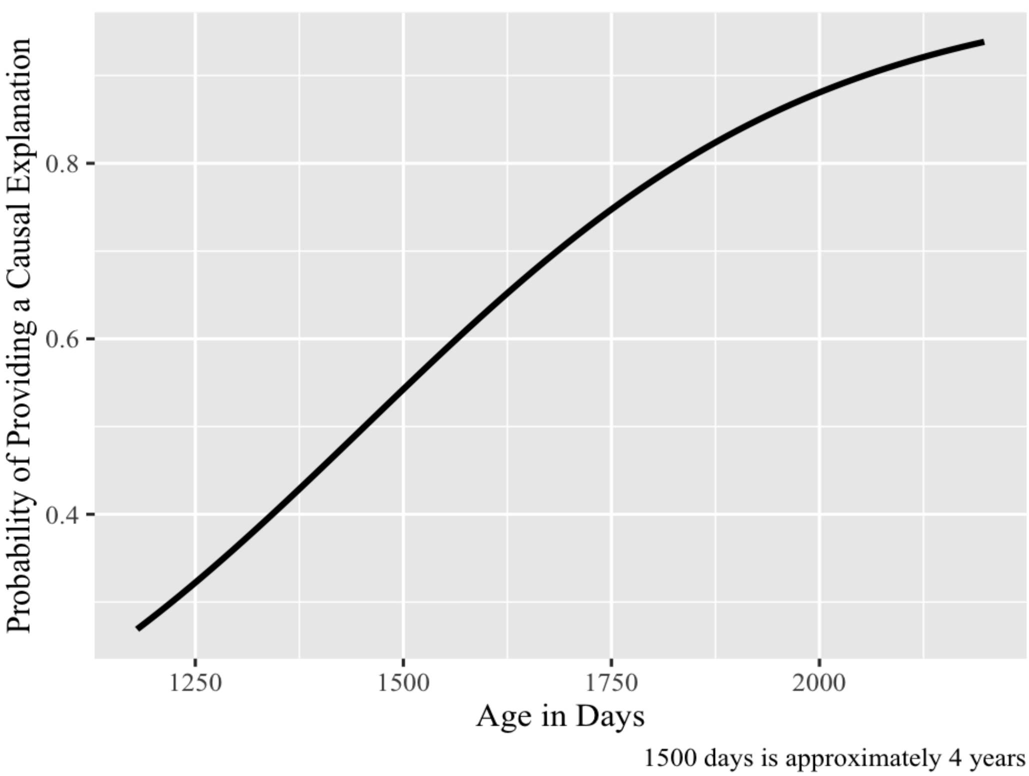


Results from the multinomial logistic regression highlight that as children become older the usage of category label explanations increases when questioned about *why* an inconsistent event occurred.

Follow-Up Explanations

After children were asked "Why did that happen?" they were also probed with follow-up questions such as "Do you have any other ideas?" or "Can you tell me more about that?" during the test trials, following Legare, et al. (2010). 40.74% of children provided further information when asked further questions (176 out of 432 total possible follow-up explanations). For the 176 children that did provide additional explanations we ran separate analyses. A binary logistic regression revealed a contradicting finding compared to the confirmation and test trials. Age was not a significant predictor in whether children would provide a causal explanation (β = 0.00634, 95% CI = -0.0135 – 0.0262, $p = 0.531$) (Figure 4), indicating that children's' age does not have an impact on using causal language in follow-up explanations. Block type, order of block presentation, nor gender were added to the model as age was not significant. For the types of causal explanations children used in their follow-up explanations, 77.2% used causal function explanations. In addition, we ran a multinomial logistic regression, using the same parameters (causal explanation type as the dependent variable, age as a covariate, and category label as the reference category). Although we found that a large percentage of children used causal function explanations in this case, we found no significant differences between types of causal explanations children use in their follow up explanations.

Figure 4: Do Children Use Causal Language in Their Follow-Up Explanations?



Discussion

The current experiment tested how 3- to 5-year-old children explain mechanical support events in contexts of inconsistency. Children were first introduced to two objects (which were labeled with different novel names) and were familiarized with their affordances (e.g., whether the objects adhered to a box or not), then asked 'Why did that happen?'. During two test phases, children then viewed one object acting consistently or inconsistently (the object now fell when it previously adhered or it adhered when it previously fell). Children were again asked, 'Why did that happen?'. The findings revealed that as age increased, the likelihood of providing causal explanations increased, both during the confirmation and test trials. When children did provide causal explanations during the confirmation trials, they predominately used category label explanations (e.g., 'They change the toma for a not-a-toma, and that's why it fell.'). On the other hand, during test children predominately provided causal function explanations (e.g., 'The toy is glued to the box') and category label explanations usage increased with age. These findings suggest that by age 3 children do map mechanical support *events* into causal language. They also suggest that children's causal understanding of mechanical support events (and/or how these events are mapped into language) changes between 3-5 years.

Previous research has shown that by 2.5 years children encode mechanical support in states, such as a toy sticking to the side of a box. The findings from the current study suggests that by 3 years, children also encode the cause of mechanical support, however, the use of causal language increases from 3- to 5-years (especially from 3-4). Why? One possibility is that children younger than 4 years may not be reasoning about support mechanisms causally yet in the current stimuli. It is possible that the limited hands-on exposure of 3-year-olds to adhesive mechanisms may affect their causal reasoning of mechanical support events involving adhesion.

That is, perhaps children at this age may not have had sufficient direct interactions or experiences with adhesive properties, thus hindering their capacity to apply this knowledge to their explanations in the context of the experiment. The limited experience with these mechanisms may contribute to a reliance on more straightforward, noncausal explanations, where the physical presence of the object on a surface is emphasized without delving into the underlying reasons for the support or lack thereof. Additionally, another possibility is that children younger than 4 years may not have yet acquired the relevant vocabulary for encoding mechanical support (glue, stick, etc.). Whether it is a limitation in causal reasoning about mechanisms and/or the limitations of language development that explain the increase of causal language use from 3 to 5 years is a question for future research.

The types of causal explanations children provided were also examined and although we cannot speak to the nature of the representations encoded by language (category switch, causal function, causal action), here we speculate regarding some possibilities. First, there was a distinction between causal explanations utilized during confirmation trials and test trials. During confirmation trials, where children are provided with information regarding the objects, there is a notable prevalence of category label explanations (e.g., 'Because it's a toma') (Figure 2), suggesting that children tend to explain the events by categorizing or labeling the involved objects. Category label explanations denote a tendency among children to attribute the cause of an event to the specific objects or categories involved. Thus, children may rely on object labeling as a convenient heuristic to make sense of the events, particularly when provided with confirming evidence or prompts. However, the type of causal explanations used shifts during test trials, where children are presented with novel scenarios and objects now act inconsistent with what was previously shown. Children used mostly causal function explanations (e.g., 'The toy is glued to the box') during test. These types of explanations suggest that children may have knowledge about adhesive properties, even when not visually apparent to them. This is consistent with other findings showing that children at young ages are able to reason about hidden causes in other types of events, such as state change events (Schulz & Sommerville, 2006). We also found that the use of category label explanations (e.g., 'It’s a not-a-toma now, that's why it fell') increased with age (Figure 2). This may suggest that older children may be more likely to think about the affordances of the objects (support mechanism) as an inherent property of the object’s kind, encompassing their adhesive property knowledge in their category representations. Older children may also be more likely to reason about unobservable mechanical properties of objects. Finally, it is also particularly intriguing to note that category label explanations inherently point towards the inconsistency. While causal function explanations could pertain to the event itself (e.g., 'Both are sticky when they stay on the box'), category label explanations distinctly refer to the inconsistency, highlighting the shift from a previous state to the current state (e.g., ‘It used to be sticky, but now it's not'). How this increased use of category label explanations over development relates to their developing causal reasoning abilities may be an interesting area for further research.

The current findings expand on our knowledge of how children develop mechanical support language, shedding light on both the developmental trajectory and the underlying cognitive processes involved. Building upon prior research, which focused on how young children encode mechanisms in events (as demonstrated in studies by Lakusta, Wefferling, Elgamal, & Landau, 2024, and Landau et al., 2016, for instance, depicting scenarios like toys adhering to the side of a box), our findings reveal a more nuanced aspect of language development. Not only do young children demonstrate the ability to encode mechanical support mechanisms, but they also exhibit an understanding of the causal factors underlying these mechanisms, as evidenced by their explanations of events involving support (e.g., attributing support to an object being "glued to the box"). However, our study also uncovers age-related changes in how children linguistically represent mechanical support events. This suggests that there is a developmental progression in the way children map their conceptual understanding of support mechanisms onto language. Such changes may reflect maturation in both cognitive and linguistic abilities, indicating a deeper integration of causal reasoning with linguistic expression as children grow older.

These findings underscore the need for further investigation into the cognitive and linguistic constraints that shape children's evolving reasoning abilities regarding causal support mechanisms. By probing the factors that influence the development of mechanical support language, future research can illuminate the interplay between cognitive processes, language acquisition, and conceptual understanding in children's emerging comprehension of mechanical phenomena. Such insights have implications not only for our theoretical understanding of cognitive development but also for the design of educational interventions aimed at fostering children's scientific reasoning skills from an early age.

References

Coventry, Kenny. R., Carmichael, Richard., & Garrod, Simon. C. (1994). Spatial prepositions, object-specific function, and task requirements. *Journal of Semantics*, *11*(4), 289–309. https://doi.org/10.1093/jos/11.4.289

Landau, Barbara. (2018). Learning simple spatial terms: Core and more. *Topics in Cognitive Science*, *12*(1), 91–114. https://doi.org/10.1111/tops.12394

Landau, Barbara, Johannes, Kristine, Skordos, Dimitrios., & Papafragou, Anna. (2016). Containment and support: Core and complexity in spatial language learning. *Cognitive Science*, *41*(S4), 748–779. https://doi.org/10.1111/cogs.12389

Lakusta, Laura., Wefferling, Julia., Elgamal, Karima., & Landau, Barbara. (2024). “dividing the labor”: Lexical verbs and the linguistic encoding of physical support in 2- to 4.5-year-old children. *Journal of Experimental Child Psychology*, *238*, 105803. https://doi.org/10.1016/j.jecp.2023.105803

Legare, Christine. H., Gelman, Susan. A., & Wellman, Henry. M. (2010). Inconsistency with prior knowledge triggers children’s causal explanatory reasoning. *Child Development*, *81*(3), 929–944. https://doi.org/10.1111/j.1467-8624.2010.01443.x

Schulz, Laura. E., & Sommerville, Jessica. (2006). God Does Not Play Dice: Causal Determinism and Preschoolers' Causal Inferences. *Child Development, 77*(2), 427–442. https://doi.org/10.1111/j.1467-8624.2006.00880.x