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Assessment of Thematic Relations in 2-4 Years Normally Developing Children

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Abstract

Objective: Children organize their conceptual knowledge in different ways such as thematic and taxonomic organization. When concepts are linked by cross-categorical relations, they are said to be thematically related. This study attempts to investigate the development of different types of thematic relations such as spatial-temporal-functional relations and causal relations in Kannada speaking typical children.

Method: A total of 216 typically developing children between age group of 2-4 years speaking Kannada were selected for the study. Match to sample task using picture stimuli were administered to assess spatial-temporal-functional relations and causal types of thematic relations. The match to sample task included one standard and four choice responses, one of which was a thematic match (either spatial and/or temporal and/or functionally related match or a causal match depending on the test carried out) to the test stimuli. Responses of the children were analyzed using a four point rating scale.

Results: Results revealed that appreciation of spatial-temporal-functional and causal types of thematic relations emerges in children as young as 2 years of age and broadens with increase in age to 3-4 years. Gender effect was not significant in both these tasks. There was no significant difference found in the performance of children between test for spatial-temporal-functional relations and test for causal relations.

Conclusion: The results of present study demonstrate that thematic relations in specific spatial-temporal-functional relations and causal relations show a similar pattern of developmental trend in preschool children of 2-4 years of age. In addition they are found to be one of the important types of organizational strategies used by 2-4 years children to conceptual world knowledge and thus play a key role in language acquisition.

Keywords: Thematic relations; Spatial-temporal-functional relations; Causal relations; Conceptual organization; Language acquisition

Introduction

A thematic relation is any temporal, spatial, causal, or functional relation between things. Things are thematically related if they perform complementary roles in the same scenario or event [1-3]. While things are grouped based on common properties in taxonomical relations, things are grouped based on space, time, causal and functional dimensions in thematic relations. Spatial relationship is defined as how an object is located in space compared to some reference object. This relationship can be inferred by eliciting response to the question 'Where'. For example, to elicit the spatial relationship between 'bird' and 'tree', one can ask the question 'Where does a bird usually sit? Likewise, temporal relationship (Example - 'tumbler' and 'plate') is defined as a relation that involves time (e.g., meal time) and this can be inferred by eliciting response to the question 'When'?; Functional relationship (Example, 'pencil and 'book') is defined as a relation that associates two objects through functional use and this can be inferred by eliciting the question 'What for'?; Causal relationship (Example, 'bulb' and 'switch') is defined as the relationship between cause and the effect and this relationship can be inferred by eliciting the response to the question 'How'?

The spatial, temporal, and causal relations of thematic links are said to play a central role in the development of children's understanding of the world [4]. They are explored by children in their spontaneous play, where activities are often centered on simulation of reality [5] and construction of event sequences [6]. It helps them in daily life to understand how people interact or use tools or other artifacts to accomplish goals. For example, when observing natural occurrences such as storms, admiring scenery, much of the perception would be interpretive, trying to figure out what is happening and how [7]. Even infants tend to place causal interpretations on events they perceive [8]. Thus, these event-like structures are a fundamentally important and natural way of organizing information. Fewer developmental and cross cultural differences are reported to be seen in understanding this type of organization [9].

In sorting tasks when meaningful objects are used, young children represent causal and temporal relations among the objects as well as spatial relations [7]. Further, thematic preferences were also found in word association tasks [10], match-to-sample [11-13], and in more structured category-elicitation tasks [7]. One of the views of conceptual organization suggests that, at the most basic level, representation may be organized around events rather than taxonomic structures [14,15].

Apprehending a thematic relation means understanding that a given concept could have different roles in the same scenario. This is

achieved by retrieving a thematic relation on an ad-hoc basis (for unconventional thematic relations) or through memory (for conventional thematic relations). Example for a conventional relation is 'nail' and 'hammer' or 'plate' and 'glass' and a unconventional relation is 'nail' and 'rock'. Recency and frequency are key factors in apprehending a thematic relation [16]. A given concept performs the same role in different contexts and people are aware of these dual thematic roles. For example 'paper' is used for 'writing'; it is also sometimes used for making boats, airplanes and covering gift items. Thus, with experience, concepts increase in frequency based on the distribution of thematic relations. Whenever a similar object is encountered, the object that fits the context with the highest frequency gets activated.

Acquisition of and comprehension of thematic relations plays an important role in verbal language comprehension both at the word level as well as the text passage level. A target word is recognized faster if there is a thematic prime than a context with an unrelated prime [17], and word pairs are more quickly recognized if there is a thematic relation that is integrated either with frequency or recency [18-22]. Such thematic thinking emerges in early childhood. Thematic relations are reported to intrude on other cognitive processes (e.g., similarity judgments, categorization, word recognition) despite being irrelevant to the task [23].

Studies have shown that thematic relations govern young children's memory than taxonomic categories [2,13,24-26]. Other studies have reported that, children are able to flexibly use both thematic and taxonomic relations with no pervasive preference for either mode of response [27,28]. Several factors such as task demands [29], nature of instructions [27], labeling the targets [4] are reported to affect the use of different conceptual groupings and account for the debate surrounding the development of conceptual relations. However no gender differences in the use of different conceptual strategies are reported in earlier studies [30,31].

Few studies [32] have compared the relative difficulty of recognizing thematic and taxonomic type of associations in contrast to the relative salience of the two types of relations. They [32] compared the ability of 2-3 year old children to identify both thematic and taxonomic associations at two points during their third year of life i.e., at 26 months (N = 15) and 34 months (N = 24). Match-to-sample task using objects and pictures was used in which half of the matches were thematic and other half were taxonomic. Results revealed that although children at both age groups were able to identify thematic matches, children at near 3 years of age were able to do better and recognize a wider range of thematic associations than children near 2 years of age. They analyzed individual items with thematic relations and reported that, though there were many variations among individual children, 60% of the thematic pairs were identified by 26-months old and 100% were identified by 34 months old though not with 100% accuracy. Further, young children were reported to perform better on thematic relations compared to taxonomic relations. Familiarity of the thematic relations to the children, method of testing and nature of instruction were reported to be the factors which contributed to ease of identification of thematic relations. Further, they reported that studies investigating developmental pattern for each of the different types of thematic relations such as spatial, temporal and causal relations with a sizeable number of test items need to be carried out. Developmentally relevant factors in growth of thematic knowledge which contribute significantly to the understanding of early conceptual development in children needs to be specified.

Categorization of objects is also reported to be affected by manipulability and sensorimotor experience on the perception of objects. It was proposed that, "As people perceive visual objects, simulations of potential actions become active in preparation for simulated action [33]". Hence, the visual perception of something, such as a picture or object, is actually an experience of perception, action, and introspection. In this sense, a visual experience (e.g., visual presentation of an object or picture) induces a sensorimotor experience as well [33]. Further, functional relations which played an important role in thematic conceptual relations were found to be particularly relevant for physically manipulable object concepts [34]. They reported that children and adults categorize thematic relationships faster for manipulable objects (e.g., an orange) than nonmanipulable objects (e.g., a bus). Furthermore, it was found that children and adults categorized perceptual similarity relations, which played an important role in taxonomic conceptual relations, faster for nonmanipulable objects than manipulable objects. They suggested that object manipulability may play a crucial role in adults' and children's concept formation, including taxonomic and thematic concepts.

Few studies assessed the impact of stimulus manipulability on taxonomic versus thematic preferences using a forced-choice match-to-sample task [35]. The author measured manipulability in two different ways: (1) whether or not participants were allowed to physically manipulate stimulus items, and (2) whether items were presented as objects (more manipulable) or pictures (less manipulable). Results revealed that adults, but not children, made more thematic links in the manipulable task condition than in the nonmanipulable task condition, as when people perceive an item, it is not just a visual experience, but also an overall sensory experience including the actions of the participant. However, participants at both ages were reported to make more thematic choices when the thematic relationship involved a direct, functional interaction than when it did not. Further, presentation of stimuli as objects or pictures did not affect responses in adults or children as reported. Overall, the findings suggested that the encouragement of real-world action can, in some contexts, lead to increased thematic classification.

In an fMRI study [36] conducted with a match-to-sample task, it was found that taxonomic and thematic conceptual strategies activate different cortical pathways. When participants chose a taxonomic match, they showed activation in areas involved in early occipital processing that are commonly recruited during perceptual tasks. In contrast, when participants chose a thematic match, they showed activation in areas related to function and manipulation knowledge in the visuomotor system. Further, taxonomic relations were identified faster for natural objects (e.g., vegetables), and thematic relations were identified faster for artifacts (e.g., a car), specifically manipulable artifacts (e.g., kitchen utensils). Thus it was concluded distinct neural roles serve for domain, manipulability, and thematic and taxonomic strategies in concept formation.

In summary, an earlier study revealed that 2-year-old children were significantly less accurate in identifying thematic matches than in recognizing taxonomic matches, and suggested that complementary relationships do not become a salient basis for grouping until subjects are 3 years or older [37]. Factors contributing to the poor performance on thematic relations in this study were reported [38]. The methodological differences such as testing all the types of associations like thematic, basic level, superordinate level, identity matches within a single session, high physical resemblance between the target and match [11], and training with identity matches made children biased towards

perceptual similarities and thus better performance on taxonomic relations [38]. In contrast, preschool year children were reported to be sensitive to both thematic and taxonomic relations [32,38]. However, there are fewer studies addressing the bases of the organizational schemes produced by children less than 3 years of age.

Most of the studies have addressed preferences between thematic relation and taxonomic relations in different age groups, and also the shift from thematic to taxonomic learning at a later age group. This study is an attempt to evaluate the development of each of the thematic attributes namely spatial, temporal, functional and causal relations in typical children of 2-4 years across age and gender. Attempt is made to compare the observations made in western studies on monolingual population (mostly English) with the outcome of this study which includes Kannada speaking children in the state of Karnataka in India (which is a multilingual country with varied social and cultural influence).

Aim of the Study

Aim of the study is to assess and compare across age and gender, the performance of typically developing Kannada speaking children in 4 subgroups between 2-4 years (>2.0 to <2.6 years; >2.6 to <3.0 years; >3.0 to <3.6 years; > 3.6 to <4.0 years) on tasks for assessing the comprehension of two different symbol association [spatial-temporal-functional relations (TSTFR) and causal relations (TCR)].

Method

Participants

A total of 216 typical children were selected from different play homes and schools in Mysore city of Karnataka. All children spoke Kannada as their first language. These children were incipient bilinguals, where they had Kannada as their first language and were exposed to English as their second language as the medium of instruction in their preschools. The children were divided into four groups based on their chronological age (>2.0 to <2.6 years; >2.6 to <3.0 years; >3.0 to <3.6 years; >3.6 to <4.0 years). The gender distribution of the group is shown in Table 1.

Gender	Age Groups in years			
	>2.0 to <2.6	>2.6 to <3.0	>3.0 to <3.6	>3.6 to <4.0
Boys	29	32	28	23
Girls	27	25	25	27
Total	56	57	53	50

Table 1: Total number of boys and girls in the study.

All the children were screened for any speech-language delay and deviations, neurological, sensory-motor, cognitive, behavioral and learning deficits by administering WHO disability screening checklist [39]. They were tested for age appropriate receptive and expressive language skills using the Assessment Checklist for Speech and Language skills [40]. All the children belonged to middle socio-economic status as on NIMH Scale [41]. Informal screening by the investigator was carried out to ensure that all the children had normal or corrected visual abilities. Ethical clearance was obtained from heads of the play homes and/or schools to enroll the children for the present study. The school principal and parents were explained the purpose and the procedures of the study and verbal and written consent were taken.

Stimuli

Two sets of 3D-color computerized picture symbols were developed with the help of a professional graphic designer. The pictures in set A included 25 pictures which depicted either spatial and/or temporal and/or functional concepts and set B had 25 pictures which depicted causal concepts. Pictures in set A and set B included both functionally interactive and noninteractive picture-pairs. The pictures were subjected to familiarity and ambiguity test wherein 2 Speech-Language Pathologists viewed the pictures and rated them on a 3-point rating scale, where '0' indicated least familiar and highly ambiguous and '3' indicated most familiar and least ambiguous. The pictures which were judged to be least ambiguous and most familiar for children as young as 2 years were included as test stimuli. The final stimuli in set A included 18 pictures for assessing either spatial and/or temporal and/or functional relational (TSTFR) and set B included 17 pictures to assess causal relations (TCR. Details of stimuli are provided in Appendix A and B. Two additional pictures were included in TSTFR and TCR tasks which were used as practice items (which were not part of the study). The cards with picture stimuli were bound in the form of book for ease of presentation to children. One of the book included a single picture in each page and the other book consisted of four pictures, one of which was a thematic match (either spatial and/or temporal and/or functionally related match or a causal match depending on the test carried out) to the test stimuli (picture).

Procedure

The children were interviewed by the examiner, one at a time, in a quiet environment in their kindergarten premises which was a familiar environment for them. The match-to-sample task was introduced to the children as if it were a game. Each child was presented with standard and four choice pictures one after the other. The examiner used the instruction *"Look at this one (pointing to the standard)!! Now, show me the picture which matches to this one (standard) amongst the four choice pictures?"* while showing the 4 pictures as choices that were in another book. Before carrying out the test phase, each child was given 2 practice items to ensure that they understood the task and the instruction. Half of the children were tested first with TSTFR and then followed by TCR task and other half was presented with these tasks vice-versa in order to counterbalance order effect. Time taken for testing was approximately 30 minutes per child with a minimum break period of 5 minutes between the tasks. The response was marked by the examiner as 'correct' if the child pointed to correct picture matching the test stimuli and as 'incorrect' if the child pointed to any one of the distracters.

Scoring and analysis

The 'correct' responses were given a score of "3", when the child selected the correct match to the test item without requiring any prompts by the investigator. A score of "2" was given if the child selected correct match after obtaining visual prompts by investigator where, the investigator pointed to each of the 4 picture symbols. A score of "1" was given if the child gave a correct response after investigator named the test item as a prompt. A score of "0" was given if the child was not able to select the correct choice even with

prompting. The scores obtained by each child for each task was tabulated in a score sheet developed for the purpose.

Test retest reliability was carried out by another examiner who is a speech language pathologist with Master degree with 2 years of work experience in the field on 10% of the total children after familiarizing the examiner with the stimuli, procedure of test administration. The Cronbach's alpha reliability coefficient was 0.91 for TSTFR and 0.87 for TCR.

Results

The data was tabulated and subjected to statistical analysis using SPSS software version 17. The effect of age and gender on TSTFR and TCR tasks was analyzed as per the objectives of the study.

The data was subjected to check for assumptions of normality, to test if the dependent variable is normally distributed for each group for the independent variables namely, age and gender. Shapiro-Wilk test of normality was run and it was found that for TSTFR task, there was normality for age groups, but not for gender and for TCR task, there was no normality for both age groups and gender. Further, the Levene's test of homogeneity of variance was run and it was found that, homogeneity of variance was present in both genders for both TSTFR and TCR but not for age groups.

Since the assumptions of normality and homogeneity of variance were not met, nonparametric tests were run on the data set. Descriptive statistics was used to obtain mean, median and standard deviation of scores in TSTFR and TCR tasks with respect to age group and gender which were the two independent variables in the study.

Test for Spatio-Temporal and Functional Relations (TSTFR) and Test for Causal Relations (TCR)

The mean, median and standard deviation (S.D) were obtained in percentage for both TSTFR and TCR tasks. The values indicated a developmental trend in the performance of children with increase in age for both the tasks, as shown in Table 2 and Figure 1. That is, children in higher age groups (>3.0 to <3.6 years and >3.6 to <4.0 years) performed better than children in lower age group (>2.0 to <2.6 years and >2.6 to <3.0 years).

Age group	Gender	N	Test for Spatial-Temporal-Functional Relations (TSTFR)			Test for Causal Relations (TCR)		
			Mean (%)	Median (%)	Standard Deviation (%)	Mean (%)	Median (%)	Standard Deviation (%)
>2.0 to <2.6	Boys	29	44.25	46.3	23.45	50.17	54.9	22.48
	Girls	27	39.03	35.19	22.51	42.34	43.14	19.79
	Total	56	41.73	43.52	22.94	46.39	50.98	21.4
>2.6 to <3.0	Boys	32	58.22	57.41	25.92	60.48	64.71	16.93
	Girls	25	58.37	64.81	18.55	62.35	64.71	15.96
	Total	57	58.28	61.11	22.79	61.3	64.71	16.4
>3.0 to <3.6	Boys	28	83.33	83.33	9.73	73.67	73.53	9.433
	Girls	25	79.78	79.63	14.57	76.71	76.47	8.19
	Total	53	81.66	81.48	12.26	75.1	74.51	8.92
>3.6 to <4.0	Boys	23	76.01	79.63	18.51	77.92	78.43	13.84
	Girls	27	83.06	85.19	11.47	83.22	86.27	11.617
	Total	50	79.81	81.48	15.37	80.78	82.35	12.84
Total	Boys	112	34.85	39	13.8	32.99	34	9.99
	Girls	104	35.05	38	13.41	33.67	36	10.98
Total		216	34.94	38	13.58	33.32	35	10.46

Table 2: Mean, Median, and Standard deviation for TSTFR and TCR in each age group and gender.

Effect of gender on TotTSTFR and TotTCR scores

Mann Whitney U test was used to test the effect of gender on TotTSTFR and TotTCR scores irrespective of age. Results revealed no significant difference in the performance across gender on both TotTSTFR (/Z/ = 0.16, p = 0.87), and TotTCR (/Z/ = 0.75, p = 0.45).

Though there was no overall gender effect, Mann Whitney-U test was used to test the difference between genders in each of the age groups for both TotTSTFR and TotTCR. The results indicated no significant difference between gender on TotTSTFR in >2.0 to <2.6 years (/Z/ = 1.24, p > 0.05), >2.6 to <3.0 years (/Z/ = 0.12, p > 0.05), >3.0 to <3.6 years (/Z/ = 0.76, p > 0.05) and >3.6 to <4.0 years (/Z/ = 1.34, p > 0.05). Also, no significant difference was found between gender on TotTCR in all the four age groups i.e., in >2.0 to <2.6 years (/Z/ = 1.79, p > 0.05), >2.6 to <3.0 years (/Z/ = 0.18, p > 0.05), >3.0 to

<3.6 years (/Z/ = 1.16, p > 0.05) and >3.6 to <4.0 years (/Z/ = 1.27, p > 0.05).

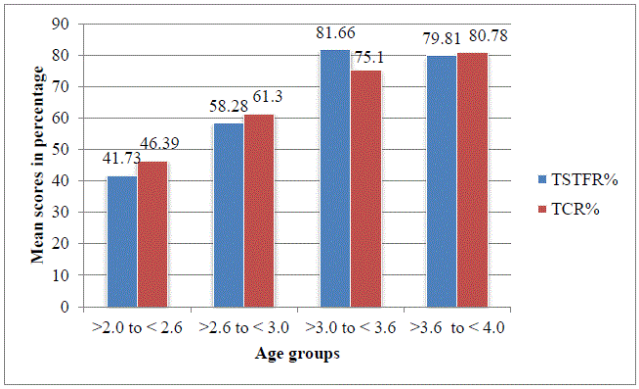

Figure 1: Mean in percentage for TotTSTFR and TotTCR in each age group.

Effect of age on TotTSTFR and TotTCR scores

Since there was no effect of gender on both TotTSTFR and TotTCR scores, the data was combined and the age effect was seen for the entire data irrespective of gender. Kruskal-Wallis-H test was used to find out the main effect of age on TotTSTFR and TotTCR scores. It was found that, there was a significant main effect of age on the total score of both TotTSTFR [χ_2 (3) = 93.44, p < 0.01], and TotTCR [χ_2 (3) = 91.80, p < 0.01].

Further, Mann-Whitney U test was used to find the age groups which performed significantly different from other age groups on TotTSTFR and TotTCR. The pairwise comparison of age groups on TotTSTFR revealed that children of >2.0 to <2.6 years performed significantly lower compared to children of all other age groups, i.e, >2.6 to <3.0 years (/Z/ = 3.55, p < 0.001), >3.0 to <3.6 years (/Z/ = 7.92, p < 0.001), and >3.6 to <4.0 years (/Z/ = 7.38, p < 0.001). Children of >2.6 to <3.0 years also performed significantly lower compared to children of >3.0 to <3.6 years (/Z/ = 5.60, p < 0.001) and >3.6 to <4.0 years (/Z/ = 5.10, p < 0.001) on TotTSTFR. There was no significant difference in the performance of children between >3.0 to <3.6 years and >3.6 to <4.0 years (/Z/ = 4.20, p > 0.05) on TotTSTFR.

On TotTCR, pairwise comparison of age groups using Mann-Whitney U test revealed that children of >2.0 to <2.6 years performed significantly lower compared to children of >2.6 to <3.0 years (/Z/ = 3.77, p < 0.001), >3.0 to <3.6 years (/Z/ = 7.31, p < 0.001), and >3.6 to <4.0 years (/Z/ = 7.51, p < 0.001). Further, children of >2.6 to <3.0 years also performed significantly lower compared to children of >3.0 to <3.6 years (/Z/ = 4.60, p < 0.001) and >3.6 to <4.0 years (/Z/ = 5.78, p < 0.001). A significant difference was found in the performance of children between >3.0 to <3.6 years and >3.6 to <4.0 years (/Z/ = 2.75, p < 0.001), where children of >3.6 to <4.0 yearsperformed better. The responses for TotTSTFR were analyzed item wise using cross tabs in SPSS, in order to identify the items which were performed better by majority of the children and the items which were difficult to the children of 2-4 years. The results are shown in Table 3. It is seen that, the item pairs 'key - lock', 'fish - pond' and 'hanger - shirt', were performed better with 74.3%, 68.0%, and 63.7% of children performing correctly without any cue for these items. For the items 'car - road', 'ball - bat', and 'kennel - dog', children obtained least scores of 42%, 41.6% and 38.7% respectively. Further it was observed that, the accuracy of the responses increased and error responses decreased with increase in age group.

Sl No	TSTFR Stimuli pairs	Total % of children obtaining scores from 0-3			
		0	1	2	3
1.	Ball - Bat	21.7	19.9	16.8	41.6
2.	Eyes - Spectacles	20.8	17.7	13.7	47.8
3.	Feet - Slippers	17.7	15.5	9.3	57.5
4.	Bird - Tree	18.6	13.7	14.2	53.5
5.	Shirt - Cupboard	38.1	6.2	9.7	46
6.	Key - Lock	5.8	8.8	11.1	74.3
7.	Toothbrush - Teeth	33.2	9.3	14.6	42.9
8.	Candles - Cake	30.5	7.5	8	54
9.	Tumbler - Plate	29.6	11.9	11.9	46.5
10.	Car - Road	38.9	8	11.1	42
11.	Soap - Soap case	15.9	9.7	11.9	62.4
12.	Pencil - Book	21.2	11.1	11.5	56.2
13.	Hanger - Shirt	16.4	4.9	15	63.7
14.	Mug - Soap	29.6	4.9	11.9	53.5
15.	Cap - Head	29.6	14.2	10.6	45.6
16.	Kennel - Dog	47.6	4.9	8.9	38.7
17.	Monkey - Tree	32.9	13.3	9.3	44.4
18.	Fish - Pond	13.8	7.6	10.7	68

Table 3: Cross tabs for test items of TSTFR.

The responses for TCR were analyzed item wise using cross tabs in SPSS. The results are shown in Table 4. It is observed that, the item pairs 'blowing balloon - inflated balloon', 'tap - bucket with water' and 'lighted candle - matchstick', were performed better with 87%, 78.2%, and 78% percentage of children performing correctly without any cue. The items 'glass of milk - cow', 'band-aid-wound', and 'broken window - ball', secured least scores amongst the entire test items, with scores being 29%, 24% and 12% respectively. Also, it was observed that the accuracy of the responses increased with increase in age group and the error responses decreased.

Sl No	TCR Stimuli pairs	Total % of children obtaining scores from 0-3			
		0	1	2	3
1.	Switch - Bulb	24.5	18.5	7.4	49.5
2.	Tap water - Water filled bucket	7.9	6.9	6.9	78.2
3.	Milk in a vessel - Stove	14.4	13.9	12.5	59.3
4.	Broken window - Ball	75.5	8.3	4.2	12

5.	Lighted candle - Match stick	6	4.7	10.7	78.6
6.	Soap - Shirt	44.9	10.6	9.3	35.2
7.	Clean teeth - Brush	15.3	12	12.5	60.2
8.	Rain - Umbrella	13	18.5	10.6	57.9
9.	Boy fallen down - Wound	19.4	15.7	9.7	55.1
10.	TV - Remote	6	12	12	69.9
11.	Neat nails - Nail cutter	17.6	25.5	14.8	42.1
12.	Watering plant - Plant growing tall	27.8	5.1	12	55.1
13.	Blowing balloon - Inflated Balloon	5.6	1.4	6	87
14.	Cup falling down - Broken cup	9.3	5.6	14.8	70.4
15.	Locked door - Key	16.2	13	13.9	56.9
16.	Glass of milk - Cow	45.8	14.4	10.6	29.2
17.	Band aid - Wound	47.2	19	9.7	24.1

Table 4: Cross tabs for test items of TCR.

Comparison of performance of children on TSTFR and TCR

The total scores were converted into percentage, as the total number of items and total raw scores were different for each task. Wilcoxon signed rank test was used to compare the performance of children between TSTFR and TCR. Though the mean values indicates slightly better performance of the children on TCR, the difference was not statistically significant in the performance of children between two tasks (/Z/ = 0.31, $p > 0.05$).

Comparison of performance of children between two tasks with respect to age

The overall mean for TSTFR and TCR were 34.94% and 33.32% respectively, indicating slightly better performance of children on TSTFR than on TCR. However, the mean values indicated better performance of children in TCR than TSTFR, in all the age groups except in >3.0 to <3.6 years, where the performance was better on TSTFR. Wilcoxon signed rank test was used to compare the performance of children on both the tasks across age and gender. The results indicated a significant difference in the performance between TSTFR and TCR only in children of >3.0 to <3.6 years (/Z/ = 3.10, $p<0.05$) with TSTFR scores being better compared to TCR scores and there was no significant difference found between two tasks in other three age groups, as shown in Figure 2.

Comparison of performance of children between TSTFR and TCR tasks with respect to gender

Wilcoxon Signed Rank test was used to compare the performance of children between TSTFR and TCR with respect to gender and it was found that the difference between TSTFR and TCR in males and females was not significant (/Z/ = 0.29, $p > 0.05$ and /Z/ = 0.74, $p > 0.05$ respectively).

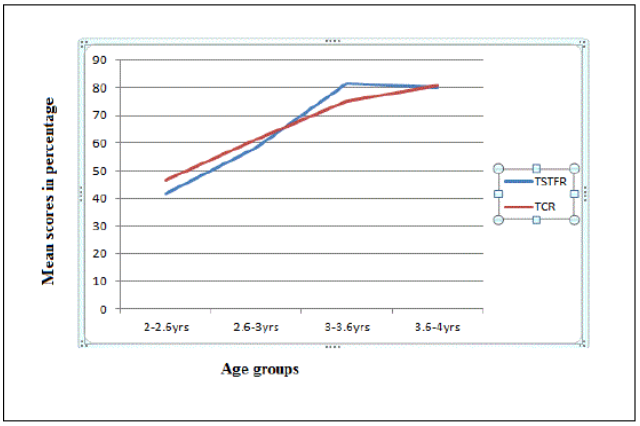

Figure 2: Comparison of performance of children on TSTFR (%) and TCR (%) in each age group.

Comparison of performance of children between TSTFR and TCR with respect to age and gender

The performance of children was compared between two tasks within gender across age and gender. Wilcoxon signed rank test was used to compare between two tasks within males across different age groups. A significant difference was found in the performance of males of only 3-3.6 years between TSTFR and TCR, with better performance on TSTFR than TCR (/Z/ = 3.23, $p < 0.01$). No significant difference was found in males of other three age groups between the two tasks. Further, there was no significant difference found in the performance of females of each age group between TSTFR and TCR scores.

In summary, the results revealed a significant developmental trend from lower age to higher age group in both TSTFR and TCR. There was no ceiling effect observed on both the tasks even at highest age group (>3.6 to <4.0 years) selected in the study. Gender effect was not statistically significant on both TSTFR and TCR tasks. Further, there was no statistically significant difference in the performance of children between TSTFR and TCR across age and gender.

Discussion

The results point to a developmental trend in the acquisition of thematic relational abilities in typical children from 2 to 4 years of age. The thematic relational understanding was better in the older age group compared to younger age groups. This result suggests that the comprehension of thematic relations in children improves with age due to increase in exposure and experience with these relations. This is in consonance to the earlier studies where it was reported that preschool age children have the ability to comprehend thematic relations [13,24,32,27]. Further reports of earlier study suggest that recognition of thematic relations between two items depends largely on the child's experience with the implied connection. It was found that children's ability to recognize thematic connections increases with age and experience, and recognition of these relations were present in children at 2 years of age and broadened with increase in age to 3 years [32]. Similar results were also reported where children at 2 years of age were found to have an emerging appreciation of both thematic and taxonomic relations compared to children of 3 and 4 years who understood both thematic and taxonomic relations better [27].

In this study, a developmental trend was observed starting from 2.0 to 4.0 years in both TSTFR and TCR tests, as seen from the better performance of children in higher age groups compared to children in the lower age groups. The effect of age and gender on both TSTFR and TCR were studied. There was no significant gender effect on both the tasks. This finding is similar to the results of few of the earlier studies [30,31]. However, there was a significant age effect found on scores of both TSTFR and TCR. The emergence of identification of both the types of relations was observed in children as young as >2.0 to <2.6 years which is reflected by their mean scores of 42% and 46% on TSTFR and TCR respectively. The mean scores reached to 50% percent on both the tasks at >2.6 to <3.0 years. This suggests that children become aware and would be able to perceive both spatial-temporal-functional and causal types of thematic relations at the same time in the developmental period. Since many of the stimuli pairs included in both TSTFR and TCR tasks were a part of events or actions (e.g., Spatial-temporal-functionally related stimuli such as key - lock; soap - soap case; pencil - book etc, and causally related items such as tap water - bucket filled with water; lighted candle - match stick; TV - remote etc) which were very frequently encountered by preschool children, children as young as >2.6 to <3.0 years, were able to achieve more than 50% of the scores, which was considered as above chance level performance. This is in consonance to the earlier studies where they reported that if conceptual knowledge is rooted in the events children take part in younger children are expected to produce more action and event relations than older children as these relations can be directly experienced in everyday life [42-44]. However, no ceiling effect was observed for both the tasks, even in the highest age group included in the study (>3.6 to <4.0 years) suggesting that both types of relations are not achieved 100% at 4 years of age. This could be attributed to the inclusion of stimuli pairs which are less frequently encountered by children of this age group (e.g., Kennel - dog; milk - cow etc). These results suggest that each of the thematic relation skills in specific spatial, temporal, functional and causal relations begin to emerges as early as 2 years and broadens as the age approaches 3 to 4 years. These results support the views of earlier studies [32,45]. These studies reported that preschoolers rely on thematic relations, wherein objects from distinct taxonomic categories share a complementary, that is functional relation (e.g., coat - hanger) and/or situational relation, appearing in the same time-space (e.g., table - stove). Further when meaningful objects are used in the sorting task, young children were found to represent causal and temporal relations among the objects as well as spatial relations [7]. In addition it can be noted that in order to understand these thematically linked objects/pictures pairs, the children need to use cognitive skills, specifically their ability to analyze the objects/pictures for their similarity, retrieve them from memory, and these enhance their skills such as categorization, inference and analogy [16].

A closer look using qualitative analysis of the performance of children on TSTFR test suggests that children performed better on few pictures that depicted relations which were more frequently encountered by them in their daily life. This observation is in support of results from earlier studies [21,22]. Further, physically manipulable objects were performed better than physically nonmanipulable objects [For example, 'key - lock' and 'hanger - shirt' can be considered as physically manipulable objects than 'car - road', and 'kennel - dog' and hence might be performed better]. In an earlier study it was proposed that as the ability of children to perceive visual objects improves, the simulations of potential actions become active in preparation for simulated action. Hence, the visual perspective of something, such as a picture or object, is actually an experience of perception, action, and introspection [33]. The results of the study are in consonance with the observations made by earlier studies who reported that functional relations, which play an important role in thematic conceptual relations, were particularly relevant for physically manipulable object concepts [34,36]. They suggested that functionally interactive pairs are defined by their real-world physical actions and spatial relationships (i.e., manipulability) than non interactive pairs. They reported that children and adults categorize thematic relationships faster for manipulable objects (e.g., an orange) than non manipulable objects (e.g., a bus). They suggested that object manipulability may play a crucial role in adults' and children's concept formation, including in taxonomic and thematic concepts. This interaction was also evident from the neuro imaging studies that show activation in visual-motor areas during categorization forced-choice tasks [36].

Further, the results pointed to the fact that the picture pairs that are characterized by one or more thematic relational attribute have better chances of being successfully identified. For example, any picture that depicts all the three features of spatio-temporal-functional attributes were identified better by children compared to pictures that depicts only the spatial attribute or only temporal attribute. For example 'key - lock', 'feet - slippers' are thematically related in spatial as well as functional aspects, compared to 'car - road' which has only spatial attribute or 'tumbler - plate' which has mainly temporal attribute. Similar results were found in previous studies where participants made more thematic choices, when thematic relationship involved a direct, functional interaction than when it did not [34,35].

The stimuli pairs in TSTFR were thematically related either spatially and/or temporally and/or functionally. For example, soap - soap case, monkey - tree was related spatially. The better performance of children across age ranges for these stimuli suggests that the children seem to be aware of the implicit relationship in such pairs. For example, a monkey is more often seen on a tree than in other places. Although 'Cycle' was presented as one of the distractor, chances of a child understanding the thematic relation as 'a monkey sitting on the cycle' were present, however this trend did not emerge. Around 44% of the children associated a 'monkey' with a 'tree'. This seemed to be influenced by their encounters of a familiar concept retrieved from the child's memory. Spatial thinking was reported to develop strongly after 8 years of age according to an earlier study [25]. They used word association task to assess the thematic relations, whereas this study attempted to understand thematic relations based on tests using picture association task. In addition, the stimuli pairs used in the present study were more familiar to the children of 2-4 years age group [e.g., soap - soap case] than those used in earlier studies [e.g., bird - nest]. Further, different levels of cueing such as visual prompts in terms of pointing to the choices, and naming the test stimuli were used in the present study and these would have helped children perform better on spatially and/or temporally related items. The results in this study also suggest that spatial relations tend to develop at an early age and they only get better with age. Most of the picture pairs selected in this study was ones that were more frequently encountered by children in the age group 2-4 years. For example, picture pairs such as 'soap - soap case', 'hanger - shirt' are more frequently encountered by children of this age group and hence identified better.

In the test for causal relationship, qualitative analysis of the response showed that amongst several picture items such as e.g., switch - bulb, rain - umbrella, which were used, the items such as tap - water and water-filled bucket were the most frequently identified pair. The items

with strong and direct associations and with functionally interactive relations between the pictures, for example "tap - water" had a high success rate. Studies report that infants tend to place causal interpretations on events they perceive [8,46,47] and the tests used in this experiment also showed that children between 2-4 years had the ability to understand the causal relationship. However, the item such as cow - milk, were performed poorly by children, as the thematic relationship present here is an indirect causal relationship (i.e., the cow produces the milk, which is processed and then eventually poured into a glass; ultimately, then, the glass of milk is a distal effect of the cow). Results of earlier studies report that functionally interactive thematic relationships are also more grounded in real-world actions and elicit better responses than non-interactive relationships [35]. For example, cow-cowbell, directly interact with one another. A cowbell is worn by the cow, and therefore this relationship becomes spatial, interactional, possibly functional, and strengthened by actions that relate the items. Functionally interactive thematic pairs elicit motor information in addition to perceptual information, given the direct, physical interaction between the two items (e.g., putting a baby into a crib), whereas non-interactive relationships do not. Therefore functionally interactive relationships can be considered more manipulable than non interactive relationships, which could explain the differences seen in thematic strength among the different types of thematic relationships. The study suggested that manipulability influences conceptual relations on many different levels (task condition, type of stimulus, stimulus conceptual relationships) [35]. Thus factors such as familiarity of the thematically related object/pictures pairs and their implied connection, their recency, frequency of exposure to the test picture, domain area, functional attributes of the stimuli, their physical attributes like manipulability, clarity of the picture, and attraction level of the pictures play an important role in successful identification of the thematic relations in children.

When each of the thematic attributes was compared on an individual basis, (Table 2), it was observed that the causal relations in three of the age groups were better identified than spatio-temporal-functional relations. However, there was no statistically significant difference in the performance of children between causal and spatio-temporal-functional relations. Both causal relations and spatial-temporal-functional relations emerge by 2 years of age and they were found to be of equal difficulty for children.

Conclusion

Comprehension of thematic relations starts emerging in children at a very young age and these relations are important for child's language development. This study is one of the initial attempts addressing the development of the different types of thematic relations such as spatial-temporal-functional and causal relations in children from 2-4 years. It was found that both these relations are achieved at the same time of developmental period. There was no significant difference between spatial-temporal-functional and causal relations, where children performed similarly on both of these tasks (TSTFR and TCR). Further the study attempted to select both functionally interactive and non-interactive thematic relationships in both spatial-temporal-functional relations and causal relation tests and provides an evidence for the better performance of children on more of functionally interactive elements. Future research should focus on how mastering thematic relations help a child in learning more languages. Future research can also include comparison of performance of children on different types of stimuli such as toy objects which are very similar to real objects and pictures can include higher number of stimuli pairs in each of the different types of thematic relations. The experiment can also have more number of distractors and there should be an attempt to measure the consistency of scores in such scenarios.

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