Object Categorisation Using Malay Shape-based Numeral Classifiers

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Abstract

Categorisation is fundamental in human cognition and language development. Cross-linguistic studies on categorisation propose numeral classifiers as a linguistic manifestation of human categorisation and conceptualisation. Thus, studies on numeral classifier acquisition enable researchers to examine how children learn to categorise objects in their environment using a constrained framework, and how this ability becomes more refined as children grow older. This study investigated the strategies children utilise in categorising objects into eight Malay shape-based numeral classifier categories using a paired discrimination task. One-hundred-and-forty-eight children ranging in age from 6 to 9 years and a comparison group of adults participated in this study. Results revealed that children categorised objects more readily when there was a strong (two-perceptual feature distinction) than weak (one-perceptual feature distinction) contrast, and when exemplars were typical rather than atypical. There appears to be a gradual transition from a perceptually biased to a broader, more rule-based system.

Keywords: children, cognition, conceptualisation, perception, typicality.

Introduction

Categorisation is an essential process in human cognition and language development. Human beings categorise objects by simplifying the environment, usually to reduce the infinite differences among stimuli (e.g., Rosch, Mervis, Gray, Johnson & Boyes-Braem, 1976). The cognitive load on human memory is reduced, which results in more efficient information storage and retrieval (Markman, 1989). In the process of categorisation, objects that are perceived as similar are sorted into the same category (e.g., Clark, 1973) and concurrently, those that are considered dissimilar are categorised into different categories (Hampton, 1998). In the categorisation of succeeding or novel objects, the relevant information on any related object that has been stored earlier is retrieved and evaluated. Only when there is a satisfactory resemblance between the new and the stored information will these subsequent or novel objects be accepted into the respective categories (Barsalou, Huttenlocher, & Lamberts, 1998; Rogers & McClelland, 2004).

Classifier languages are spoken by a large portion of the world's population (Gao & Malt, 2009). They offer researchers a unique opportunity to examine how children learn to categorise and label objects using a constrained framework or system. The numeral classifier (NumCl) system is one of the few types of classifiers that are typically used in counting objects. Speakers need to learn how to categorise objects in their environment and pair them with the appropriate numeral classifier using the language-specific classification system.

Researchers propose that a numeral classifier system is a manifestation of a conceptual category. Although members of numeral classifier categories may be diverse, their membership may be explained in terms of "motivated extensions...reflecting the imaginative aspects of mind" (Lakoff, 1987, p. 113). As in metaphors (Salehuddin, 2004), classification of objects into the respective numeral classifiers also involves the interaction between one's conceptual system and one's encyclopaedic knowledge (i.e., knowledge of the world). However, categorisation in numeral classifiers is different from categorisation in nouns because, while categorisation of nouns highlights features that are inherent to the objects, categorisation in numeral classifiers highlights the way a particular speech community perceives the entities physically, socially, and functionally (Allan, 1977).

Shape-based numeral classifiers (a subcategory of the numeral classifier system) in Malay have intrinsic perceptual features associated with the particular categories. In order to correctly allocate an object to a particular shape-based numeral classifier category, features involving either dimensionality and rigidity, or dimensionality and size need to be considered. Typical members in general adhere to the membership category criteria; however, atypical members are much less clear-cut or transparent in their membership to a particular category. More opaque members have to be individually learned or memorised either through explicit or implicit learning. There are distinct differences between numeral classifier categories in terms of how "well defined" the categories are; that is, to what degree its members adhere to the category criteria and share one or more features (Gao & Malt, 2009, p. 1136).

The current study aims to investigate the strategies that Malay children use to categorise objects into shape-based numeral classifier categories. First, the general categorisation strategies utilised by children will be discussed. Subsequently, the Malay shape-based numeral classifier system and research on Malay numeral classifier acquisition will be reviewed, prior to outlining the aims and research questions of the current study.

Categorisation Strategies Utilised by Children

"An enduring debate in cognitive science is whether key aspects of human cognition are rule-based or similarity-based" (Johansen & Palmeri, 2002, p. 483). The perceptual features of objects play a prominent role in the categorisation and labelling of objects by young children (e.g., Hampton, 1998; Mandler, Bauer, & McDonough, 1991). Previous categorisation studies (e.g., Bowerman, 1978) indicate that shape is particularly salient to young children and helps them in the process of learning lexical categories. Landau, Smith, and Jones (1988), for example, reported that young children focused more on shape than size, texture, and colour when they were asked to select an object that shared the same name with the stimulus. According to Keil (1989), children's understanding of concepts gradually shifts from a similarity-based concept to a deeper 'theory-based' concept. Children learn not to rely solely on perceptual similarity but gradually learn a fuller or more 'hidden' conceptual representation (Hampton, 1998).

In sorting numeral classifier exemplars into Japanese numeral classifier categories, Uchida and Imai (1999) found that young children tend to categorise objects based on the similarity of perceptual features in determining group membership; whereas older children are able "to synthesise pieces of partial knowledge and form them into a cohesive whole" (Uchida & Imai, 1999, p. 50), which is a necessary skill for categorising objects into numeral classifier categories. In addition, in order to effectively sort objects into their respective numeral classifier categories, children also need to be able to exclude perceptually similar non-members of the category. In short, children who are competent at categorising objects are able to identify the shared features among category members, and/or distinctive features among category non-members (Hammer, Diesendruck, Weinshall & Hochstein, 2009).

It also appears that young children's ability to categorise objects into categories proceeds through a differentiation from broader to finer distinctions (Mandler et al., 1991; Yamamoto & Keil, 2000). For example, in an examination on the categorical knowledge of numeral classifiers in Japanese children using a discrimination task, Yamamoto and Keil (2000) found that comprehension of numeral classifiers proceeds through a differentiation of broader categories (animal classifiers vs. shape-specific classifiers vs. functional classifiers) to much finer distinctions (small animal classifier vs. large animal classifier vs. bird classifier).

The Role of Typicality in Categorisation

According to prototype theory, a member with more attributes in common with other members of the category, and with more dissimilarities with members of contrasting categories, is graded as a more prototypical or typical member (the best exemplar) of a particular category. Conversely, any members on the borderline (i.e. those having fewer features in common with other members within the same category, especially with the most typical member) are graded as atypical members of a category (Matsumoto, 1985). Initially, children appear to learn categorisation rules through typical exemplars and then gradually proceed to learning the rules associated with more atypical members of the particular category (e.g., Markman, 1989; Rosch & Mervis, 1975). Children also tend to initially restrict category labels to only typical members, resulting in "immature" categorisation whereby atypical exemplars get excluded from the category and out-of-category instances that do share these properties are inappropriately included (Rogers & McClelland, 2004).

Typical exemplars are categorised more quickly in comparison with atypical exemplars (Rogers & McClelland, 2004). Atypical members of a category take longer to verify than typical members (e.g., Rogers & McClelland, 2004; Rosch, 1973). The reaction times to typical exemplars in a category-membership verification technique were faster than to atypical exemplars in 10-year-olds in comparison to adults (adults' reaction times to typical and atypical exemplars were not significantly different), indicating that typical exemplars are learned prior to atypical exemplars (Rosch, 1973).

Malay Shape-based Numeral Classifiers

Similar to most numeral classifier languages, Malay shape-based numeral classifiers classify objects based on dimensionality of the objects (Salehuddin & Winskel, 2008). In Malay, objects are further categorised based on either rigidity or size of the objects (Figure 1). One-dimensional (1D or long) and two-dimensional (2D or flat) objects are classified based on their rigidity. Rigid 1D objects like a pen, are paired with *batang* [1D: +rigid] (e.g., *satu batang pen* [one NumCl pen]), whereas flexible 1D objects like a necklace, are classified with *utas* [1D: -rigid] (e.g., *satu utas rantai* [one NumCl necklace]). Rigid 2D objects like a wooden plank, are classified with *keping* [2D: +rigid] (e.g., *satu keping papan* [one NumCl wooden plank]), flexible 2D objects like a piece of cloth are classified with *helai* [2D: -rigid] (e.g., *satu helai kain* [one NumCl cloth]). Three-dimensional (3D or rounded) objects are classified based on their size. Fine 3D objects like rice are classified with *butir* [3D: fine] (e.g., *satu butir beras* [one NumCl rice]), small 3D objects like a ball are paired with *biji* [3D: small] (e.g., *satu biji bola* [one NumCl ball]), medium-sized 3D objects like a stone are classified with *ketul* [3D: medium] (e.g., *satu ketul batu* [one NumCl stone]), and big 3D objects like a bus are classified with *buah* [3D: big] (e.g., *satu buah bas* [one NumCl bus]). The categorisation of objects into their respective numeral classifier categories are not only for counting purposes but also for pragmatic reasons (Salehuddin, Winskel & Marlyna Maros, 2011).

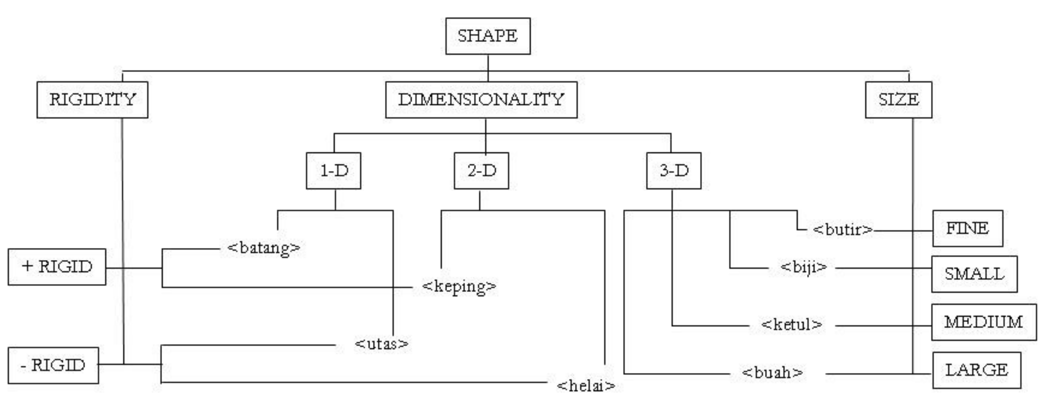

Figure 1: The classification of Malay shape-based numeral classifiers (adapted from Salehuddin & Winskel (2008:73))

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Malay Numeral Classifier Acquisition

In a recent study, Salehuddin and Winskel (2009a) investigated the acquisition of Malay numeral classifiers through an elicited production task with 140 6- to 9-year-old Malay children. They found that Malay numeral classifier acquisition is a relatively delayed and prolonged process, which continues to develop into late childhood and adolescence. If we examine the developmental patterns of numeral classifier production exhibited, young children (6- and 7-year-olds) tended to omit the numeral classifier, whereas the older children tended to substitute an alternative numeral classifier in place of the correct numeral classifier. These types of errors can provide us with clues about the categorisation strategies children utilise in sorting objects into numeral classifier categories (Bernstein Ratner, 2000). Children tend to use or select an alternative numeral classifier that shares the same dimensionality type with the correct numeral classifier. For example, the numeral classifiers *buah* [3D: big] and *biji* [3D: small] were used predominantly in place of other 3D classifiers; *buah* was mainly used in place of other 3D classifiers (51% of responses) rather than replacing 1D (29%) or 2D (19%) classifiers; *biji* was used predominantly in place of other 3D classifiers (77%) in contrast to 1D (8%) and 2D (15%) classifiers. Children also frequently used alternative numeral classifiers that shared the same rigidity type. For example, children produced *helai* [2D: -rigid] most frequently in place of *utas* [1D: -rigid] (48%), and *batang* [1D: +rigid] in place of *keping* [2D: +rigid] (61%). Similar results were found in a matching comprehension task (Salehuddin & Winskel, 2009b). Errors revealed that children also had difficulty in making finer distinctions and distinguishing between the size of objects and between the dimensionality of objects (i.e., 1D and 2D) when categorising objects, as size and dimensionality is a relative concept dependent on the manner objects are presented and how they are perceived. For example, a wooden plank is 2D (flat) when it is laid flat; however it can also be 1D (long), if it is viewed from a vertical perspective. In sum, these substitution errors indicate that children have difficulty in making finer categorisation distinctions, particularly in terms of dimensionality and size, which are relative concepts. Hence, evidence indicates that children gradually refine their conceptualisation and progress from making broader to finer distinctions.

In the current study, an experiment was conducted to investigate the children's ability in the categorisation of objects into Malay shape-based numeral classifier categories. The aim of the "Paired Discrimination" task was to examine if children rely on the number of perceptual feature differences in the categorisation of objects into numeral classifier categories and if categorisation proceeds through a differentiation from broader to finer distinctions (Mandler et al., 1991). In addition, the role that typicality plays in the acquisition of category representation was examined. According to prototype theory, typical exemplars have a special or privileged role when learning categorisation rules or membership. Two objects from different numeral classifier categories that differed in either one or two perceptual features and in terms of typicality were presented to participants. Participants were required to select the object that matched the numeral classifier category.

Based on prior research, it was predicted that if children are relying on the number of perceptual feature differences to categorise objects into their respective classifier categories, then we can expect categorisation in the strong contrast condition (two feature difference) to be more accurate and have faster reaction times (RTs) than the weak contrast condition (one feature difference). For example, children will give more accurate responses and faster RTs when the contrast is between exemplars from *batang* [1D: +rigid] and *buah* [3D: big] than between *batang* [1D: +rigid] and *utas* [1D: -rigid].

Method

Typicality ratings

The stimuli consisted of pictures of objects that were selected based on earlier ratings by 30 adult Malay native speakers. Adults were asked to rate pictures of familiar, everyday objects from most typical to most atypical exemplars for each of the eight numeral classifier categories. An object rated as a very typical exemplar was given a score of '5', whereas a very atypical exemplar was given a score of '1'. The responses given by the adults were averaged and subsequently typical and atypical objects were selected based on these rating scores.

Participants

One hundred and forty children attending a preschool and a primary school in the same school participated in the experiment. The children were all native speakers of Malay and spoke Malay as their first language. All the 6-year-olds (age range between 5 years and 8 months and 6 years and 7 months) were preschoolers whereas the 7-, 8-, and 9-year-olds were in their first, second, and third year of primary school respectively. Twenty adults participated in the experiment as a comparison group. The adults lived in the vicinity of the school and had a mixed educational background. All participants were from middle SES. A description of the participants, including gender is given in Table 1.

Table 1: Description of participants

Age group	Age range	Mean age	No. of participants	No. of males	No. of females
6-year-olds	5;8 – 6;7	6.18	31	14	17
7-year-olds	6;8 – 7;6	7.13	36	13	23
8-year-olds	7;9 – 8;8	8.25	41	19	22
9-year-olds	8;11 – 9;8	9.28	32	10	22
Adults	17;3 – 77;8	48.07	20	7	13
Total			160	63	97

Picture-familiarisation session

Prior to the experimental session, a slide display of 44 pictures with an audio presentation of the names of the respective objects in the experiment were shown to the children. In this picture-familiarisation session, children were asked to repeat the names of the objects after the audio presentation of the respective objects before proceeding to the next slide. This was to ensure that the children were familiar with the items presented to them.

The experiment was carried out using e-Prime (Psychology Software Tools, Inc.), a research application suite which allows experiment generation and millisecond precision data collection. Stimuli were displayed on an LG LS70 Express laptop.

Stimuli and procedure

The objects for categorisation in this experiment were pictures of typical and atypical exemplars of eight Malay shape-based numeral classifiers, which were paired based on the number of contrasts between the numeral classifier categories (strong vs. weak), and degree of typicality of the numeral classifier exemplars (typical vs. atypical). The strong contrast was achieved by pairing numeral classifier exemplars with two differences in semantic features (e.g., pairing exemplars of *batang* [1D: +rigid] with *buah* [3D: big]). The weak contrast was achieved by pairing numeral classifier exemplars with only one difference in semantic features (e.g., pairing exemplars of *batang* [1D: +rigid] with *utas* [1D: -rigid]). In addition, all exemplar pairs were also paired based on their typicality type, so that a typical exemplar of, for example, *batang,* was paired with a typical exemplar of *utas,* and an atypical exemplar of *batang* was paired with an atypical exemplar of *utas* (refer to Table 2).

Table 2: Description of test stimuli for the Paired Discrimination Task for the strong contrast condition

Numeral classifier pair	Typical exemplars		Atypical exemplars	
	First picture pair	**Second picture pair**	**First picture pair**	**Second picture pair**
batang [1D: +rigid] vs. *buah* [3D: big]	Pencils – Buses	Trees – Boxes	Rivers – Planets	Roads – Robots
keping [2D: +rigid] vs. *ketul* [3D: medium]	Planks – Stones	Pictures – Meat	CDs – Gold Ingots	Cakes – Chocolates
utas [1D: -rigid] vs. *biji* [3D: small]	Necklaces – Rambutans	Ropes – Balls	Watches – Cups	Chain Links – Plates
helai [2D: -rigid] vs. *butir* [3D: fine]	Papers – Rice	Shirts – Stars	Pants – Seeds	Handkerchiefs – Sand

Table 3: Description of test stimuli for the Paired Discrimination Task for the weak contrast condition

Numeral classifier pair	Typical exemplars		Atypical exemplars	
	First picture pair	Second picture pair	First picture pair	Second picture pair
batang [1D: +rigid] vs. *utas* [1D: -rigid]	Pencils – Necklaces	Trees – Ropes	Rivers – Watches	Roads – Chain Links
keping [2D: +rigid] vs. *helai* [2D: -rigid]	Planks – Papers	Pictures – Shirts	CDs – Pants	Cakes – Handkerchiefs
buah [3D: big] vs. *ketul* [3D: medium]	Buses – Stones	Boxes – Meat	Planets – Gold Ingots	Robots – Chocolates
biji [3D: small] vs. *butir* [3D: fine]	Rambutans – Rice	Balls – Stars	Cups – Seeds	Plates – Sand

Each numeral classifier was tested four times; twice with typical exemplars and twice with atypical exemplars. Each picture pair appeared twice (but not consecutively) to counterbalance the position of each exemplar. In total 64 trials were presented to each child. The task of the child was to select the object that matched the named numeral classifier when each picture pair was presented simultaneously on a laptop.

Practice trial

Six practise trials were presented to the children prior to the experimental session. This included the presentation of four pairs of *orang* [animate: human] versus *ekor* [animate: animal] exemplars and two pairs of *bentuk* [specific: ring/hook] versus *pasang* [pairs] exemplars, with an audio prompt of the respective numeral classifier name (i.e. *orang, ekor, bentuk,* or *pasang*).

Children were instructed to press the red dot (placed on the "z"-key of the laptop keyboard) with their left index finger if they thought the numeral classifier name they heard at the onset of the picture display was used to count the item with a red dot underneath it (see Figure 2). Alternatively, children pressed the green dot (placed on the "m"-key) with their right index finger if they thought the numeral classifier name they heard was used to count the item with a green dot beneath it. A feedback display page appeared after they had keyed in their response to indicate whether or not they had responded correctly (in blue font) or incorrectly (in red font). Only when the children had achieved 100% correct responses in the practice session could they proceed to the experimental session.

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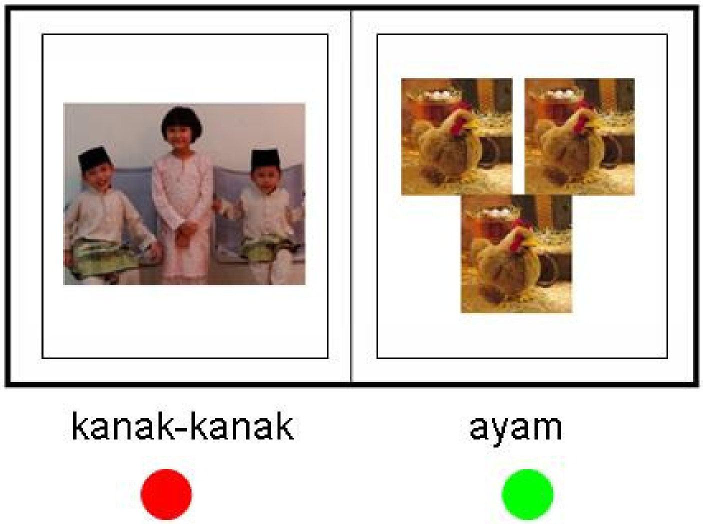

Figure 2: The picture-stimuli

The experimental trials

In the experimental session, the procedure was similar to the practice trial session, except that in the experimental session the feedback display page was not shown to the children. Once the children pressed either the red or the green dot, the *press the 'spacebar' key* page was displayed to indicate to the children that they could now proceed to the next item. Thus, the pace of the experiment was controlled by the children. The 64 trials for each contrast condition (32 trials for each contrast type) were presented in a random order unique for each child. The entire experiment lasted approximately 15 minutes for each child.

Results

Correct responses

In order to examine the effect of contrast type and typicality type on the mean number of correct responses produced by the children, an 8 (numeral classifier) X 2 (contrast type) X 2 (typicality type) X 4 (age group) X 2 (gender) repeated measures ANOVA with numeral classifier, contrast type (strong, weak), and typicality type (typical, atypical) as within-subjects factors, and age group (6-year-olds, 7-year-olds, 8-year-olds, 9-year-olds) and gender as between-subjects factors was conducted.

Mauchly's Test of Sphericity indicated that the assumption of sphericity for the following within-subjects effects was violated: numeral classifier ($\chi^2(27) = 49.17$, $p < .01$), numeral classifier X contrast type ($\chi^2(27) = 135.37$, $p < .001$), numeral classifiers X typicality type ($\chi^2(27) = 48.30$, $p < .01$), and numeral classifier X contrast type X typicality type ($\chi^2(27) = 57.33$, $p < .01$). As a result, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity. The assumption of sphericity for the other within-subjects effects, namely contrast type, typicality type, and contrast type X typicality type, were not violated.

There was a significant main effect of numeral classifier, $F(6.37, 866.06) = 41.14$, $p < .001$, partial $\eta^2 = .232$. The mean number of correct responses for strong contrast exemplars were significantly higher than for weak contrast exemplars, $F(1, 136) = 24.22$, $p < .001$, partial $\eta^2 = .151$. In addition, the mean number of correct responses for typical exemplars were higher than for atypical exemplars, $F(1, 136) = 144.95$, $p < .001$, partial $\eta^2 = .516$. There was a significant effect of age group, $F(3, 136) = 88.06$, $p < .001$, partial $\eta^2 = .660$. Tukey's post hoc analysis at $\alpha = .05$ showed that correct responses by the 6-year-olds were significantly lower than those of the 7-year-olds, which in turn were significantly lower than those of the 8- and 9-year-olds, which were not significantly different. Gender, however, was not significant, ($p = .87$). Furthermore, there was no interaction between contrast type and typicality type ($p = .08$).

However, there was a significant interaction between numeral classifier and contrast type, $F(5.59, 759.58) = 21.74$, $p < .001$, partial $\eta^2 = .138$. Paired samples *t*-tests revealed that the mean number of correct responses for strong contrast stimuli were significantly higher than for weak contrast stimuli for *biji* [3D: small] $t(143)=10.75$, $p < .001$, and *butir* [3D: fine] $t(143) = 3.32$, $p = .001$. The mean number of correct responses for strong contrast stimuli were significantly lower than weak contrast stimuli for *ketul* [3D: medium] $t(143)=-2.59$, $p < .05$, and there was no significant difference for the other numeral classifiers.

In addition, there was a significant interaction between numeral classifier and typicality type, $F(6.42, 898.12) = 21.90$, $p < .001$, partial $\eta^2 = .135$. Paired samples *t*-tests revealed that the mean number of correct responses for typical exemplars were significantly higher than for atypical exemplars for *batang* [1D: +rigid] $t(143) = 7.71$, $p < .001$, *utas* [1D: -rigid] $t(143) = 7.10$, $p < .001$, *keping* [2D: +rigid] $t(143) = 2.62$, $p = .001$, *buah* [3D: big] $t(143) = 2.93$, $p < .01$, *ketul* [3D: medium] $t(143) = 6.22$, $p < .001$, and *biji* [3D: small] $t(143)=12.48$, $p < .001$. The mean number of correct responses for the different typicality types was not significantly different for *helai* and *butir*.

There was also a significant interaction between numeral classifier, contrast type and typicality type, $F(6.31, 857.80) = 7.90$, $p < .001$, partial $\eta^2 = .055$. Paired samples *t*-tests revealed that the total mean number of correct responses corresponded to the following sequence: strong-typical > weak-typical > strong-atypical, weak-atypical.

Reaction times

To investigate if children's reaction times (RTs) for correct responses were faster in the strong contrast condition than in the weak contrast condition, a univariate ANOVA was conducted on the mean RT for each correct numeral classifier response, with contrast type (strong, weak) and typicality type (typical, atypical) as the fixed factors. The mean RTs for correct responses were significantly longer in the strong contrast condition in comparison to the weak contrast condition, $F(8, 319) = 4.80$, $p < .001$, partial $\eta^2 = .107$.

In addition, the mean RTs for typical exemplars were significantly shorter than for atypical exemplars, $F(8, 319) = 13.94$, $p < .001$, partial $\eta^2 = .259$.

Discussion and Conclusion

We predicted that categorisation of numeral classifier exemplars would be an easier task for children if the perceptual feature differences between exemplars of the two shape-based numeral classifiers were strong (two differences in dimensionality and rigidity, or dimensionality and size) rather than weak (one difference in either rigidity or size). Results from the current study in general support the prediction that children categorise objects more readily when there are strong rather than weak contrasts between exemplars of shape-based numeral classifiers. Results also reveal that typicality of exemplars plays a significant role in categorisation, as typical exemplars of numeral classifier categories were more readily categorised in comparison to atypical exemplars. This gives support to the notion that categorisation progresses from making broader distinctions to making finer distinctions. Evidence also indicates that typicality plays a prominent role in young children's categorisation, which gives support to prototype theory, that is, the idea that categorisation developmentally progresses from primarily categorising typical members to also including atypical members (Barsalou et al., 1998). These results agree with findings from previous categorisation studies (e.g., Hampton, 1998) and numeral classifier acquisition studies (e.g., Carpenter, 1991; Matsumoto, 1985; Uchida & Imai, 1999).

Interestingly, the significant response between the strong contrast and the weak contrast was only evident for *biji* [3D: small] and *butir* [3D: fine]. For the other classifiers i.e., *helai, batang, keping, utas, ketul,* and *buah*, children's correct responses were not significantly different in either the strong or weak contrast conditions possibly because children had better comprehension of the numeral classifiers in comparison to *biji* and *butir*. In Salehuddin and Winskel (2009b), *biji* and *butir* were the last two shape-based numeral classifiers to be comprehended by the children. Children's correct responses to *biji* and *butir* in the strong contrast condition were significantly higher than in the weak contrast condition probably due to the fact that they had not fully comprehended the underlying semantics of the numeral classifiers, and this is manifested in their performance on the atypical exemplars of the two numeral classifiers. Due to the fact that the number of perceptual feature differences have been found to influence the categorisation of objects in children (e.g., Markman & Maddox, 2003), for *biji* and *butir,* the correct responses for the strong contrast condition (two differences) were significantly higher than the number of correct responses for the weak contrast condition (one difference).

Intriguingly, children's RTs for exemplars with strong contrasts were significantly longer than those with weak contrasts. The longer RTs for exemplars in the strong contrast condition in comparison to those in the weak contrast condition could be due to the relative semantic complexity of exemplar pairs. For example, when presented with the audio-prompt *batang* [1D: +rigid] in the strong contrast condition, both dimensionality and rigidity of the two comparison exemplars had to be evaluated. However, when presented with the audio-prompt *batang* [1D: +rigid] in the weak contrast condition, only the rigidity of each exemplar needs to be evaluated. This is because in the weak contrast condition, the exemplars in the picture pair share similarity in one of the dimensions. An additional consideration is that according to Folstein, Van Petten, and Rose (2008, p. 477), participants in multifeatured-stimuli experiments are not likely to give their response before completing their stimulus evaluation because accuracy (more correct responses) is considered more important than speed, which can result in a longer RT.

However, typical exemplars in the strong contrast condition did not receive the highest mean number of correct responses from the children and neither did atypical exemplars in the weak contrast condition receive the lowest; hence, rejecting the final prediction made for this experiment (i.e., strong-typical > weak-typical > strong-atypical, weak-atypical). This suggests that contrast condition and typicality type operate independently in the categorisation process.

In the current study, we examined the categorisation strategies that children use to sort pictures of objects into shape-based numeral classifiers. In the Paired Discrimination Task, perceptual feature distinctions were shown to play a prominent role in categorisation. Children categorised objects more readily when there were strong (two perceptual feature differences) rather than weak (one perceptual feature difference) contrasts between the exemplars of shape-based numeral classifiers.

Children's knowledge of the semantics of numeral classifier categories becomes more developed and refined with age, "triggered by an actual exposure to such uses in the input" (Matsumoto, 1985, p. 84). Objects that are least frequently encountered by children are poorly recognised (Lederman, Klatzky, Chataway, & Summers, 1990), and are consequently categorised less accurately by young children (Matsumoto, 1985; Uchida & Imai, 1999). The acquisition of numeral classifiers depends not only on how much the child is exposed to actual use of the numeral classifiers, but also, how relevant the nouns used with the numeral classifiers are to the children (Hu, 1993). For example, in Malay, although *buah* is a frequently used numeral classifier (Salehuddin & Winskel, 2009a), children had difficulty in categorising 'robot' and 'planet' when the numeral classifier *buah* was presented to them possibly because both these items are not common objects in the Malay children's environment. Children continue to modify and refine the semantic representation of numeral classifiers based on input, through both implicit and explicit learning, until eventually they achieve an adult-like mental representation of the numeral classifier categories.

Categorisation of an object basically involves the retrieval and evaluation of stored information on related objects, and when there is a satisfactory resemblance between new and stored information then an object is accepted into the respective category (Barsalou et al., 1998). There is a high degree of variation in the ease with which objects are classified into numeral classifier categories; some objects are more readily categorised than others. Some objects can be placed into several different categories based on sometimes quite fine perceptual distinctions or if they are perceived from a different perspective. These difficulties are reflected in the results from the oldest children and adults, as they still occasionally made mistakes or varied in their categorisation responses. This indicates the "fuzziness" of category membership judgments and how some objects can acceptably be categorised into different numeral classifier categories dependent on interpretation of the rules associated with a given category or categories. An additional consideration in numeral classifier categorisation, is that there are distinct differences between numeral classifier categories in terms of how "well defined" the categories are, that is, to what degree its members adhere to the category criteria and share one or more features (Gao & Malt, 2009, p. 1136). In Malay, the commonly used shape-based numeral classifier *buah* is used to categorise rounded, big objects, which includes, for example, a human-like object such as a robot; so, *buah* is more heterogeneous in its membership. In contrast, the numeral classifiers *batang* and *helai* are considered narrower or more "well defined" categories, as members conform to a greater degree to the category criteria.

Mental representation of a classifier category develops based on both prototypical exemplars and on experience with different exemplars (typical and atypical members) of that particular category. This experience assists the child in developing a fuller representation of the numeral classifier categories (cf. Dopkins & Gleason, 1997). Categorisation within the Malay numeral classifier system involves building up a comprehensive knowledge of complex inherent semantic characteristics of the different numeral classifier categories. Accordingly, it takes an extended period of time for children to acquire.

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