Weakening the Trivalent Semantics of Quantifiers: Evidence from Mandarin Chinese

Yaxuan Wang Brian Buccola

1. Introduction

Presupposition is the phenomenon whereby speakers linguistically mark information as being taken for granted. One of the core properties of presuppositions is that they generally project out of a variety of embedding environments that cancel otherwise entailed content. However, intuitive judgments are less clear-cut when it comes to projection out of the nuclear scope of quantifiers. As shown in (1), the nuclear scope of the quantifier (the "λx [...]" structure in the Logical Form) triggers the presupposition that *x is lucky*. But when x is bound by a quantifier, what exactly does the whole sentence presuppose? Four dominant theories make different predictions, which we briefly describe below.

(1) Each/Some/None$_i$ of the students knows that he$_i$ is lucky.
LF: [Each/Some/None of the students] λx [x knows that x is lucky]

(i) Universal theories (e.g. Heim 1983) predict a default universal presupposition, *that each of the students is lucky*, for all quantifiers. This follows from the general admittance condition that a sentence S_p is admitted by the current conversation context C only if there exists a superset of the individuals in C satisfying the presupposition p in S_p. This condition applies incrementally to sentences of the form $[Qx : R(x)]S_p(x)$. The initial context C is first updated with the restrictor: $C + R(x)$. The nuclear scope is admissible in this updated context if and only if (abbreviated as *iff*) there exists a superset of the individuals satisfying the restrictor to satisfy the presupposition of the nuclear scope. Universal theories also have local accommodation as a remedy to derive existential presuppositions (*that at least one of the students is lucky*) for *some* and presuppositionless readings (*that none of the students is lucky*) for *none*.

(ii) Existential theories (e.g. Beaver 2001) argue that the universal presupposition is too strong and suggest that the nuclear scope is admissible in the updated context iff there is a set of individuals such that at least one satisfies both the restrictor and the presupposition of the nuclear scope. Thus, they predict a default existential presupposition for all quantifiers.

(iii) Similarity Theory (Chemla 2009b) assumes that a presupposition trigger S_p raises two sets of similar alternatives: one is presupposition p and tautology $\top$, and the other is $\neg p$ and contradiction $\bot$. They form a scale of items linearly ordered by logical strength, $\langle \top, p, S_p, \neg p, \bot \rangle$. The Weak Similarity principle (WS) states that two propositions ϕ and ψ are *epistemically similar* if the speaker believes one to be true iff she believes the other one to be true as well, schematically, $B_s[\phi] \leftrightarrow B_s[\psi]$. WS can be supplemented with contextual assumptions about the speaker's state of knowledge. For *each*, only universal presupposition is predicted, which is derived from the application of WS to the set of alternatives $\{p, \top\}$: $B_s[\forall x : p(x)] \leftrightarrow B_s[\forall x : \top]$. Since no other inference predicted is stronger than this universal presupposition, this is the overall prediction. For *some*, the default presupposition is an existential one, based also on $\{p, \top\}$: $B_s[\exists x : p(x)] \leftrightarrow B_s[\exists x : \top]$. As this is not the strongest, a stronger one is derived based on $\{\neg p, \bot\}$: $B_s[\exists x : \neg p(x)] \leftrightarrow B_s[\exists x : \bot]$, yielding $\neg B_s[\exists x : \neg p(x)]$, which is further strengthened to $B_s[\forall x : p(x)]$. The quantifier *no(ne)* is predicted to have a default universal presupposition based on $\{\neg p, \bot\}$: $B_s[\text{No } x : \neg p(x)] \leftrightarrow B_s[\text{No } x : \bot]$, i.e., $B_s[\text{No } x : \neg p(x)] \leftrightarrow B_s[\top]$, yielding $B_s[\text{No } x : \neg p(x)]$, i.e., $B_s[\forall x : p(x)]$.

(iv) Trivalent Logic Theory (e.g. Fox 2013) assumes that quantified sentences $[\![Q]\!](R)(\lambda x.N(x)_{p(x)})$ denote one of three truth values: truth (1), falsity (0), or the third value (#). Stalnaker's Bridge Principle (Stalnaker 2002) states that a sentence S can be felicitously used in a context set C only if $\forall w \in$

* Yaxuan Wang, Michigan State University, wangyax3@msu.edu. Brian Buccola, Michigan State University, buccola@msu.edu. We would like to thank Alan Beretta, Karthik Durvasula, Alan Ke, Alan Munn, and the audiences at WCCFL 41 for insightful feedback.

	each	*some*	*none*
Existential Theories	$\exists_d$	$\exists_d$	$\exists_d$
Universal Theories	$\forall_d$	$\forall_d/\exists_{\text{weak triggers}}$	$\forall_d/\text{pspless}_{\text{weak triggers}}$
Similarity Theory	$\forall_d$	$\exists_d/\forall_{\text{strengthened}}$	$\forall_d$
Trivalent Logic	$\forall_d$	$\exists_d/\forall_{\text{strengthened}}$	$\forall/\text{pspless}$

Table 1: Predictions made by different theories. The subscript "weak triggers" means this reading is predicted to be available only for sentences with weak triggers. "d" refers to the default reading.

$C, [\![S]\!](w) \neq \#$. Therefore, the presupposition for quantified statements is the disjunction of the truth (1) and falsity (0) conditions. For *each*, a universal presupposition is derived, $\forall x \in R : p(x) \wedge N(x)$, while for *some* and *none*, a disjunctive presupposition is derived, $[\forall x \in R : p(x)] \vee [\exists x \in R : p(x) \wedge N(x)]$. It is assumed that the disjunctive presupposition is pragmatically marked and triggers one of two repair strategies, either the Assertion Operator (A-operator) or Pragmatic Strengthening. For speakers adopting the A-operator, *some* has existential presuppositions, and *none* has universal presuppositions or presuppositionless readings. Those who resort to Pragmatic Strengthening are predicted to always obtain universal presuppositions for all quantifiers. These two mechanisms will be explained in detail in Section 3. Table 1 summarizes all the predictions just described.

Previous experimental studies suggest that presupposition projection out of quantified statements is not a uniform phenomenon. Generally, universal presupposition projects from the scope of the universal quantifier, and existential presupposition projects from the scope of the existential quantifier. Both universal and existential presupposition can project from the negative quantifier, with presuppositionless readings available as well. However, no study that we are aware of tests the predictions of all four theories. For example, Chemla's (2009a) experiment in French only considers weak triggers and excludes the possible presuppositionless inference from the analysis; Tiemann's (2014) study in German and Creemers et al.'s (2018) study in English do not include the quantifier *none*, while Zehr et al.'s (2016) study in English only focuses on *none*, and with only one trigger; and neither Sudo et al.'s (2012) study in English nor Geurts & van Tiel's (2016) study in English differentiates the non-universal inferences. In addition, to our knowledge, only European languages have been experimentally investigated, and with some exceptions (e.g. Sudo et al. 2012), inter-speaker variation has generally not been considered. The experiment presented in the next section is designed to investigate the existence of all three of the readings (i.e. universal, existential, presuppositionless) for all three quantifier types (*each*, *some*, *none*) and their interaction with trigger types (strong vs. weak) in Mandarin Chinese, while also considering inter-speaker variation in the analysis.

2. Current experiment

All experimental materials, including the experiment stimuli, raw data, and the code for analysis, are available at `https://doi.org/10.17605/OSF.IO/XG3ED`.

2.1. Design and methods

Three quantifiers, *meige* 'each', *youde* 'some', and *meiyou* 'none', and four triggers, *houhui* 'regret', *zaici* 'again', *yishidao* 'realize', and the possessive pronoun *zijide* 'self', were included in the study, of which *regret* and *again* are strong triggers, and *realize* and *self* are weak triggers. The stimuli design was adapted from Tiemann (2014). Each trial began with a context story description, and each story had three variants that entail universal, existential, and presuppositionless readings, respectively. As shown by an example translated into English in (2), all the context descriptions began with a sentence introducing three people who shared a common property, such as they are all primary school students. The following sentences then specified another property, like being late for school, which was true for all the three people, only for two people, or for no one. There were 12 (3×4) different combinations of context types and triggers. For each combination, two different stories were created, making 24 (2×12) target trials

total. After the context, three separate target sentences of the form $[Qx : R(x)]S_{p(x)}$ were presented, as shown in (3). The partitive construction was used to avoid the potential effect of domain restriction. Participants were asked to judge the naturalness of each sentence under the context in question on a scale from 1 to 7, with 1 representing extremely unnatural and 7 very natural. In addition, 12 (4×3) fillers were created. The fillers were of the same form as that of the stimuli, except that quantifiers were substituted by proper names in the three target sentences. All in all, each participant was presented with 36 trials and was asked to judge the naturalness of 108 (36×3) sentences. The trials were pseudo-randomized so that the same combination of context story and trigger never appeared in succession. In each trial, the three target sentences were also randomized. The baseline condition in the current experiment is the rating scores of *each* sentences. The scores of *each* sentences obtained in existential and presuppositionless contexts represent extremely unnatural, while those obtained in universal contexts represent very natural. Scores of other conditions were compared to these baselines.

(2) a. *Universal context:* Tom, Jack, and Harry are primary school students. This morning, Tom and Jack missed the school bus. They were late to the first class. Harry got up too late to catch the first class.

b. *Existential context:* Tom, Jack, and Harry are primary school students. This morning, Tom and Jack missed the school bus so they were late for the first class. Harry got up early and arrived at school on time.

c. *Presuppositionless context:* Tom, Jack, and Harry are primary school students. This morning, Tom and Jack took the school bus, and Harry rode his bicycle to school. They arrived at school on time.

(3) zhe san ge nanhai zhong, {meige/youde/meiyou} ren houhui ziji chidao.
the three CL boy among {each/some/none} person regret self being-late
'Among the three boys, {each/some/none} regretted being late.'

2.2. Participants

60 native speakers of Mandarin Chinese participated in the study. 6 were recruited on Prolific. 54 were recruited from Michigan State University and Peking University. Each participant was paid $4 USD for their participation. The task took approximately 15–20 minutes. 7 participants were excluded from the analyses because they had completely opposite ratings for the filler items, which indicates they did not understand the task, were not paying attention, or were not trying to complete the task in earnest.

2.3. Data analysis

One of the trials in the *Universal context + Regret* condition and in the *Presuppositionless context + Realize* condition was removed from the analyses because the pseudo-randomization operation accidentally put the two trials at the very beginning of the survey for all participants, which caused a significant difference in rating between the two context stories for the same condition.

The overall results were analyzed as 3×3×2 factorial robust ANOVAs in R (version 3.6.2) using the *ezANOVA* function of the *ez* package. Post hoc Tukey's tests were conducted for factors with significant effects using the *pairwise.t.test* function. Bonferroni corrections were applied to the function as well. Moreover, to explore the individual variation, line graphs with 95% CI error bars were drawn by the *ggplot2* package in R. Based on the patterns shown in the graphs, participants were further classified into different groups. 3×3×2 factorial robust ANOVAs and Post hoc Tukey's tests were also conducted to analyze each group. The percentage of each group was calculated as well.

2.4. Results

The results of the 3×3×2 factorial robust ANOVA for the overall data collected from 53 participants show a significant main effect of context type (*universal*, *existential*, *presuppositionless*) with a large effect

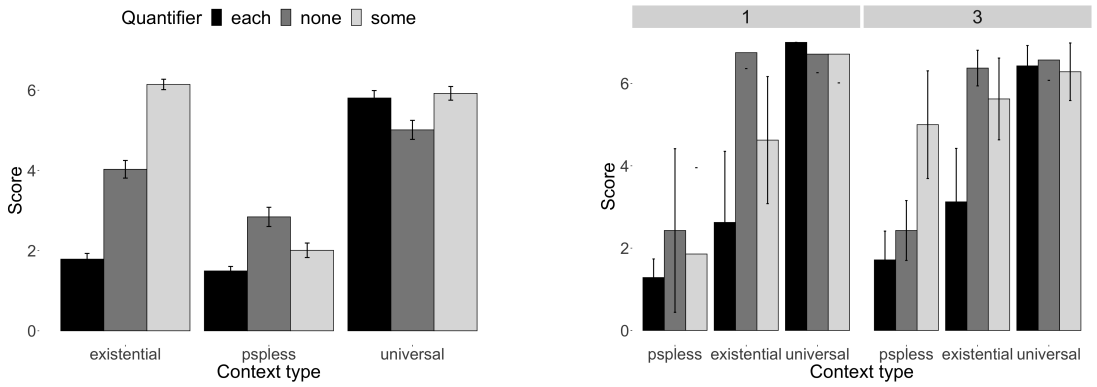

Figure 1: Naturalness scores of sentences. Left: overall participants. Right: participant no. 1 & no. 3

size, $F(2, 936) = 515.59$, $p < .001$, $\eta_p^2 = .40$; a significant main effect of sentence type (*each*, *some*, *none*) with a medium effect size, $F(2, 936) = 118.45$, $p < .001$, $\eta_p^2 = .09$; and a significant interaction effect between context type and sentence type with a large effect, $F(4, 936) = 95.68$, $p < .001$, $\eta_p^2 = .15$. Although the interaction of *Context Type* × *Sentence Type* × *Trigger Type* was also found to be statistically significant, $F(4, 936) = 2.63$, $p = .03$, since its effect size is extremely small, $\eta_p^2 = .00$ and the post hoc Tukey's tests show no significant difference between trigger types once the other two factors were controlled, we conclude that the ANOVA analysis for the overall data indicates that trigger type does not influence participants' judgment towards the target sentences.

The results of Tukey post hoc pairwise comparisons between different combinations of context types and sentence types are shown in Figure 1: Left. It exhibits a nonsignificant difference between existential and presuppositionless contexts for *each* sentences, which conforms to our prediction for the baseline assumption. The results further reveal that a significant difference was not found between *some* sentences and *each* sentences in universal contexts nor between existential contexts and universal contexts for *some* sentences. Except for the aforementioned pairs, all other condition pairs show significant distinctions from each other.

By calculating the mean and the variability of the responses of each participant (see example in Figure 1: Right), two dominant patterns of presupposition projection were identified (Figure 2: Left). Specifically, for 51% (27 out of 53) participants, *none* sentences have a similar presupposition projection pattern to *some* sentences. The three types of quantified target sentences only significantly differ in existential contexts, with *each* sentences extremely unnatural, *some* sentences very natural, and *none* sentences fairly natural. The results of the ANOVA analysis indicate that speakers with this inference pattern do not differentiate trigger types, as neither the main effect nor the interaction effects involving the trigger type factor were statistically significant.

By contrast, for 49% (26 out of 53) participants, the ratings for *some* sentences and for *each* sentences pattern with that of the first group, but the results of the naturalness of uttering *none* sentences in the three types of contexts do not significantly differ from each other. *None* sentences in any contexts were rated as fairly natural. The ANOVA test identified a significant interaction effect among all three factors, namely, *Context Type* × *Sentence Type* × *Trigger Type*. Therefore, a post hoc Tukey's test was performed, and the results are illustrated in Figure 2: Right. It shows that in presuppositionless contexts, *none* sentences with a weak trigger are significantly more natural than those with a strong trigger, $p = .01$, $\Delta\text{Mean} = 1.53$ (95% CI = $[-.15, 3.21]$). Except for that, no other significant pairwise differences were found. In addition, no significant difference was found within each trigger type, i.e., the difference between the *none*-presuppositionless context-*another* condition and the *none*-presuppositionless context-*regret* condition is not significant, $p = 1.00$; the difference between the *none*-presuppositionless context-*self* condition and the *none*-presuppositionless context-*realize* condition is not significant, either, $p = 1.00$.

Table 2 summarizes the results. Overall, the analysis finds two dominant patterns among Mandarin Chinese speakers. In the first, *each* sentences only have universal presuppositions, while *some* and *none* sentences both have existential presuppositions. Trigger type does not exert any effect on projection

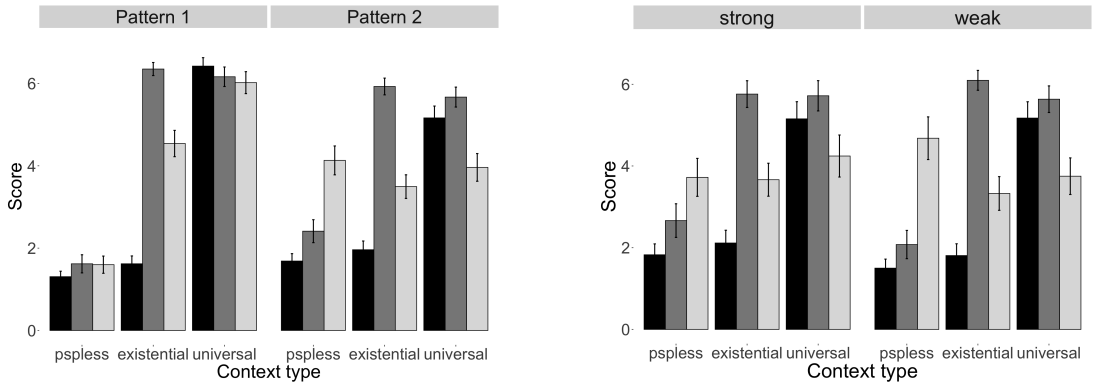

Figure 2: Naturalness scores of sentences. Left: 2 patterns of participants. Right: strong vs. weak triggers

	each	*some*	*none*
Pattern 1	∀	∃	∃
Pattern 2	∀	∃	∃/pspless$_{\textbf{bias}}$ for weak triggers

Table 2: Summary of the results

behavior. In the second pattern, *each* sentences only have universal presuppositions, and *some* sentences have existential presuppositions, while *none* sentences have either existential presuppositions or presuppositionless readings. There is also a trigger type effect: in presuppositionless contexts, *none* sentences with a weak trigger are significantly more natural than those with a strong trigger. However, the results based on data pooled from all subjects do not show any effect of trigger type on participants' judgments towards target sentences.

3. Discussion

Empirically, the current results are generally consistent with previous experimental studies. The new findings are that (i) a trigger type effect is attested once an individual variation factor is taken into consideration; (ii) existential presuppositions are highly available from *none* sentences (pace Chemla 2009a); and (iii) no participant showed a pattern in which universal presuppositions projected from all types of quantifiers (pace Sudo et al. 2012).

Theoretically, none of the four dominant theories straightforwardly accounts for our data. Specifically, Universal Theories and the Similarity Theory fail to predict the existential presuppositions projected out of the quantifier *none*. Universal Theories wrongly predict the default presupposition projected from the quantifier *some* to be a universal rather than an existential one, while Existential Theories wrongly expect the default presupposition projected from the quantifier *each* to be an existential instead of a universal one. In addition, neither Existential Theories nor the Similarity Theory has a mechanism to derive presuppositionless readings for the *none* sentences for the second group of speakers. Lastly, no evidence in the current study supports the prediction of the Trivalent Logic Theory that there is a group of speakers who always strengthen the existential presuppositions of *some*.

Nevertheless, we propose to modify the Trivalent Logic Theory for two reasons. First, the predictions made by the Trivalent Logic Theory best match with the current results. Second, consider that Milsark (1977) classifies weak and strong quantifiers based on their acceptability in existential sentences. As the following *there*-insertion existential sentence tests show, if we make the assumption that weak quantifiers are permissible types whereas strong ones are always prohibited types, *each* is strong (4a), while *no(ne)* and *some* are weak (4b-c). This classification forms an argument against all the theories which treat *no(ne)*, a weak quantifier, as patterning with the strong universal quantifier rather than with the weak *some*. But among the theories, only Trivalent Logic Theory succeeds in predicting such a pattern.

(4) a. *There was each student in the room.

b. There was no student in the room.

c. There were some students in the room.

In the original Trivalent Logic account, quantified sentences include a universal statement in the truth and falsity conditions. However, to account for the current results, we propose that this statement is merely existential, not universal, as underlined in (5–7). (For simplicity, we give just the extensional versions of denotations here.)

$$(5)\quad [\![\text{each}]\!](R)(N) = \begin{cases} 1 \text{ if } \underline{\exists x}[R(x) = 1 \wedge N(x) \neq \#] \wedge \forall x[R(x) = 1 \rightarrow N(x) = 1] \\ 0 \text{ if } \underline{\exists x}[R(x) = 1 \wedge N(x) \neq \#] \wedge \exists x[R(x) = 1 \wedge N(x) = 0] \\ \# \text{ otherwise} \end{cases}$$

$$(6)\quad [\![\text{some}]\!](R)(N) = \begin{cases} 1 \text{ if } \underline{\exists x}[R(x) = 1 \wedge N(x) = 1] \\ 0 \text{ if } \underline{\exists x}[R(x) = 1 \wedge N(x) \neq \#] \wedge \neg\exists x[R(x) = 1 \wedge N(x) = 1] \\ \# \text{ otherwise} \end{cases}$$

$$(7)\quad [\![\text{none}]\!](R)(N) = \begin{cases} 1 \text{ if } [\![\text{some}]\!](R)(N) = 0 \\ 0 \text{ if } [\![\text{some}]\!](R)(N) = 1 \\ \# \text{ otherwise} \end{cases}$$

Following Stalnaker's Bridge Principle, the presupposition of a quantified statement is the disjunction of the truth and falsity conditions. Thus, the presupposition of *each* sentences is $[\forall x[R(x) = 1 \rightarrow N(x) = 1] \vee \exists x[R(x) = 1 \wedge N(x) = 0]] \wedge \exists x[R(x) = 1 \wedge N(x) \neq \#]$, which, assuming that the restrictor R is nonempty, reduces to $\forall x[R(x) = 1 \rightarrow N(x) = 1] \vee \exists x[R(x) = 1 \wedge N(x) = 0]$, a disjunctive presupposition. By contrast, the presupposition of *some* and *none* sentences is predicted to be the same disjunction $\exists x[R(x) = 1 \wedge N(x) = 1] \vee [\exists x[R(x) = 1 \wedge N(x) \neq \#] \wedge \neg\exists x[R(x) = 1 \wedge N(x) = 1]]$, which reduces to $\exists x[R(x) = 1 \wedge N(x) \neq \#]$. Therefore, an existential presupposition is predicted to be the default one.

Following Fox (2013), we also take the A-operator as an additional repair mechanism. The semantics of the A-operator is repeated below:

$$(8)\quad [\![\text{A}]\!] = \lambda q \begin{cases} 1 \text{ if } q = 1 \\ 0 \text{ if } q = 0 \text{ or } q = \# \end{cases}$$

For *each* sentences, when the quantifier is above A, $[\![\text{each}]\!](R)(\lambda x.[\![\text{A}]\!](N(x)_{p(x)}))$, the sentence is true iff $\forall x[R(x) = 1 \rightarrow (N(x) = 1 \wedge p(x) = 1)]$, which entails $\forall x[R(x) = 1 \rightarrow p(x) = 1]$, a universal reading. Likewise, when A is above the quantifier, $[\![\text{A}]\!]([\![\text{each}]\!](R)(\lambda x.N(x)_{p(x)}))$, the sentence has the same truth conditions, entailing the same universal reading. For *some* sentences, when the quantifier is above A, $[\![\text{some}]\!](R)(\lambda x.[\![\text{A}]\!](N(x)_{p(x)}))$, the sentence is true iff $\exists x[R(x) = 1 \wedge (N(x) = 1 \wedge p(x) = 1)]$, which entails $\exists x[R(x) = 1 \wedge p(x) = 1]$, an existential reading. Likewise, when A is above the quantifier, $[\![\text{A}]\!]([\![\text{each}]\!](R)(\lambda x.N(x)_{p(x)}))$, the sentence has the same truth conditions, entailing the same existential reading. For *none* sentences, when the quantifier is above A, $[\![\text{none}]\!](R)(\lambda x.[\![\text{A}]\!](N(x)_{p(x)}))$, the sentence is true iff $\neg\exists x[R(x) = 1 \wedge (N(x) = 1 \wedge p(x) = 1)]$, which entails $\neg\exists x[R(x) = 1 \wedge p(x) = 1]$, a presuppositionless reading. Conversely, when A is above the quantifier, $[\![\text{A}]\!]([\![\text{none}]\!](R)(\lambda x.N(x)_{p(x)}))$, the sentence is true iff $\exists x[R(x) = 1 \wedge N(x) \neq \#] \wedge \neg\exists x[R(x) = 1 \wedge (N(x) = 1 \wedge p(x) = 1)]$, entailing an existential reading, $\exists x[R(x) = 1 \wedge p(x) = 1]$.

We assume that the A-operator does not select particular quantifiers; instead, it can apply to any type of quantifier. But the application of the A-operator has two triggering sources. The first trigger is the one assumed by Sudo et al. (2012) and Fox (2013), namely, the pragmatically marked disjunctive presupposition. The second trigger is the previous context in which comprehenders find it does not entail the presupposition encoded in the current target utterance.

Since *each* sentences have a disjunctive presupposition, the A-operator always applies to them and only universal presupposition is derived no matter what. That is why all the participants gave high naturalness scores to *each* sentences only when these sentences appear after universal contexts. But for *some* and *none* sentences, as their default presupposition is an existential rather than a disjunctive one, the application of the A-operator to them is only triggered when comprehenders find that the context does not satisfy the existential presupposition, which is the presuppositionless context. The A-operator applied to *some* sentences still yields existential presupposition readings, which explains why all the speakers gave low naturalness scores to *some* sentences only when they saw them in presuppositionless contexts. By contrast, the A-operator applied to the nuclear scope of *none* sentences yields presuppositionless readings, which makes sentences much more natural to utter in presuppositionless contexts. However, because inserting the A-operator into the nuclear scope is generally considered as local accommodation, which is a last resort strategy, a natural outcome of it is that some speakers may resist or not have access to the local accommodation at all. Therefore, only those who readily access the A-operator in the nuclear scope derive the presuppositionless readings for *none* sentences, which is exactly what we observed in the second inference pattern. In addition, under local accommodation, the assumption is that presuppositions triggered by weak items are easier to accommodate than those of strong triggers; thus, people who can readily apply the A-operator in the nuclear scope should feel it less natural to utter *none* sentences with strong triggers in presuppositionless contexts. This is also attested by the current results.

In Fox's (2013) proposal, a mechanism of Pragmatic Strengthening is proposed, which relies on the assumption the nuclear scope of a quantified sentence is subscripted with the presupposition that it triggers and that this subscript is "real". As a consequence of this assumption, together with the mechanism of Pragmatic Strengthening, "the universal inference turns out to be a potential strengthening of all simple quantificational sentences". However, no participant in our study showed a pattern in which universal presuppositions projected from all types of quantifiers. (This result is actually more or less compatible with Sudo et al.'s (2012), in that they only found 10% of participants deriving such a pattern, as compared to the other pattern observed by 95% of their participants.) Under our modified Trivalent Logic account, both *some* and *none* sentences only get existential presuppositions, thus capturing participants' judgments on such sentences. The Pragmatic Strengthening mechanism thus becomes redundant under the current account, which thereby also avoids the mysterious status of the subscripting of presuppositions.

We would also like to point out that although it is widely agreed that strong triggers resist local accommodation, the current results display a significantly higher naturalness score for *none* sentences with strong triggers in presuppositionless contexts than that for *each* and *some* sentences in the second group. This may suggest that it is not impossible for strong triggers to reconcile with local accommodation. Strong triggers do allow, but just disprefer, local accommodation as compared to weak triggers.

Finally, we mention here one limitation of our proposal. In Fox's (2013) account, the trivalent denotations of quantifiers are derived from their classical bivalent denotations through the application of a general recipe based on Strong Kleene logic (cf. George 2008). Here, we have merely stipulated that the universal statement included in all quantifiers' denotations under Fox's account is actually existential. In future research, we hope to investigate how to achieve this outcome with a similar general recipe.

4. Conclusion

This study adopted a naturalness judgment paradigm to investigate presupposition projection from the scope of three types of quantifiers (*each*, *some*, and *none*) in Mandarin Chinese. The results are generally consistent with previous studies, with new findings that (i) a trigger type effect is attested once individual variation is taken into consideration; (ii) existential presuppositions are highly available from *none* sentences (pace Chemla 2009a); (iii) no participant showed a pattern in which universal presuppositions projected from all types of quantifiers (pace Sudo et al. 2012).

None of the major theories proposed so far, namely, Universal Theories in Dynamic Semantics, Existential Theories in Dynamic Semantics, Similarity Theory, or Trivalent Logic Theory, is sufficient to account for the data. We proposed a modification of the Trivalent Logic Theory that weakens the truth and falsity conditions of quantified statement meanings. We adopted the A-operator as an additional repair mechanism but eliminated the Pragmatic Strengthening strategy as redundant under the current account. We argued that, in addition to the default disjunctive presupposition, unsatisfiable global contexts can

also serve as a trigger for the application of the A-operator in the nuclear scope. We further suggested that there are generally two types of Mandarin Chinese speakers: one type of speaker never uses the A-operator in the nuclear scope, and the other type always uses the A-operator in the nuclear scope. Moreover, the availability of the A-operator in the nuclear scope is affected by trigger types, with presuppositions from weak triggers easier to accommodate than from strong triggers. The modified version of Trivalent Logic Theory was shown to account for the current results.

Zooming out to the larger picture, first, this study lends support to the trivalent logic approach and the assumption that presuppositions can be collapsed with truth conditions. Second, the lexical meaning of quantifiers on the presupposition level should be an existential rather than a universal one, independent of the quantifier's type. Third, our account gives an explicit answer to the ongoing debate about whether a special mechanism for quantified presupposition strengthening is needed, which is no (pace Fox 2013). Fourth, the current results suggest that the strong vs. weak trigger distinction is just a relative notion in that both types of triggers accept local accommodation; strong triggers merely disprefer it as compared to weak triggers. Lastly, our study in Mandarin Chinese extends the empirical landscape of quantified presupposition projection by investigating a non-European language. It would be interesting to see future works investigating a wider range of triggers and quantifiers in other unexplored languages.

References

Beaver, David. 2001. *Presupposition and assertion in dynamic semantics*. CSLI.

Chemla, Emmanuel. 2009a. Presuppositions of quantified sentences: Experimental data. *Natural Language Semantics* 17. 299–340. https://doi.org/10.1007/s11050-009-9043-9.

Chemla, Emmanuel. 2009b. Similarity: Towards a unified account of scalar implicatures, free choice permission and presupposition projection. Unpublished manuscript. https://semanticsarchive.net/Archive/WI1ZTU3N/Chemla-SIandPres.html.

Creemers, Ava, Jérémy Zehr & Florian Schwarz. 2018. Interpreting presuppositions in the scope of quantifiers: *Every* vs. *at least one*. In *Sinn und Bedeutung*, vol. 22, 331–348. https://ojs.ub.uni-konstanz.de/sub/index.php/sub/article/view/94.

Fox, Danny. 2013. Presupposition projection from quantificational sentences: Trivalence, local accommodation, and presupposition strengthening. In *From grammar to meaning: The spontaneous logicality of language*. Cambridge University Press. https://doi.org/10.1017/cbo9781139519328.011.

George, B. R. 2008. Predicting presupposition projection: Some alternatives in the Strong Kleene tradition. Unpublished manuscript. https://semanticsarchive.net/Archive/DY0YTgxN/.

Geurts, Bart & Bob van Tiel. 2016. When "all the five circles" are four: New exercises in domain restriction. *Topoi* 35. 109–122. https://doi.org/10.1007/s11245-014-9293-0.

Heim, Irene. 1983. On the projection problem for presuppositions. In *West coast conference on formal linguistics*, vol. 2, 114–126.

Milsark, Gary. 1977. Toward an explanation of certain peculiarities of the existential construction in English. *Linguistic Analysis*. 1–29.

Stalnaker, Robert. 2002. Common ground. *Linguistics and philosophy* 25(5/6). 701–721. https://doi.org/10.1023/A:1020867916902.

Sudo, Yasutada, Jacopo Romoli, Martin Hackl & Danny Fox. 2012. Presupposition projection out of quantified sentences: Strengthening, local accommodation and inter-speaker variation. In *Amsterdam colloquium*, vol. 18, 210–219. https://doi.org/10.1007/978-3-642-31482-7_22.

Tiemann, Sonja. 2014. *The processing of 'wieder' ('again') and other presupposition triggers*. Universität Tübingen phd. http://hdl.handle.net/10900/57169.

Zehr, Jérémy, Cory Bill, Lyn Tieu, Jacopo Romoli & Florian Schwarz. 2016. Presupposition projection from the scope of *none*: Universal, existential, or both? In *Semantics and linguistic theory*, vol. 26, 754–774. https://doi.org/10.3765/salt.v26i0.3837.