Testing theories of SDA via acquisition

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Abstract

The aim of this study is to examine how children and adults interpret indicative and counterfactual conditionals with disjunctive antecedents, such as "if A or B, C". Disjunctive antecedent conditionals (DACs) are associated with a debated inference known as the *simplification of disjunctive antecedents* (SDA), where a DAC is interpreted as equivalent to the conjunction of its *simplifications*: "if A, C" and "if B, C".

To explore this, we administered a picture-supported Truth Value Judgment Task to 140 children (aged 5;0–9;11) and 28 adults. Participants were asked to evaluate the truth or falsity of 16 DACs in both indicative and counterfactual mode, with position effects controlled (e.g., testing both "if A or B" and "if B or A"). Our results reveal that the SDA interpretation emerges as early as age 5. Moreover, a growing preference for the SDA interpretation is associated with a decreasing tendency to adopt an alternative interpretation, in which a DAC is analyzed as the disjunction of the two simplifications.

1 Introduction

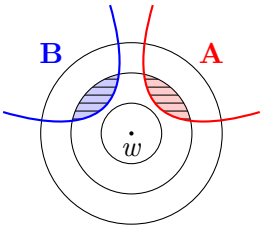
The present study examines *disjunctive antecedent conditionals* (henceforth, DACs), which are conditionals of the form "If A or B, C". These structures are commonly interpreted as equivalent to the conjunction of their *simplifications*, "If A, C" and "If B, C". This interpretation is known as *SDA interpretation*, which stands for *simplification of disjunctive antecedents*. Consider the following example:

(1) a. If it had rained or snowed, the hike would have been cancelled.
b. If it had rained, the hike would have been cancelled, **and** if it had snowed, the hike would have been cancelled.

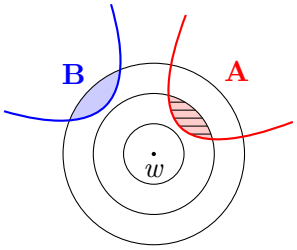
Sentence (1-a) intuitively implies both "if it had rained, the hike would have been cancelled" and "if it had snowed, the hike would have been cancelled", as expressed in (1-b). However, this intuition stands in contrast to the predictions of the classical framework for counterfactuals, known as *Minimal Change Semantics* (Lewis, 1973). This framework introduces a key parameter in the evaluation of counterfactual conditionals: *comparative similarity*. Given an evaluation world w, this parameter ranks possible worlds according to their similarity to w.

Assuming that an A-world is a world in which the proposition A is true and the set $\min_w(\mathsf{A})$ is a subset of the set of A-worlds which differ minimally from w, a counterfactual conditional statement "if A, C" is judged true at w only if all closest A-worlds are also worlds where the consequent C holds. For a DAC such as "if A or B, C", this framework yields different interpretations depending on the configuration of the two disjuncts:

- If the closest A-worlds and B-worlds are equally realistic relative to w, the SDA interpretation is predicted, as we consider some A-worlds and some B-worlds and require that C holds in both (as in Figure 1a). The red area represents the closest A-worlds ($\min_w(\mathsf{A})$) relative to w, and the blue area the closest B-worlds ($\min_w(\mathsf{B})$). The regions with horizontal lined patterns depict the worlds that are closest to w within the union $\mathsf{A} \cup \mathsf{B}$.
- Conversely, if, for instance, A-worlds are considered more realistic than B-worlds, the selection function driven by comparative similarity will favor A-worlds, disregarding B-worlds. Thus, the evaluation reduces to assessing "if A, C", as B-worlds are not considered (as illustrated in Figure 1b). We will refer to this interpretation as the *asymmetric reading* (AR).



(a) Case 1



(b) Case 2

Figure 1

Nevertheless, even when judging (1-a) with respect to an evaluation world set in summer and assuming that we enjoy hiking even when it rains but that snow is too dangerous, it appears that we are considering both disjunct worlds despite the fact that snow-worlds are typically perceived as less realistic than rain-worlds during this season.

To explain the robustness of SDA, a number of accounts have been proposed. Semantic accounts, pioneered by Alonso-Ovalle (2009) (also Ciardelli, 2016; Ciardelli et al., 2018; Santorio, 2018; Khoo, 2018; Cariani and Goldstein, 2020), exploit the idea that a disjunctive antecedent "if A or B" is associated with a set of two propositions, $\{|\mathsf{A}|, |\mathsf{B}|\}$ (a result obtained using *alternative*, *inquisitive*, or *truth-maker semantics*), and that the truth of the conditional requires the consequent to follow on the supposition of each proposition in the set. To this, some accounts (Santorio, 2018; Cariani and Goldstein, 2020) add an assumption of *homogeneity*: when the antecedent is associated with multiple propositions, the conditional is *true* if all of them imply the truth of the consequent, *false* if all of them imply the falsity of the consequent, and lacks a truth-value in mixed cases. A different, pragmatic account (Bar-Lev and Fox, 2020) views SDA as an implicature, arising through a grammatically encoded, non-Gricean exhaustification process. Further, most authors regard SDA as connected to the phenomenon of *free-choice inferences*, whereby from "you may A or B" one infers both "you may A" and "you may B". In this case, too, the inference is not predicted by standard modal semantics, and the same ideas discussed above have been invoked to explain it. As our discussion indicates, the question about the nature and source of SDA is tied to some important theoretical debates in semantics: SDA is taken by some to motivate a refinement of intensional semantics, by others to provide evidence for a particular kind of non-Gricean strengthening recipe. To shed light on this key question, we conducted an empirical study.

2 Experiment

2.1 Research questions

We now present the empirical questions addressed in our study and discuss their implications for the theoretical debate.

1. *At what age does SDA first arise?*
   Recent experimental works (Zhou et al., 2013; Tieu, Romoli, et al., 2015; Huang and Crain, 2019) have found that 5-year-old children can compute free-choice inferences. If SDA and free-choice are manifestations of the same phenomenon, as widely assumed, we would expect the SDA interpretation to emerge early as well.

2. *Do children shift from AR to SDA as they grow?*
   According to Bar-Lev and Fox 2020, SDA results from the pragmatic strengthening of a sentence whose literal meaning follows the Lewisian AR.

   If the relevant strengthening mechanism is not yet universally acquired at age 5, we expect to see some proportion of AR readings in younger children, decreasing with age in favor of an SDA interpretation. While the absence of such a trend would not necessarily be evidence against the account of Bar-Lev and Fox, it would imply that the pragmatic abilities involved in deriving SDA are universally present in children already at age 5.

3. *Do children shift from a Disjunctive Conditional Reading (DCR) to SDA?*
   According to Santorio (2018) and Cariani and Goldstein (2020), DACs involve a homogeneous quantification over the alternatives introduced by the disjunction, similar to the one commonly associated with plural definites (Löbner, 2000; Križ, 2019). Recent experimental work (Tieu, Križ, et al., 2019) has shown that a notable number of younger children display an existential reading of plural definites, which shifts to a universal reading with age. If DACs involve homogeneity, we may expect a similar developmental pattern: younger children might exhibit an existential reading of DACs, accepting them when *some* disjunct implies the consequent. This interpretation, called the *disjunctive conditional reading* (DCR), treats DACs as the *disjunction* of their simplifications. Over time, this reading may give way to a universal interpretation, equivalent to SDA, where *every* disjunct implies the consequent. This shift is not predicted by other accounts.

4. *Does SDA arise earlier or more strongly for indicatives than for counterfactuals?*
   Some authors (e.g., Stalnaker, 1968; Adams, 1975; Khoo, 2022) support a uniform view of conditionals, while others (e.g., Veltman, 1985; Gauker, 2005) argue that indicatives and counterfactuals follow different logics: indicatives are strict, validating SDA, whereas counterfactuals are variably strict, potentially invalidating SDA. If SDA appears earlier or more robustly in indicatives than in counterfactuals, this would support the latter view. Conversely, a parallel emergence of SDA across both types of conditionals would suggest a unified logical status for SDA.

2.2 Methodology

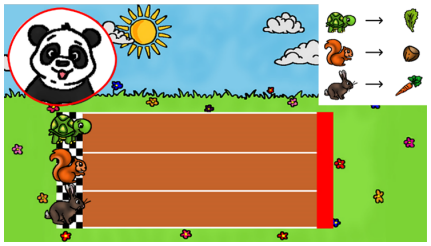
A total of 140 Italian monolingual children, aged between 5;0 and 9;11, and 28 adults participated in a picture-supported Truth Value Judgment Task. Participants were asked to evaluate statements made by Panda, a character who occasionally lies. The task included 4 pre-test items, 16 DACs, 16 *control* items featuring simple conditionals (e.g., "if A, C"; 8 requiring a true judgment and 8 requiring a false judgment), and 4 *bonus* items with conditionals containing negated antecedents (e.g., "if not A, B"). Eligibility criteria were as follows: participants had to correctly complete the pre-test, which assessed task understanding, interpretation of simple present indicative conditionals, and comprehension of disjunctions in main clauses; correctly judge at least 14 out of 16 control items; and complete the test without interruptions. The experiment involved four race scenarios, each featuring three animals of different speeds (e.g., tortoise, squirrel, hare) competing for unique prizes (e.g., lettuce leaf, hazelnut, carrot). To avoid the possibility that children might mistakenly interpret the disjunction as a conjunction (Singh et al., 2016; Tieu, Yatsushiro, et al., 2016), only one animal could win each race.

In addition to the pre-test items, the mode was manipulated across two sets of scenarios: 2 scenarios (18 items) presented in indicative mode (see item (1) for an example of a DAC in indicative mode) and 2 scenarios (18 items) presented in counterfactual mode (see item (2) for an example of a DAC in counterfactual mode).

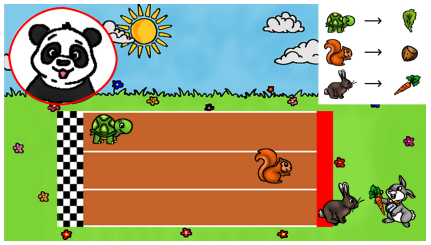
(1) Se lo scoiattolo o la tartaruga vincerà la gara, avrà in premio una nocciola.
If the squirrel or the tortoise win.FUT.3SG the race, get.FUT.3SG as prize a hazelnut.
If the squirrel or the tortoise wins the race, it will get a hazelnut.

(2) Se lo scoiattolo o la tartaruga avesse vinto la gara, avrebbe avuto in premio una nocciola.
If the squirrel or the tortoise have.SBJV.IPFV.3SG win.PTCP.PST the race, have.COND.3SG get.PTCP.PST as prize a hazelnut.
If the squirrel or the tortoise had won the race, it would have gotten a hazelnut.

Two of the four scenarios displayed all competitors at the starting line (Figure 2a), involving indicative conditionals. The other two scenarios showed the end of the race, with the fastest animal winning (Figure 2b), and involved counterfactuals. Participants were divided into two groups: List 1 judged the first and third scenarios in indicative mode and the second and fourth in counterfactual mode, while List 2 received the reverse order. Each scenario contained 4 DACs, 4 control items, and a bonus item, presented in that order. To avoid facilitating access to the simplifications of the DACs, control sentences were presented after the target items. We manipulated position in DACs at a design level: both "if A or B" and "if B or A" were tested to ensure a balanced evaluation of the disjuncts.



(a) Indicative scenarios



(b) Counterfactual scenario

Figure 2: Comparison of indicative and counterfactual scenarios in the experiment.

The interpretation of the DACs was determined by the pattern that emerged from the four target items presented in each scenario to each participant. The SDA pattern requires a false judgment ("F") of all four items, as the consequent must hold for each disjunct in the antecedent. The DCR interpretation, on the other hand, arises when all target items are judged as truth ("T"), since it only requires that at least one of the two disjuncts follow the consequent. An AR interpretation arises only if the most realistic disjunct (in this case, the squirrel) is linked to the prize in the consequent.

Table 1: Interpretation patterns of *target sentences*.

	SDA if A, C **and** if B, C	DCR if A, C **or** if B, C	AR if A, C*
(1) if **Squirrel** or Tortoise, **Hazelnut**	F	T	T
(2) if Tortoise or **Squirrel**, **Hazelnut**	F	T	T
(3) if Squirrel or **Tortoise**, **Lettuce**	F	T	F
(4) if **Tortoise** or Squirrel, **Lettuce**	F	T	F

* Assuming A is regarded as the most realistic disjunct.

Note: In the antecedent, the unique competitor among the two disjuncts correctly associated with the prize in the consequent is highlighted in bold, as is the prize itself.

Additionally, each scenario included a *bonus item* (e.g., 3), designed to assess participants' evaluations of the relative closeness of the disjuncts in a DAC. A *true* response indicated that the participant regarded one disjunct in the target DAC as closer than the other.

(3) Se non vincerà/avesse vinto la lepre, vincerà/avrebbe vinto lo scoiattolo.
If the hare doesn't win/hadn't won, the squirrel will win/would have won.

2.3 Results

Figure 3 presents a bar chart illustrating the distribution of interpretative patterns derived by participants across different scenarios. The data is segmented by age group, revealing a significant proportion of SDA patterns starting at age 5 (33.0%). Data were fitted to a Generalised Mixed Model (multinomial)[1]. The dependent variable was "Pattern", consisting of four values: SDA, AR, DCR and *Others*. The predictors were mode (indicative, counterfactuals), Age (in months) and their interaction. The model shows that SDA is derived more than AR, DCR and Others. The unique effect which is significant either including adults (Table 2) or excluding from the sample (Table 3) is Age between DCR and SDA (p = 0.002 including adults; p = 0.013 excluding them).

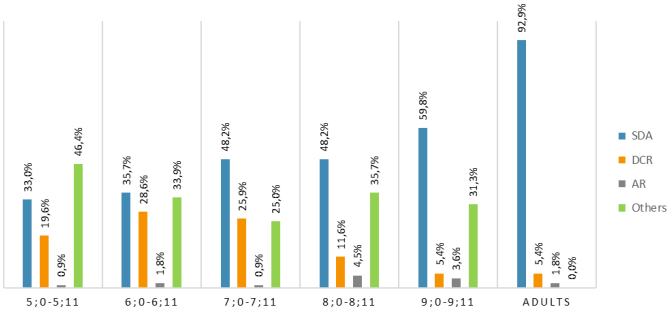


Figure 3: Interpretations of DACs among age groups

Response	Names	Effect	Estimate	SE	Exp(B)	95% Confidence Intervals		z	p
						Lower	Upper		
AR - SDA	(Intercept)	(Intercept)	-3.474	0.484	0.031	0.012	0.080	-7.179	< .001
AR - SDA	Mode	Ind. - Ctf.	-0.729	0.828	0.482	0.095	2.444	-0.880	0.379
AR - SDA	Age	Age	-0.013	0.011	0.987	0.967	1.008	-1.194	0.233
AR - SDA	Mode * Age	Ind. - Ctf.	-0.013	0.017	0.987	0.955	1.021	-0.759	0.448
DCR - SDA	(Intercept)	(Intercept)	-2.745	0.461	0.064	0.026	0.159	-5.958	< .001
DCR - SDA	Mode	Ind. - Ctf.	0.843	0.673	2.323	0.621	8.683	1.253	0.210
DCR - SDA	Age	Age	-0.038	0.012	0.963	0.940	0.986	-3.155	0.002
DCR - SDA	Mode * Age	Ind. - Ctf.	0.020	0.015	1.020	0.990	1.050	1.291	0.197
Others - SDA	(Intercept)	(Intercept)	-1.443	0.341	0.236	0.121	0.461	-4.234	< .001
Others - SDA	Mode	Ind. - Ctf.	0.260	0.537	1.297	0.453	3.713	0.484	0.628
Others - SDA	Age	Age	-0.030	0.010	0.971	0.952	0.989	-3.082	0.002
Others - SDA	Mode * Age	Ind. - Ctf.	0.012	0.013	1.012	0.987	1.038	0.946	0.344

Table 2: Parameter Estimates (Fixed Coefficients) - children ad adults. (Full Model Summary: AIC = 989.743; BIC = 1097.989; LRT X^2 = 921.437; Dev = 941.743)

Response	Names	Effect	Estimate	SE	Exp(B)	95% Confidence Intervals		z	p
						Lower	Upper		
AR - SDA	(Intercept)	(Intercept)	-3.109	0.394	0.045	0.021	0.097	-7.892	< .001
AR - SDA	Mode1	Ind. - Ctf.	-0.238	0.718	0.788	0.193	3.217	-0.331	0.740
AR - SDA	Age	Age	-0.002	0.027	0.998	0.947	1.052	-0.071	0.944
AR - SDA	Mode * Age	Ind. - Ctf.	-0.023	0.043	0.978	0.899	1.063	-0.529	0.597
DCR - SDA	(Intercept)	(Intercept)	-0.800	0.214	0.449	0.295	0.683	-3.743	< .001
DCR - SDA	Mode	Ind. - Ctf.	0.079	0.362	1.082	0.532	2.200	0.217	0.828
DCR - SDA	Age	Age	-0.045	0.018	0.956	0.922	0.991	-2.485	0.013
DCR - SDA	Mode * Age	Ind. - Ctf.	0.020	0.022	1.020	0.977	1.065	0.906	0.365
Others - SDA	(Intercept)	(Intercept)	-0.516	0.208	0.597	0.397	0.898	-2.478	0.013
Others - SDA	Mode	Ind. - Ctf.	-0.171	0.334	0.843	0.438	1.623	-0.511	0.609
Others - SDA	Age	Age	-0.028	0.018	0.973	0.940	1.007	-1.582	0.114
Others - SDA	Mode * Age	Ind. - Ctf.	0.016	0.017	1.016	0.983	1.051	0.955	0.340

Table 3: Parameter Estimates (Fixed Coefficients) - only children. (Full Model Summary: AIC = 1009.269; BIC = 1113.139; LRT X^2 = 591.381; Dev = 961.269)

[1]Model: mclogit::mblogit Pattern ~ 1 + Mode + Age + Mode:Age + (1 | Scenario_List) + (0 + Age | ID participant). "Scenario_List" is the scenario combined with the list assigned:i.e. *A.1* is the scenario A of List 1.

The absence of a mode effect is further supported by an individual analysis. The two tables below provide a detailed examination of each participant's responses (see Table 4 for children and Table 5 for adults). These tables illustrate whether participants exhibit consistency across both scenarios presented in the indicative mode and both scenarios in the counterfactual mode. In addition to the four response categories previously discussed—SDA, DCR, AR, and *Others*—a fifth category, "Mix", has been introduced. This category captures instances in which a participant derives two different interpretations within scenarios of the same mode. Upon excluding the "Mix" column and row, it is notable that all but one participants are positioned along the diagonal of the tables, thereby confirming their tendency to generate consistent interpretations across modes, irrespective of the specific interpretation chosen.

Counterfactual \ *Indicative*	**SDA**	**DCR**	**AR**	**Others**	**Mix**
SDA	**50**	0	0	0	3
DCR	0	**14**	0	0	3
AR	0	0	**2**	0	0
Others	0	0	0	**28**	7
Mix	8	0	0	9	8

Table 4: Children's profiles (total: 140)

Counterfactual \ *Indicative*	**SDA**	**DCR**	**AR**	**Others**	**Mix**
SDA	**26**	0	0	0	0
DCR	0	**1**	0	0	0
AR	0	**1**	**0**	0	0
Others	0	0	0	**0**	0
Mix	0	0	0	0	0

Table 5: Adults' profiles (total: 28)

We now turn to the analysis of the results related to the bonus item. The inclusion of this item was primarily motivated by the need to examine whether an equally realistic condition is a necessary prerequisite for SDA. The data in Table 6 have been filtered to include only those participants who answered "T" for the corresponding bonus item within the same scenario. It is important to note that answering "T" corresponds to the computation of a non-equally realistic condition, which, according to Minimal Change Semantics, leads to AR. However, despite this, SDA remains the preferred interpretation among these participants, indicating that SDA does not depend exclusively on equidistant conditions.

Pattern	**Children**	**Adults**
SDA	41.1%	87.8%
AR	3.0%	4.1%
DCR	20.8%	8.2%
Others	35.1%	0.0%
Total	100.00%	100.00%

Table 6: Interpretative patterns of participants who answered "T" to the bonus item

3 Conclusion

Our results indicate that the SDA interpretation of DACs emerges early, with a preference for this interpretation evident as early as age 5. This supports the view that SDA is linked to free-choice inferences, which also develop early (Zhou et al., 2013; Tieu, Romoli, et al., 2015; Huang and Crain, 2019). While SDA rates increase with age, this increase is not accompanied by a decrease in AR rates; in fact, AR is nearly unattested, even among participants whose answer to the bonus item indicated that they regarded one disjunct as strictly closer than the other. On the account of Bar-Lev and Fox, the absence of AR can be explained by assuming that the strengthening mechanism responsible for SDA is fully acquired at age 5; this, however, leaves the subsequent increase in SDA unexplained. This increase is accompanied by a decrease in DCR rates, in line with the predictions of homogeneity-based accounts (Santorio, 2018; Cariani and Goldstein, 2020), that can ascribe this trend to the independently attested shift from existential to universal interpretations of homogeneous predication. Finally, SDA rates are not significantly different between indicatives and counterfactuals, in line with the predictions of uniform accounts of conditionals. Future research could test the hypothesis that the SDA interpretation is linked to homogeneity by testing the same children on both plural definites and DACs and comparing their answers.

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