Conversational Implicatures in Counterexample Retrieval: Working Memory and Crystallized Pragmatics

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Abstract

Conditional inference patterns are influenced by the availability of counterexamples. We show that aside of the semantic counterexamples that are stored in long-term memory, there is an additional pool of counterexamples that stem from conversational implicatures. Experiment 1 showed that for young adults the retrieval of pragmatic counterexamples requires working memory resources. Experiment 2 showed that for senior adults (aged 58 to 88) working memory resources were significantly lower. Nonetheless, seniors retrieved at least as many pragmatic counterexamples as young adults. As pragmatic counterexamples are key examples of cultural conventions, it is argued that senior adults compensate for limitations in working memory by relying on their acquired cultural expertise.

Introduction

You can't live a long life without aging, and aging comes with a cost. Cognitive deficits start occurring at early adulthood and increase with age. Extensive research established robust age-related deficits in working memory functioning (Fisk & Sharp, 2004; Salthouse, 2001) and working memory function is shown to be on its turn a crucial determinant of performance in several cognitively complex tasks (see e.g., Kyllonen & Cristal, 1990). While laboratory tasks involving higher-level cognition show a pronounced age-related decline, seniors perform at level with young adults in everyday life. It is argued that senior adults cope with the cognitive shortcomings by adapting their behavior. We examine the hypothesis that elderly are more versed in cultural conventions and can compensate the atrophy in their cognitive hardware by relying on crystallized conversational pragmatics (Baltes, 1997). One of the capital domains where pragmatics are manifestly present is everyday communication and reasoning. The current research focuses on the use of pragmatic, conversational implicatures in everyday causal conditional inference making. First, we discuss the nature of conversational implicatures and the derivation of pragmatic counterexamples during reasoning. Next, we turn to the working memory involvement for pragmatic counterexample retrieval and compare performance of young adults with senior adult reasoners.

Pragmatic counterexamples

Grice coined the idea of 'conversational implicatures' in 1975 and it is still a hot topic for linguists and psychologists alike (see e.g., Bezuidenhout & Cutting, 2002; Garrod & Pickering, 2004; Levinson, 2000; Noveck, 2001). Conversational implicatures refer to subtle yet strong implicit inference processes that govern all human communication. They arise because the interlocutors customarily obey the conversational maxims governing the efficient co-operative use of language. These maxims state that every speaker should make a contribution that is:

1. adequately – not overly- informative (quantity maxim)
2. build on adequate evidence (quality maxim)
3. relevant (maxim of relevance)
4. clear, brief and orderly (maxim of manner)

Every speaker is believed to follow these maxims, which enables listeners to make specific inferences about what is implicated. For example, whenever someone says: '*There is a man in my office'* this triggers the implicature '*This man is not the speakers husband, boyfriend or friend'*. Following the quantity maxim, the speaker had otherwise provided this more specific information (Levinson, 2000). Despite its compelling nature, the role of these implicatures in reasoning has been widely neglected. We argue that reasoners can rely on conversational implicatures to derive counterexamples in conditional reasoning. Even for causal conditionals —where the felicity conditions relating to the adequate utterance of a speech act are minimal— conversational implicatures play a significant part in the inference process. We briefly discuss the principles of causal conditional reasoning and the role of counterexample retrieval.

In conditional reasoning, reasoners are given a conditional sentence as major premise, while the minor premise affirms (denies) the antecedent or consequent clause of the major. We focus on the two affirmation inferences: Modus Ponens (MP) and Affirmation of the Consequent (AC). Some examples:

MP: If you water a plant well, then the plant stays green.
A plant is well watered. Will it stay green?

AC: If a dog has fleas, then it will scratch itself.
A dog scratches itself. Does this dog have fleas?

Whether reasoners accept the given conclusion depends on their consideration of disabling conditions (MP) or alternative causes (AC). For MP, when reasoners think of '*deprivation of sunlight'* they do not conclude that the plant stays green. Likewise for AC, when they think of '*an allergic reaction'* they do not accept that the dog has fleas. Disabling conditions and alternative causes are together referred to as counterexamples. The probability of retrieving a counterexample is related to the number of counterexamples that a reasoner can retrieve from background knowledge. When there are more disablers available, less MP are made, when there are alternatives available, less AC are made. The robust impact of available counterexamples on conditional

reasoning patterns is well documented (e.g., Cummins, Alksnis, Lubart, & Rist, 1991; Politzer & Bourmaud, 2002). Markovits and collaborators assume that counterexamples are retrieved from semantic memory (Markovits & Barrouillet, 2000; Markovits, Fleury, Quinn, & Venet, 1998). We argue that the majority of the counterexamples are indeed semantic counterexamples that are 'ready-to-retrieve' from long-term memory but that there is an additional and considerable pool of pragmatic counterexamples. These pragmatic counterexamples arise from the active cancellation of compelling yet defeasable conversational implicatures. The reasoner is aware that the conditional triggers certain implicatures, and that a well-aimed suspension of these implicatures yields a possible counterexample. The difference between semantic and pragmatic counterexamples is illustrated with the sentence: *'If you drink lots of coke, then you gain weight'*. Semantic disablers are: *the person got sick, he sports regularly, he is exposed to stress,* etc. Pragmatic disablers are: (a) *the person lied about his weight*, this flaunts the quality maxim: one must speak truthfully, (b) *the person drinks diet-coke*, this flaunts the quantity maxim: if you mean diet coke, say diet coke, (c) *after he gained weight, he went on a diet,* this flaunts the maxim of manner/order. Semantic alternatives are: *The person does not exercise, he eats high-carb snacks, he's genetically predisposed for gaining weight,* etc. Pragmatic alternatives are: (a) *he has put on weight belts*, this flaunts the maxim of relevance, (b) *drinking coke does not cause weight gain*, this flaunts the maxim of quality: implies that there is no adequate evidence for the given conditional, (c) *the person is anorexic and only* thinks *he gained weight*, also flaunting the maxim of quality, there is evidence lacking for inferring weight gain.

We investigate the retrieval characteristics of pragmatic counterexamples. In Experiment 1 we investigate the relation between working memory and pragmatic counterexample retrieval in young adults. In Experiment 2 we compare their performance with senior adults. First, we discuss the role of working memory in pragmatic counterexample retrieval.

Working memory and deriving implicatures

Noveck and colleagues examined whether deriving implicatures is part of an effortful process (Noveck & Posada, 2003; Bott & Noveck, in press). They focused their research on scalar implicatures, a specific kind of implicatures arising from the quantity maxim (be adequately informative), an example:

A: Do you like his friends?
B: Some of them.
Scalar implicature: I *don't* like *all* of his friends (otherwise the speaker would not have have said 'some').

Noveck and Posada (2003) presented participants with a range of sentences, some of which were pragmatically false (underinformative) but logically true (e.g. Some elephants have trunks). Participants judged the sentences as true or false while their reaction times as well as the event related potentials (ERP's) to the last word of each sentence were recorded. They concluded that scalar implicatures are not made automatically because (1) pragmatic responses resulted in higher reaction times than logical responses and (2) the N400 peak remained flat for underinformative sentences while automatically detected semantic anomalities normally yield a ERP peak 400 ms after the appearance of an unexpected word. If indeed, scalar implicatures are part of a late-arriving and cognitively demanding decision process, then deriving conversational implicatures should draw on the executive function of working memory. Because pragmatic counterexamples require an active well-aimed cancellation of inferred implicatures, it can be argued that working memory capacity is a crucial mediator of pragmatic counterexample retrieval. Some preliminary findings were presented by Verschueren, De Neys, Schaeken, and d'Ydewalle (2002). In Experiment 1 we compare three different span groups to investigate the mediating role of working memory capacity in pragmatic counterexamples retrieval.

Experiment 1

Studies involving verbal reports already revealed important representational and semantic information for different kinds of reasoning tasks (Ford, 1995; Stenning & Van Lambalgen, 2001; Verschueren, Schaeken, & d'Ydewalle, 2003). It is known that concurrent verbalization does not affect the basic performance or the gross structure of the thought processes about actively attended verbal codings (Ericsson & Simon, 1984). For tasks involving higher order cognition and manipulation of verbal contents thinking-aloud methods are well suited to tap conscious and easy verbalizable processes. In Experiment 1 we asked participants from different working memory span groups, to solve MP and AC inferences in a thinking-aloud setting. By using a thinking-aloud setup we are able to monitor the specific counterexamples that participants take into account while reasoning. This information is left implicit when a standard evaluation task is used. We will verify the occurrence of semantic and pragmatic counterexamples and relate their occurrence to working memory capacity scores.

Method

Participants. A total of 54 first year psychology (generation-) students participated in return for course credits. There were 18 students for each span group. The low-span group had a mean Gospan-score of 18.5 (*SD*=4.38), the medium group had a mean score of 32 (*SD*=1.46), the high span group had a mean score of 47.9 (*SD*=4.22).

Material and design. We selected 16 causal sentences based on previous generation task results (Verschueren, Schaeken, De Neys, & d'Ydewalle, 2004): There were 4 sentences with few available disablers and few available alternatives, 4 sentences with few disablers and many alternatives, 4 sentences with many disablers and few alternatives, and 4 sentences with many disablers and many alternatives. The 16 sentences were presented in MP as well as AC form. The order of the inference forms was blocked.

Procedure. Working memory capacity was tested on computer in groups of 20 to 30 students. A total of 292 first year psychology students were pre-tested for their working memory capacity by use of a word-operation span test. We

used the Dutch computerized version of the operation span task as designed by Turner and Engle (1989) [see De Neys, Schaeken, d'Ydewalle, and Vos (2001)]. The reasoning task was run individually. Each reasoning problem was presented on a different sheet. Participants read the problem aloud and were asked to give whatever information they considered relevant to answer the question in an everyday setting. Their answers were recorded on audiotape. Reasoners were free to elaborate or revise their conclusions on-line and leafed through the pages in a self-paced manner. When participants answered only 'yes' or 'no', the experimenter asked the participants for a short motivation. The subsequent responses are not included in the analysis; the purpose of the intervention was to stimulate reasoners to think aloud on the following trials. It took participants about 25 to 30 minutes to complete the task.

Results

The recorded tapes were literally transcribed. We labeled all counterexamples as semantic or pragmatic. Previous research showed that semantic and pragmatic counterexamples can be well distinguished. Verschueren and Schaeken (2005) presented participants with a generation task. The obtained counterexamples were categorized as semantic or pragmatic by a psychologist as well as a pragma-linguist. The initial proportion of interrater agreement was .75 (kappa=.632, 'good') for disablers and .89 for alternatives (kappa=.498, 'moderate'). After discussion both raters could agree on every counterexample. For each participant, we summed the number of semantic and pragmatic counterexamples over 8 sentences (MP: 8 with few disablers - 8 many disablers; AC: 8 few alternatives - 8 many alternatives).

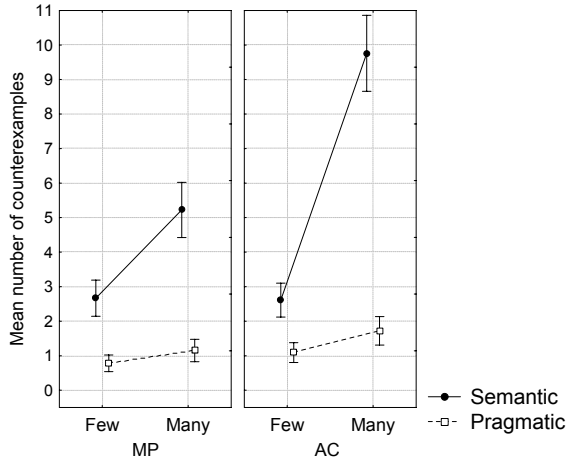

Figure 1: Number of semantic and pragmatic counterexamples retrieved during reasoning

We ran an ANOVA with three within-subject factors: inference type (MP-AC), available counterexamples (few-many) and type (semantic-pragmatic) and one between-subject factor (span group). The inference type, number of available counterexamples, and type of counterexample interacted significantly, $F(1,51) = 43.06$, $p < .001$. Figure 1 illustrates this interaction. There were overall more counterexamples generated for sentences with many counterexamples (M_{many}=4.46) than on sentences with few counterexamples (M_{few}=1.79), $F(1,51) = 289.8$, $p < .001$. There were less counterexamples given for MP (M_{MP}=2.45) than for AC (M_{AC}=3.80), $F(1,51) = 58.6$, $p < .001$. Finally, there were more semantic (M_{sem}=5.06) than pragmatic (M_{prag}=1.19) counterexamples, $F(1,51)$=212.4 $p < .001$.

Although the semantic counterexamples are more prevalent than the pragmatic counterexamples, 18.96% of all counterexamples that reasoners retrieved were pragmatic counterexamples. The prevalence of these actively constructed pragmatic counterexamples puts the assumption that counterexamples are automatically retrieved from semantic memory into perspective: It is possible that the majority of counterexamples is retrieved from semantic memory, but an active well-aimed cancellation of compelling conversational implicatures accounts for an additional part of counterexample availability. In the present research we only used causal conditionals. This type of factual conditionals is less susceptible to effects of speech acts than deontic conditionals, like permissions, promises or threats. For other types of conditionals, there may be an even higher incidence of pragmatic counterexamples. We now discuss the effects of working memory capacity.

Previous research revealed a stable relation between span group and inference acceptance: Working memory span and AC acceptance rates show a negative linear relation, whereas for MP this relation follows an U-shape (De Neys, Schaeken, & d'Ydewalle, 2003). They argued that the ability to retrieve counterexamples increases with working memory capacity but that high span reasoners inhibit counterexample retrieval because it conflicts with normative standards. Given these findings, we expect a positive relationship between span group and counterexample retrieval on AC and an inverse U-shape relation on MP. There was a marginally significant span-related linear increase in the overall number of alternatives (AC), $F(1,51) = 3{,}45$, $MSE = 3{,}45$, $p = .07$. On MP, there was a marginally significant inverse U-shaped relation between the overall number of disablers and span group, $F(1,51) = 2{,}93$, $MSE = 5{,}24$, $p = .09$. These effects are in line with our expectations. When taking a closer look, we found that the effects were different for semantic and pragmatic counterexamples. There was a significant third-order interaction between inference type, number of counterexamples, type of counterexample and span group, $F(2,51) = 3{,}36$, $p < .05$. Planned comparisons yielded a significant positive linear trend between span group and the number of pragmatic alternatives, $F(1,51) = 5{,}83$, $MSE = 2{,}0$, $p < .05$ (M_L=0.97, M_M=1.47, M_H=1.78) while this trend was not significant on semantic counterexamples ($p = .23$). On MP, the inverse U-shaped relation was significant for pragmatic counterexamples, $F(1,51) = 20{,}2$, $MSE = 0{,}84$, $p < .001$ (M_L=0.61, M_M=1.58, M_H=0.69), but not for semantic counterexamples (p =.65).

Not only did we demonstrate that pragmatic counterexamples constitute a considerable part of the counterexamples reasoners use, the present results suggest that the overall relation between counterexample retrieval and span group, is boosted when the analysis is confined to pragmatic counterexamples. We can thus conclude that for young adults, working memory plays a key role in the

retrieval of pragmatic counterexamples. In Experiment 2 we will see what happens in senior adult reasoning.

Experiment 2

Only recently researchers considered conversational implicatures from a developmental perspective (Noveck, 2001; Noveck & Chevaux, 2001). The general finding is that children's awareness of conversational implicatures increases with age. Noveck and colleagues convincingly showed that when approaching adulthood the pragmatic interpretation of operators (and, or) and quantifiers (some) overrides their logical interpretation. One possible explanation is that deriving conversational implicatures draws on cognitive resources and cognitive resources increase with age. When turning to senior adults, we are confronted with the abundant evidence for the cognitive aging deficit: When adults age, their working memory resources gradually decline (Fisk & Sharp, 2004; Salthouse, 2001). Given that calculating implicatures is effort-demanding and that finding counterexample by actively defeasing these implicatures relates to working memory capacity, we expect a dramatic decline in the number of pragmatic counterexamples. On the other hand, it is possible that because of the acquired expertise in conversational processes, senior adults are more aware of conversational conventions and more skilled in deriving them. This complies with the compensation view on aging (Baltes, 1997): The incremental crystallized pragmatics compensate the age-related decline in fluid mechanisms— such as working memory capacity. In this case, we expect that the elderly's routine acquaintance with conversational conventions counters the effect of waning cognitive capacity on pragmatic counterexample retrieval. In Experiment 2 we test the two hypotheses.

Method

Participants. A total of 38 senior students (aged 58 to 88) volunteered to participate in the experiment.

Material, design and procedure. The material, design and procedure are similar to Experiment 1. The senior adults were tested for working memory and reasoning in the same session.

Results

Although some seniors spoke with persuasive and powerful sentences, others showed a marked difficulty in finding their words and finishing sentences (see also Burke & Shafto, 2004). All of the answers were again literally transcribed and coded for semantic and pragmatic counterexamples by two independent raters.

The mean Gospan score of the tested senior adults was 18.29, *Range* [2,37] (young adults: *M*=32.6, *Range* [9,60]). The working memory span of seniors was significantly lower than that of young adults, t(90)=-6.06, p < .001. We ran an ANOVA analysis similar to that of Experiment 1 (without the variable related to working memory span). The three-way interaction between inference type, number of available counterexamples and type of counterexample was again significant, $F(1, 51) = 5.79$, $p < .05$. Figure 2 displays this interaction effect., you can see that the pattern of results was virtually similar to Experiment 1: There was a main effect of the number of available counterexamples, $F(1,37)=125,14$, $p < .001$ ($M_{few}=1.63$, $M_{many}=3.93$), inference type yielded a second main effect, $F(1,38)= 91,68$, $p < .001$ ($M_{MP}=1.74$, $M_{AC}=3.82$) and there were more semantic than pragmatic counterexamples ($M_{prag}=1.41$, $M_{sem}=4.15$), $F(1,37) = 62,59$, $p < .001$. Although there is a vast difference in the available working memory resources, the number of retrieved counterexamples is strikingly similar.

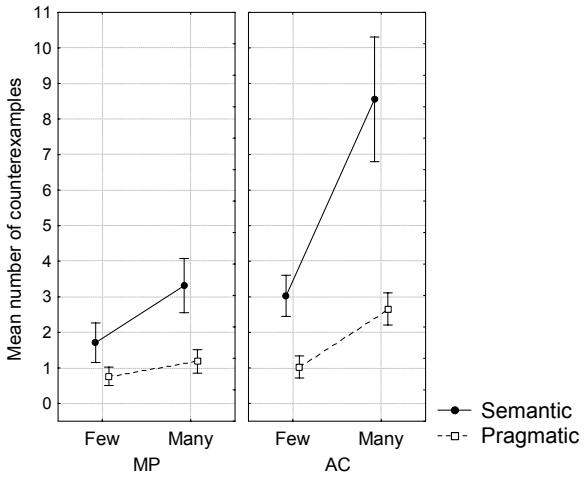

Figure 2: Number of semantic and pragmatic counterexamples retrieved by senior reasoners.

To compare the reasoning results of young and old adults on semantic and pragmatic counterexample retrieval, we ran an ANOVA analysis with inference type and counterexample type as within-subject variable and age group as between-subject variable. When both age groups are taken together, we observed the same effects as in Figure 1. We found a significant interaction between age group and counterexample type, $F(1, 90) = 6,97$, $p < .001$. Senior adults generate considerably less semantic counterexamples than young adults, $F(1, 90) = 4.5$, $MSE = 16,45$, $p < .05$ ($M_{young}=5.15$, $M_{senior}=4.14$). In contrast, there were more pragmatic counterexamples generated by seniors ($M_{seniors}=1.41$) than by young adults ($M_{young}=1.19$), although this difference is not significant ($p = .10$). The interaction effect is displayed in Figure 3. The effects on semantic counterexample retrieval are in line with the decline in working memory resources. However, while semantic counterexample retrieval is heavily affected by the age-related decrease in working memory capacity, pragmatic counterexample retrieval is virtually unaffected. Formulated differently, in senior reasoning pragmatic counterexample retrieval gains importance over semantic counterexample retrieval (25,33% of all counterexamples were pragmatic counterexamples). When we confine the analysis to young and senior adults with a similar working memory span [9, 24] these effects become even more clear (see Figure 4): Young adults generate more semantic counterexamples, $F(1, 40) = 4.53$, $MSE = 6.11$, $p < .05$ ($M_{young}=4.63$, $M_{senior}=4,16$) but less pragmatic counterexamples, $F(1, 40) = 4.36$, $MSE = 0.71$, $p < .05$ ($M_{young} = 0.79$, $M_{senior}= 1.49$).

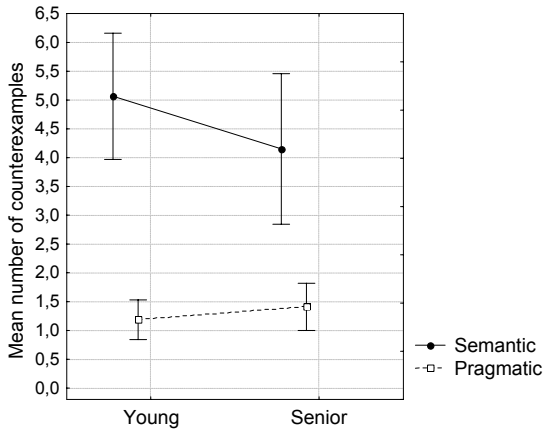

Figure 3: Difference in semantic and pragmatic counterexample use in young and senior adults.

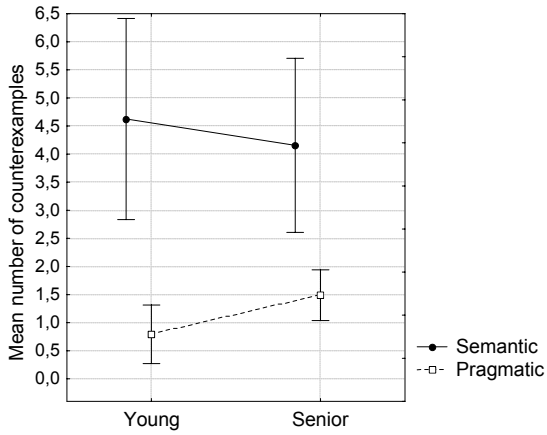

Figure 4: Semantic and pragmatic counterexample use for young and senior adults with the same span range.

When comparing the results of Experiment 1 with Experiment 2, we are faced with an apparent contradiction. In young adults, the retrieval of pragmatic counterexamples is clearly related to working memory capacity: The more resources reasoners have available, the more pragmatic counterexamples are retrieved. The working memory capacity scores of older adults were markedly lower than those of young adults, yet they produced at least as many pragmatic counterexamples as young adults. A possible explanation is that the characteristics of the retrieval process for pragmatic counterexamples are different for young and senior adults. We assume that younger adults are less cognizant of the reigning conversational principles, making it more effort-demanding to derive counterexamples from suspending conversational implicatures. Senior adults are more versed in conversational principles and settings and compensate their overall loss in semantic retrieval by relying on pragmatics.

General discussion

Conversational implicatures are omnipresent and enable interlocutors to communicate efficiently. Although information from semantic memory accounts for the lion's share of the background information that reasoners consult in everyday reasoning, it is not surprising that conversational implicatures are often used to construct alternative explanations for conditional arguments.

It is beyond doubt that people's cognitive potential wanes with age. The observed difference in working memory span between the young and senior adults corroborates the robust decline in working memory resources. Recently, researchers have given a positive twist to the pessimistic view on cognitive aging: Elderly exhibit a marked plasticity and potential to compensate (e.g., Reuter-Lorenz, 2002). One of the most developed accounts on successful aging is the Selection-Optimization-Compensation theory of (e.g., Baltes, 1997; Baltes, Lindenberger, & Staudingen, 1995): Their dual-process account on life-span intellectual development distinguishes between available cognitive resources (fluid mechanisms) and the information that culture provides in the form of factual and procedural knowledge about the world, human affairs, socialization, human agency, etc. (crystallized cognitive pragmatics). From the age of thirty, the fluid mechanisms gradually decline, whereas the crystallized pragmatics stagnate at least to the age of seventy. This enables individuals to adaptively further their development by maximizing potential gains from cultural resources. The effectiveness of SOC attains its limit when adults reach the fourth age (80 and above).

When facing the sturdy and irreversible cognitive decline starting already in young adulthood, the question arises why the negative consequences of this sturdy decline are not more prevalent in seniors' everyday functioning. We argue that there it is important to distinguish performance in everyday settings from performance on abstract, laboratory tasks. Krampe & Baltes (2002) state that tests and experiments with litte ecological relevance underestimate the capacities of older adults. Because of their limited external validity the tests are unable to capture the adaptive potential enabling seniors to cope with the age-related cognitive impairment. This applies also to reasoning tasks: Although most research on reasoning in later adulthood focuses on decontextualized normative reasoning, successful reasoning performance in everyday life requires a skilled contextualization, i.e. relating the premises to relevant information from context and background knowledge. Although the available information is often too complex and underspecificated to allow strict deduction, the human well-aimed contextualization process enables successful reasoning performance in spite of these computational limitations. The present research gives a first impetus in considering the contribution of pragmatics and acquired knowledge in the development of everyday reasoning. We like to interpret the current findings as exhibiting such everyday compensatory behavior: The age-related decline in working memory resources is countered by enhanced pragmatic skills. While reasoning on abstract tasks declines with age, seniors can compensate their losses in the cognitive hardware by relying on pragmatics and skilled contextualisation.

There is however still a range of questions that need to be answered. The present findings suggest that seniors are more versed in conversational implicatures. To our knowledge, no research has yet been conducted to investigate the developmental aspects of conversational implicatures from

adulthood to senescence. If indeed seniors are more skilled in pragmatic issues, further research may test and fine-tune the possible trade-off consisting of a gradual decline in cognitive resources and an increased call for crystallized pragmatics.

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