

Doctoral School of Psychology
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Evolutionary and Cognitive Psychology
Doctoral Program

Social-cognitive and pragmatic aspects of language acquisition from a developmental perspective

Theses of Doctoral (PhD) dissertation

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1. Introduction and purpose of the study

The experimental investigation in the present dissertation aimed to give a bird’s eye view of the unfolding of pragmatic competence and identify the cognitive background mechanisms of this process, among these the cognitive ability that is essential in non-compositional, holistic meaning construction.

Overall, the crucial role of mentalization was supported in trials measuring metaphor, humor, irony processing and conversational abilities. In the case of humor and the conversational maxims the mindreading ability is further completed by complex social and cultural knowledge, together with memory skills improving in school years.

1.1. The psycholinguistics of non-compositional meaning construction

The first chapter reviews some of the theoretical issues surrounding metaphor, delineating the major models of metaphor processing, their strong claims and their weaknesses. Pragmatic competence is defined as the ability to understand non-compositional constructions, where the central component of the interactive process of interpretation is based on theory of mind, stemming from intentionality, which enables the hearer to decipher speaker’s intention, and thus to decipher intended meaning. The cognitive developmental background of the unfolding of this competence is sketched, and an empirical test of the model is outlined, targeting the role of mentalization in metaphor processing.

In the mentalistic model proposed in the present study (Fig. 1.), mentalization plays a central role, as this is a basic skill crucial in both the semantic and the pragmatic aspects of language acquisition that may account for the ease and the equal reaction times in current psycholinguistic findings (Gibbs-Nayak-Cutting 1989, Gibbs 1994).

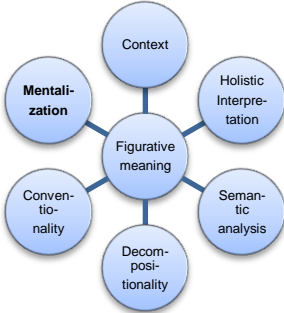


Figure 1.

The mentalistic model, building on mentalization

2. Empirical study on idiomaticity in view of social-cognition

The study tests pragmatic competence with metaphor tasks (see Appendix), while the simile condition served as the control condition, given that in the case of similes, the word “like” makes the comparison explicit. In metaphor, however, it stays implicit, where in deciphering intended meaning one needs to rely on intention reading, thus ToM abilities. The empirical study tested preschoolers’ mentalization skills with a puppet-play adaptation of the classic false belief task (Wimmer-Perner 1983) based on unseen displacement in the framework of Baron-Cohen’s Sally-Anne test version (1985) (Fig 2a,b).

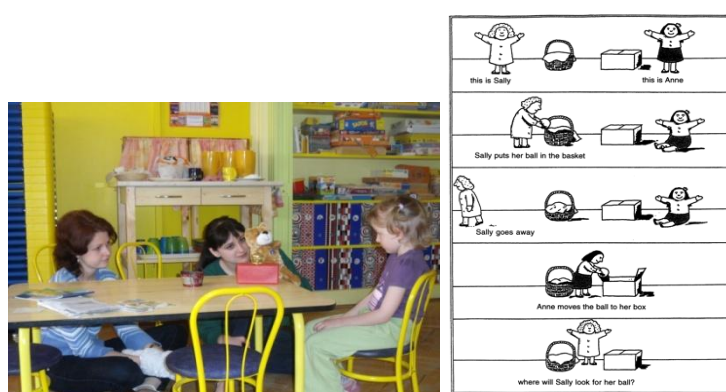


Fig. 2 a,b

The FBT testing mentalization skills

Methodology: different ToM tasks (Verbal first order, verbal second order, Non-verbal Eyes test) were administered, yielding a group of passers (ToM group), and failers (NoToM group) in the verbal tasks, which was contrasted with the Eyes test to reveal the latter’s validity and reliability. The performance of the two ToM groups was compared in the linguistic tasks targeting different aspects of pragmatic competence (Simile-, Metaphor-, Humor-, Irony-processing, Maxim infringement recognition). The sample consisted of 45 (final: 41) preschoolers, between the ages 3-6, 19 boys and 26 girls, of a mean age of 5;1 years (ranging from 3;7 to 7;3). Pragmatic tests contained 5 tasks in each condition, 1 point was earned for all correct answers in each condition. The findings confirmed that theory of mind is a core component of metaphor processing (fig. 3a,b).

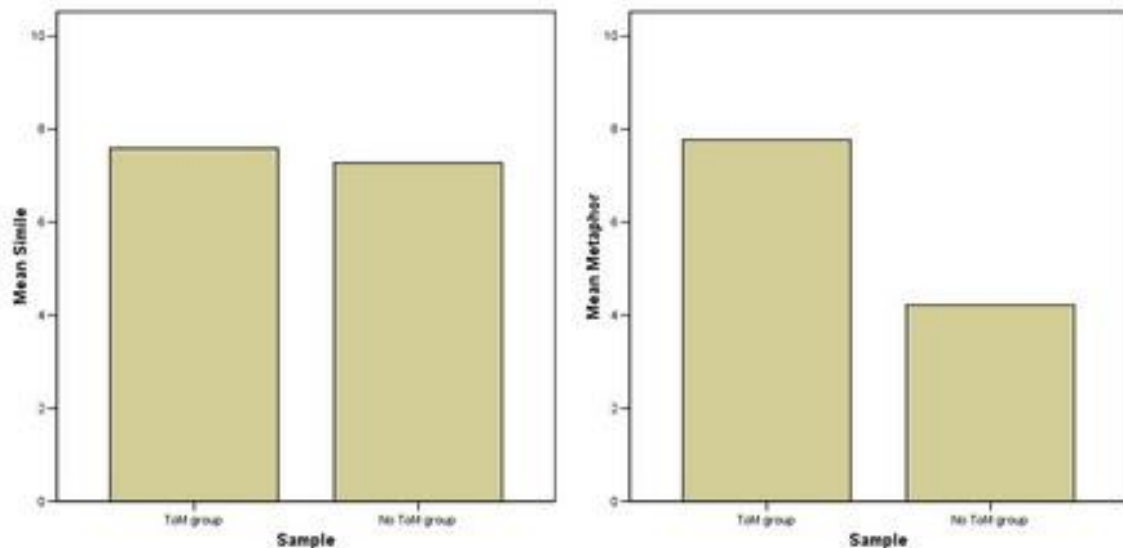


Fig. 3a.

Simile and Metaphor comprehension in view of ToM skills

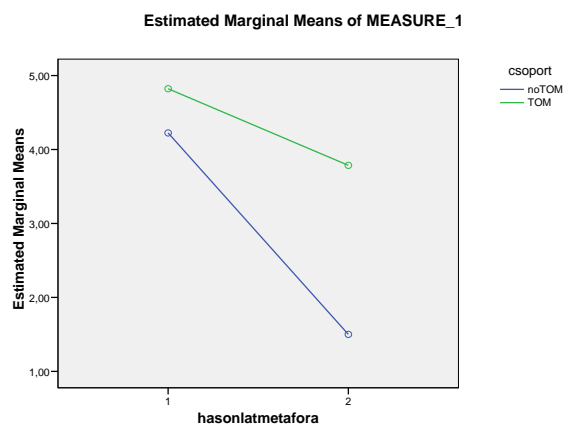


Fig.3b.

Idiomatic and pragmatic skills in line with ToM competence

1.: Simile condition 2.: Metaphor condition

The ToM group was significantly more successful in the metaphor condition where due to its implicit nature, the deciphering of intended meaning required inferential strategies, i.e. ToM ($F(1,43)=134$, $p_{\text{metaphor}} < 0,01$). There was no interaction between the simile and the metaphor conditions. In the simile (control) condition ($F(1,43)=0,5$, $p_{\text{simile}} > 0,05$), where semantic interpretation suffices, there was no significant difference in the performance of the two groups, suggesting that pragmatic competence is largely dependent on the ability to mentalize, which enables the efficient decoding of intended, figurative meanings.

3. Mentalization and the development of humor comprehension

The next chapter targeted cognitive interpretative processes of non-literal meaning in general, and of humorous utterances in particular. The continuum of mentalization and humor is outlined in identifying the cognitive, linguistic and psycholinguistic background of humor research. The same empirical test used in the idiomaticity chapter was extended with 3 verbal humor trials (decontextualized: one-liners and riddles, and a contextual trial involving classical jokes ending in punch-line) and 1 non verbal, visual based humor task, together with a second-order verbal ToM test and an Eyes test of semi-verbal nature (see App.), in order to see if verbal performance limitation is significant in the classical false belief tests of mentalization, and to see the interaction of verbal- and non-verbal results in the pragmatic tasks.

3.1. Validity and reliability of the Eyes test

The Eyes test was not designed to break down the sample into further groups of ToM competence, rather, it was included to see if the non-verbal variety can be predictive and passed earlier, ensuring the avoidance of performance limitation. The results seem to back up the expectations, supporting a moderate performance limitation of verbalization. While in verbal ToM tests children were successful at the age of 5;4, in the non verbal test measuring complex mentalization mean age of passers was 5. This suggests that by eliminating verbal performance limitation, the non-verbal Eyes test can be completed 4 months earlier (Sullivan 1994). Our eyes test thus proved to be valid and predictive concerning mentalization abilities, even though it was aimed to be less demanding due to its semi-verbal nature (Fig. 4.)

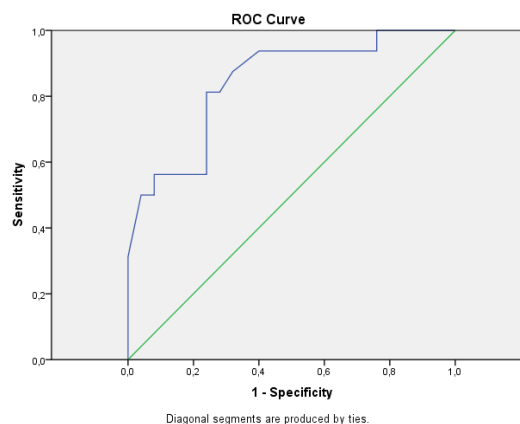


Fig. 4.

Area under RoC curve showing the diagnostic accuracy of the Eyes test

Somers'd measure in the statistical analysis has shown that there is a significant difference in the performance of the two groups in terms of Eyes test results Somers's d $T=4,503$; $p < .001$ suggesting that the ToM group is significantly better in the Eyes test, which confirms its predictive value and efficiency.

3.2. Humor processing in view of mentalization

The empirical investigation aimed to identify if mentalization is an important factor in humor processing, since ToM subjects performed better in humor tasks, however, ToM in this particular case does not seem to be sufficient, since the ToM group's performance was weaker in the humor trials than in the metaphor trial $F(2,82)=222,29$, $p < 0,01$, Interaction: $F(2,82)=22,97$, $p < 0,01$. (Fig. 5a,b.). This suggests that beyond ToM, social and cultural factors also contribute to the acquisition of productive discourse skills in terms of humor (Pexman et al. 2005). Non verbal results support the Cognitive Congruence principle in that those in the NoToM group preferred non verbal humor trials, and performed weaker in both verbal humor conditions, while the ToM group performed better in both verbal humor tasks, and was least successful in the non verbal trial $F(2,82)=2,744$; $p < 0,1$. (Fig. 6.).



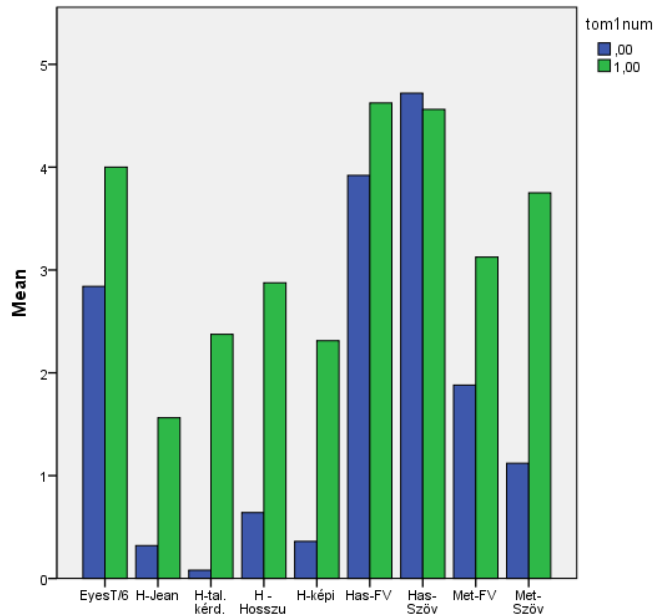


Fig 5a,b.

**1. Simile 2. Metaphor 3. Humor processing
in relation to ToM skills**

1 – Eyes Test; 2 – H - One-liners, 3 – H-Riddles, 4 – H-Jokes, 5 - H-visual, 6 - Similes (Dctx), 7 – Simile (Ctx),
8 – Metaphor (Dctx), 9 – Metaphor (Ctx).

00: NoToM group (blue, left side) 01: ToM group (green, right side)

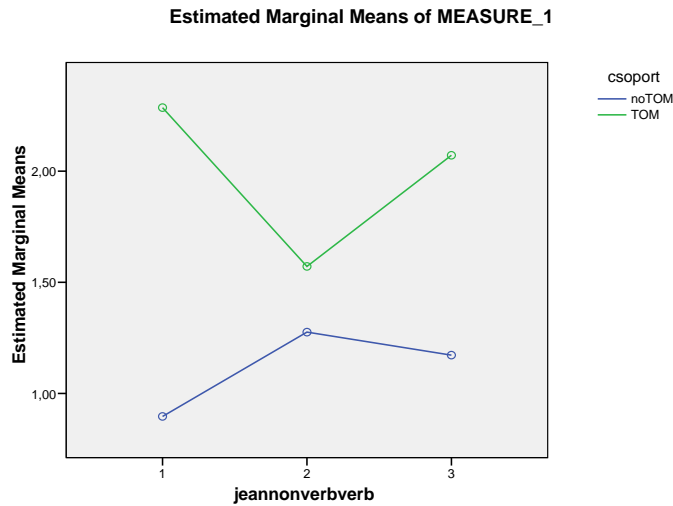


Fig. 6.

**(1) Decontextualized (2) Non-Verbal and (3) Contextualized humor comprehension skills
in view of mentalization**

Contextual effects support the basic psycholinguistic axiom that contextual cues facilitate comprehension, since in contextual tasks context enhanced subjects' performance $F(1,41)=0,228$ n.s. (Fig. 7.). In humor tasks context's facilitating effect (Fig. 6.) is apparently present in the NoToM group's performance, where probably, in short of a fully-fledged ToM contextual information facilitates comprehension.

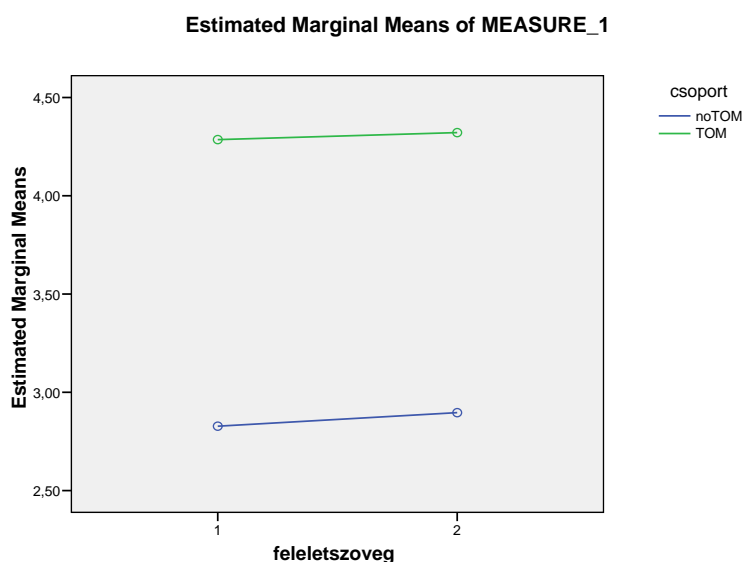


Fig. 7.

Contextual effects in idiomatic processing in view of mentalization

(1) Decontextualized (multiple choice) (2) Contextual (stories ending in metaphor / simile)

The Eyes test maintains the possibility of a wide range of further investigations. Future methodologies building on the Eyes test can give even more insight into the interaction of non-verbal mentalizing skills and non-verbal inferential processes, and possibly clarify issues surrounding the levels of pragmatic competence and its associations to performance limitation.

4. The development of irony comprehension in view of mentalization

The chapter on social cognitive abilities and irony briefly summarized the psycholinguistics background of irony, touching on some definitional problems in theory and research, discussing its distinctive features which make it salient in interpretation, and outlined its differences compared to humor (Wilson – Sperber 1992, Wilson 2009). The empirical test aims to contribute to the resolution of long standing debates on irony processing (Wilson 2013). Its methodology is based on the previous chapters' procedure, extended with three

irony tasks: genuine contextual ironies based on hyperbole, an irony with linguistic task, and a control task. The findings indicate that irony in fact is processed fairly early in preschool years (Fig. 8a). It was the easiest of all the non-compositional constructions tested (Fig. 8b.).

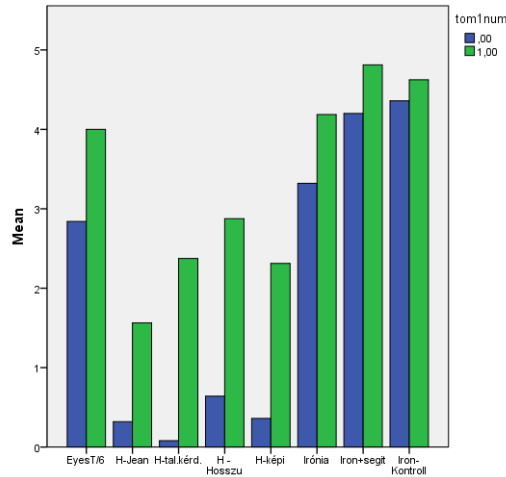


Fig.8a.

Relationship of [V-ToM skills] and [NV-ToM, Humor and Irony competence]

1 – Eyes test, 2 – H-One-liners, 3 – H-Riddles, 4 – H-Jokes, 5 – H-Visual, 6 – Irony, 7 – Irony with lg. help, 8 – Control (Irony).
 00: NoToM group (blue, left side); 01: ToM group (green, right side)

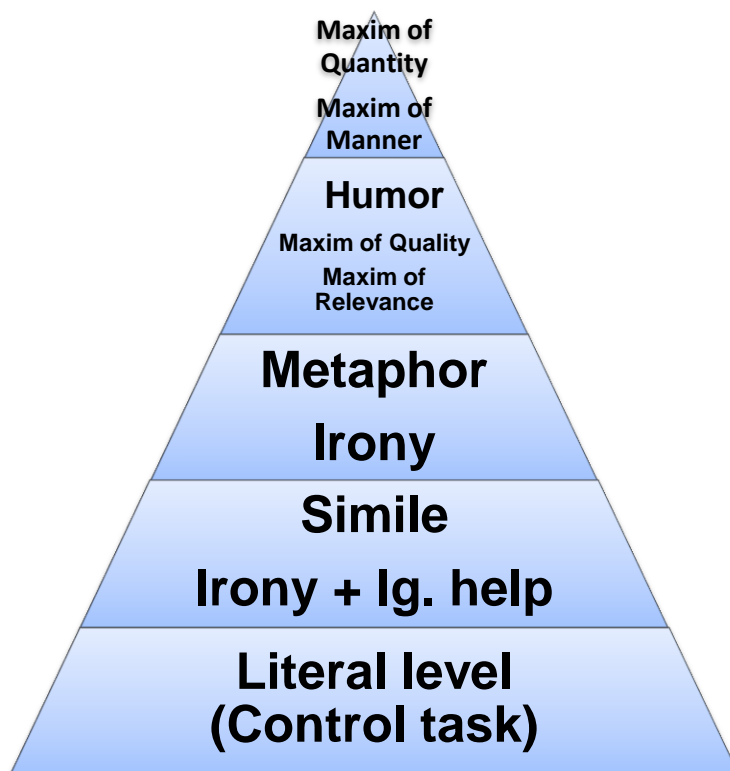


Fig. 8b.

The relative place of irony in the continuum of non-compositionality, in view of ToM

The Mann Whitney analysis of the mean ranks of two independent samples indicated that there was a significant difference in the performance of the NoToM and the ToM group in Irony tasks, i.e. the difference in results is due to their mentalization ability. $U=115,5$, $p=.019$, $r=.36$.

In the irony with linguistic cue task $U=150$, $p=.104$, $r=.25$; there was no significant difference in the two group's performance (mean rank for the ToM group being 24, for the NoToM group: 19), but this difference is visibly bigger than in the case of the control task. This suggests that the surface cue providing explicit information about the speaker's mental state indeed facilitated non-compositional meaning construction, and the NoToM group was more successful in interpreting this, explicitly put irony than the genuine irony. This confirms the role of mentalization in irony processing and in pragmatic competence, along with the facilitating effect of surface cues, and context in interpretation.

In the control condition requiring only semantic interpretation the analysis indicates that there is no significant difference in the results of the two groups, 20,44 being the mean rank in the NoToM group, whereas 21,88 in the ToM group. This shows that the difference in mean performance is very small, meaning, that the NoToM group, in short of a fully fledged mentalizing ability is equally successful in semantic tasks, as the ToM group, since in this trial no mentalization and thus no pragmatic meaning construction was needed, and semantic interpretation sufficed: $U=186$, $p=.664$, $r=.067$.

In general humor is apparently more difficult for preschoolers than irony (Fig. 23), and metaphor (Fig. 22), see also Fig. 24 for relative difficulty. The relative placement of the different types of non-compositional constructions yields a developmental trajectory of pragmatic development: among the three targeted forms of non-compositionality, the easiest to handle is apparently irony, then comes metaphor, and eventually humor, for which a number of social and contextual situational, and cultural factors need to be considered in order to explain full productivity (Colston-Gibbs 2002, Pexman et al. 2005).

Since in the case of irony the comparison to be drawn is based on conflict of meanings, a shortcut strategy seems to be employed by subjects, which also explains early success in comprehension. The Linguistic cue condition significantly facilitated interpretation, since the significant difference in the two groups' performance disappeared. The control conditions required only semantic processing, and as expected, there was no significant difference in the performance of the two groups.

Irony is apparently easier for preschoolers than metaphor, due to its distinctive features (ironical tone of voice, mocking attitude, normative bias) which function as ostensive cues

(Csibra 2010) and trigger the shortcut strategy (Györi et al. 2002) based on a heuristics of taking the opposite meaning (Fig. 9.).

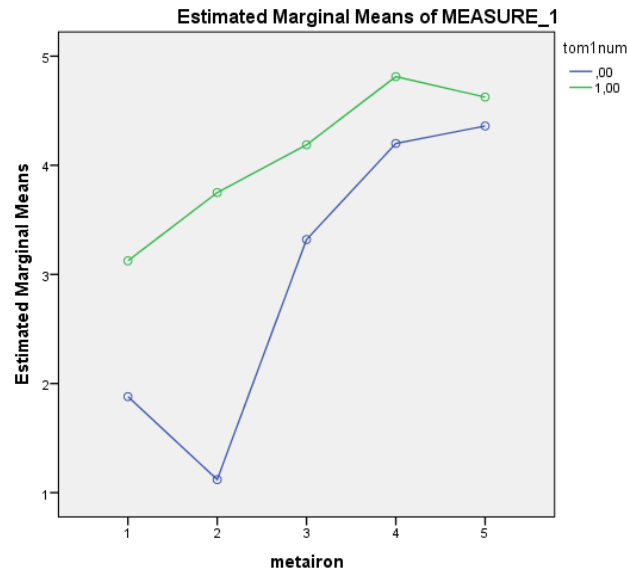


Fig. 9.

Metaphor vs. irony processing in view of mentalization

Lower line (00): NoToM, Upper line (1,00) ToM group

1- Decontx. Metaphor; 2- Context. Metaphor; 3- Irony, 4- Irony with surface cue; 5- Control task (irony condition)

Significant differences were found in the performance of the two groups in the irony task, confirming the key role of ToM in irony processing. ToM group was significantly more successful in the irony task than the NoToM group. Mann Whitney $U=115,5$; $p<0,01$. In the irony with surface cue condition no significant difference was found between the performance of the two groups $MWU=150$; $p= .104$; Contextual cues made the mental state of speaker explicit, thus, semantic interpretation suffices (Csibra 2010); and also in the control condition, the No-ToM group was equally successful as the ToM group. $MWU=186$; $p= .664$. since in these scenarios no human agents participated and thus children did not have to mentalize about intentions and intended meanings. A pure semantic interpretation suffices.

Apparently metaphor is more complex, probably due to the emergent properties involved in metaphors, where comparison is based on an optimal relevance based traits of similarity, making it a more graded conceptual phenomenon (Colston-Gibbs 2002, Wilson – Carston 2006). The findings reveal that metaphor and irony performance of the ToM and NoToM group differ significantly. Metaphor is more difficult than irony. $p<0,01$; mean: 2,503; (F) 4,156=44,305 Mixed Way ANOVA. Context facilitates comprehension – in ToM

group contextual stimuli was decoded with more success; which supports Cognitive Congruence (Zigler et al. 1966).

Irony also proved to be easier to process than humor, which is again indicated to be a more complex competence where incongruity is not purely linguistic but often broader, rather contextual, based on social-constructions and cultural patterns that come with socialization and with age, thus delegating productivity in humor comprehension to early school years (Gibbs 1994, Pexman et al. 2005). The Irony with linguistic help trial also confirmed findings of the facilitating effect of contextual cues in interpretation. Eventually a continuum of pragmatic phenomena is drawn up reflecting the levels of cognitive difficulty and mentalization based inferential activity required in each pragmatic phenomenon. The pyramid thus formed reveals the order of the emergence of the examined non-compositional constructions in development, from similes, through metaphor, irony, to humor.

5. Mentalization and the recognition of the infringement of the Gricean maxims

The findings on preschoolers' conversational skills in view of their mentalization abilities, testing success in the recognition of the infringement of the Gricean maxims indicated that children have an awareness of the maxims before they fully understand that these maxims can in fact also be infringed on purpose, creating implicatures deliberately with the intention to convey implicit meaning. The success rates of the two ToM groups did differ significantly in 3 out of 4 maxims, i.e. in 75% of the cases, in the Quantity, Relevance and Manner tasks. The ToM group reached the lowest scores on the Quantity maxim infringement task (see Table 1. and Fig. 10a.) which further supports the well known tendency for preschoolers and children to demonstrate a universal difficulty in the acquisition and productive use of quantifiers in language- and conceptual development (Musolino-Lidz 2006) and the ToM alone is not sufficient in the mastering of quantifiers, the competence stabilizing in early school years.

Maxims	ToM group success in %	NoToM group success in %
Quantity	71%	44%
Quality	78%	68%
Relevance	90%	67%
Manner	82%	56%

Table 1.

Recognition of the infringement of the Gricean maxims in view of mentalization skills

In the Quality maxim task the difference was not significant, which may be explained by the predominant magical thinking at this age. The 75% predictive force of ToM in the recognition of maxim infringement proves that ToM plays a significant role in this conversational ability (Fig. 10a). This yields a general trajectory of the cognitive effort required for the smooth handling of the maxims (Fig. 10b.).

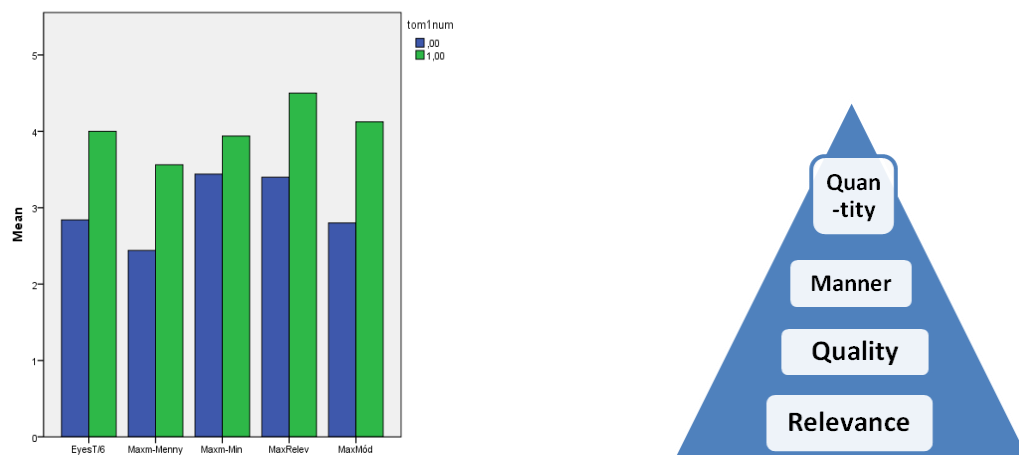


Figure 10a,b.

Results and trajectory of the Maxim infringement task in view of mentalization

In the case of the maxim of **Quantity** infringement recognition, the NoToM group was significantly less successful: $p = .028$; $U = 120$ $r = .34$ in rejecting those utterances that violated the maxim of quantity.

In the case of the recognition of the maxim of **Quality** the difference in the performance of the two groups in this trial is apparently not significantly different: $p = .142$; $U = 147,5$ $r = .22$.

As for the maxim of **Relevance**, the recognition success of the ToM group was significantly higher $p = .003$ $r = .46$ value suggests that the difference in the performance of the two groups is significant; $U = 93$; i.e. the ToM group was significantly more successful in recognizing Relevance maxim infringements in conversation.

The difference in the performance of the two groups is the second most pronounced in the maxim of **Manner** trial: $p = .008$; $U = 103,5$ $r = .41$, suggesting that the group relying on theory of mind skills are apparently significantly more successful in recognizing if the speaker violates the maxim of manner in conversation, i.e. fails to stay clear and orderly in their utterances.

The NoToM group was around chance in the recognition of the infringement of the maxims, which suggests their awareness, while the ToM group was significantly more successful in the majority (75%) of the maxim tasks, approaching productive conversational skills which stem from productive mindreading abilities.

The findings of the experimental pragmatic investigation suggest that the order of the ability to follow the maxims is very varied in development, emerging and reinforcing in several stages, where after awareness children actually develop an ability to apply such knowledge and understand the principles of intentionality based infringements in conversation. The maxims are not in place until early school years, hence forming the ultimate two levels of the trajectory of the development of pragmatic competence, together with contextual metaphor and contextual humor. The maxim of Relevance seems to play a key role, bringing along the rest of maxims, confirming Sperber-Wilson's (1986) view that the three maxims can be integrated into that of Relevance, which functions as a universal cognitive principle in the working of the human mind. The pyramid, completed with the maxims yields a detailed continuum of pragmatic development in view of mentalization skills (Fig.8b).

The recognition of the infringement of the quantity maxim is the last to finally be in place, in line with the findings of a number of studies on why children are universally unsuccessful in the productive use of quantifiers. In the Quantity maxim's case preschoolers seem to follow the principle of pragmatic tolerance (Katsos-Bishop 2011), in that they tend to accept these infringed utterances in a binary evaluative setting, and do not instantly reject them.

6. Full trajectory of non compositionality in view of mentalization skills and effort required

In the case of humor incongruity is probably not at the linguistic and conceptual level only but it is deeply embedded in a social, cultural, context. Therefore, such socio-cultural incongruity needs to be deciphered, beyond the linguistic and cognitive levels. This may explain its observed level of difficulty in the trajectory of pragmatic development (Fig 11).

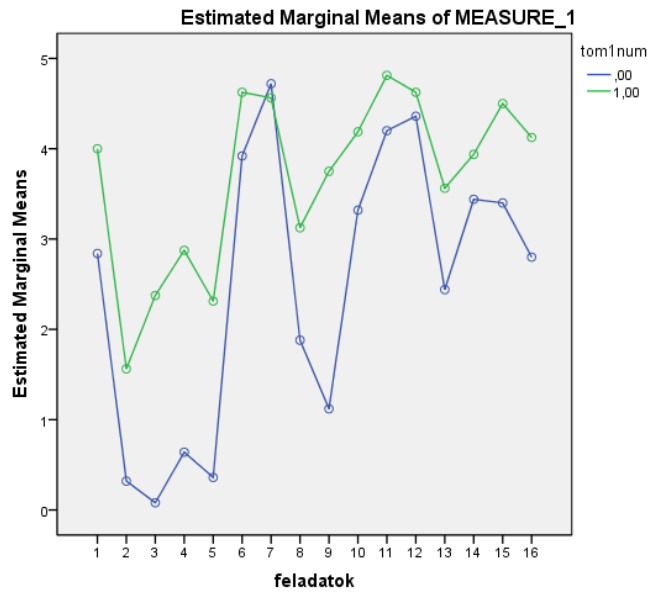


Figure 11.

Synopsis of results in one chart – Bird’s eye view on pragmatic development

Lower line: NoToM group, Upper line: ToM group.

1 - Eyes test	9. Contextual METAPHOR
2. Decontextualized HUMOUR (One-liners)	10. IRONY
3. Decontextualized HUMOUR (Riddles)	11. IRONY with linguistic help
4. Contextual HUMOUR (jokes ending in punch line)	12. CONTROL task in irony condition
5. Non verbal HUMOUR (visual) (NV)	13. MAXIM of Quantity
6. Decontextualized SIMILE	14. MAXIM of Quality
7. Contextual SIMILE	15. MAXIM of Relevance
8. Decontextualized METAPHOR	16. MAXIM of Manner

The results of the secondary ToM test almost fully overlapped with those of the first order ToM test, suggesting that those who can think with one other head can also think with two heads. This suggests that mentalization is not quantitatively determined but rather in a qualitative aspect: a basic level of *representation* forms the basis for a higher level *attributional* ability, followed by the ability to *apply* and execute mental states, enabling the person to integrate behavior and social cognitive aspects of human communication (Abu-Akel- Shamay-Tsoory 2011, Wilson 2009, 2013) see Fig. 12).

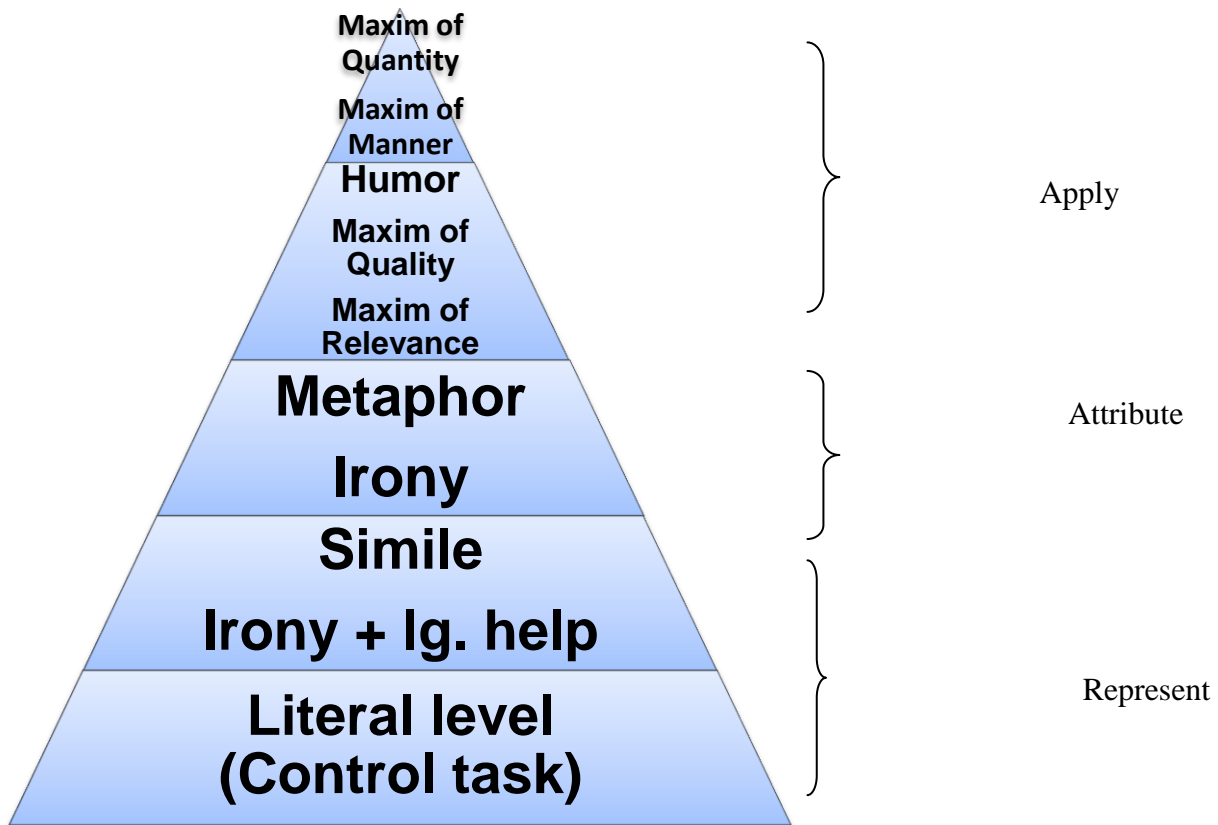


Fig 12.

The entire continuum of the development of pragmatic competence incorporating the suggested order of acquisition of the maxims, in view of mentalization effort required

7. Neuropragmatic investigations

7.1. Irony processing and pragmatic deficit in schizophrenia

In line with the developmental study, the neuropragmatic investigations also target a form of polysemy with high pragmatic relevance: irony comprehension, and its relations to the mentalization deficit in schizophrenia.

Methodology: The methodology aligns to that of the developmental study. Verbal tests of first- and second order ToM were administered (see App.), and investigate the relationship between the mentalization deficit found in schizophrenia, along with the irony comprehension difficulties in the condition. The study employed linguistic tests targeting different aspects of pragmatic competence as in the developmental study (metaphor, irony, humor and maxim

infringement recognition) (see App.). The findings indicate that schizophrenic patients performed significantly worse in the irony comprehension task than healthy controls.

The fMRI data analysis also revealed that the two groups had markedly different brain activation patterns. The control group presented activations mainly in Theory of Mind related brain areas and in regions associated with non-literal language processing, while patients activated regions associated with semantic and auditory processing. Patients were significantly less successful in irony comprehension. Our hypothesis was confirmed by the finding that the patients' group performed significantly less accurately in the irony(I) condition, compared to healthy subjects. Schizophrenic patients showed considerably greater activity during the processing of the context phase of the irony task than healthy subjects (see Fig.13, panel A). In the processing of the ironic statement of the irony task brain areas show significantly greater activity in healthy subjects than in patients (Fig. 13, panel B). During the context phase of the irony task the activations of the patients group differed significantly from the activations of the control group (Fig. 13 panel A), proving the existing alteration/impairment of the processing of the social context by schizophrenic patients.

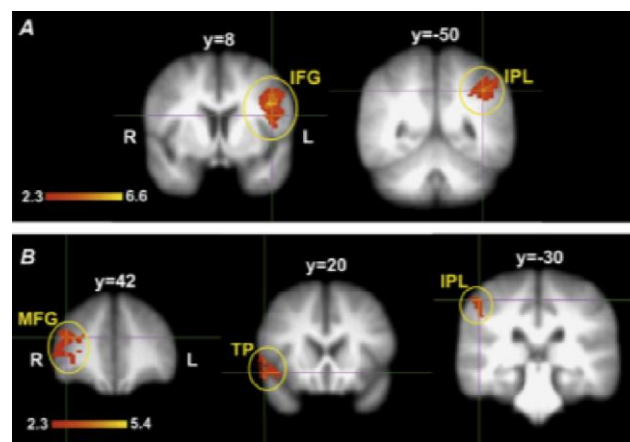
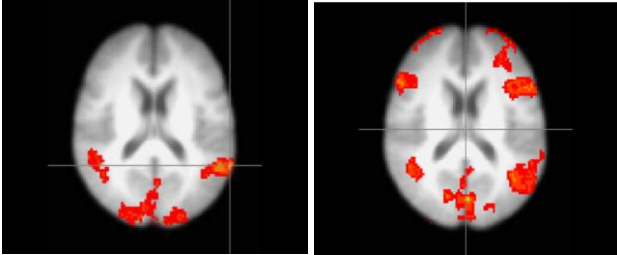


Fig. 13.

Panel A: Between-group comparison of the context phase of the irony task. Brain areas show significantly greater activity in schizophrenic patients than in healthy control subjects. Panel B: Between-group comparison of the ironic statement phase of the irony task. Brain areas show significantly greater activity in healthy control subjects than in schizophrenic patients. L left, R right, IFG inferior frontal gyrus, IPL inferior parietal lobule, MFG middle frontal gyrus, TP temporal pole. Source: Varga et al. (2013).

The integration of social context (Sperber and Wilson 1986, Wilson 2009) is essential for irony comprehension so as to be able to represent the speaker’s mind and to recognize that the actual intention expressed by the speaker is contrary to the literal meaning of the utterance at hand and expresses a mocking attitude about an attributed thought. Our results show that during processing of the social context of the irony tasks, the control group (CG) activated the TPJ (reaching also the precuneus) (Fig. 14), while schizophrenic patients (patients’ group: PG) activated a more widespread brain network including not only the TPJ/precuneus but also several frontal, temporal, as well as parietal brain regions (Fig. 15).



Figures 14 and 15 showing activation patterns in CG (14) and PG (15) during irony processing

During the processing of the ironic statement phase of the irony tasks (where we suppose the mentalizing network would engage) healthy subjects activated brain areas associated with mentalizing, and importantly, the precuneus we hypothesize to be the meta-module (Sperber-Wilson 2002) responsible for inferential meaning construction and for pragmatic processing (Schnell et al. 2016), was also engaged and activated in control subjects (Fig. 16). Conversely, while the control group showed widespread activations in several ToM related areas during the interpretation of the ironic statement of the irony task, patients, in the same setting, activated mainly those regions, which are classically associated with semantic processing, proving, that no pragmatic inference based mentalizing activations occurred (Fig. 17).

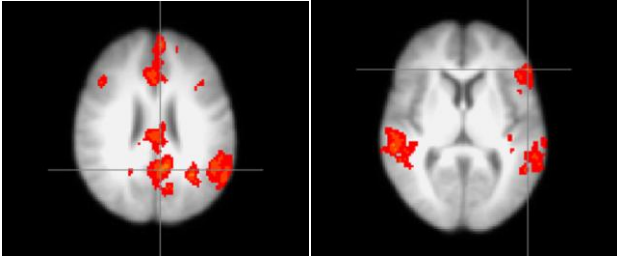


Figure 16 and 17

Activation patterns of CG (16) and PG (17) during irony processing involving the ToM circuit and the precuneus (16), while PG activated areas mainly responsible for semantic processing

In the between-group differences, patients showed significantly less activations in several brain areas associated with mentalizing, compared to the control group (Fig. 13, panel B), which suggests disturbed mentalizing abilities in schizophrenia.

Linguistic cues enhanced comprehension significantly in the patient group. After the insertion of a short linguistic help, which rendered information embedded in the linguistic context more explicit, revealing the speaker's implicit mental state (thus unfolding implicatures), patients responded significantly more accurately in the irony trials, which enhanced their irony comprehension, and the statistically significant differences between the patients' and the healthy controls' groups disappeared. Due to the insertion of the linguistic help, patients' activation patterns also became similar to that of healthy subjects, activating the ToM network, including the precuneus (Fig. 18, 19).

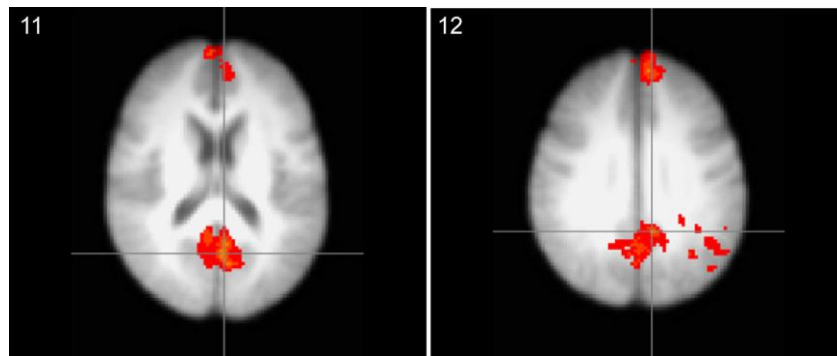


Figure 18 and 19

Within-group activations of schizophrenic patients during the ironic statement phase of the irony with linguistic help tasks (Fig.18), and within-group activations of the control subjects during the ironic statement phase of the irony with linguistic help task (Fig. 19).

The linguistic cue condition also supports the facilitating effect of context in interpretation, and highlights the crucial role of mentalization in deciphering speaker's intentions as a basis of successful pragmatic meaning construction. All in all, the results of our neuropragmatic study support the crucial role of mentalization in the success of irony comprehension, revealing deficient irony comprehension due to a mentalization deficit in schizophrenia.

7.2. Mentalization deficit as a source of pragmatic deficit in schizophrenia in patients with good neurocognitive skills

The second neuropsychiatric investigation centered on the compensatory effect of good neurocognitive skills, where patients with higher IQ proved to be more successful in some pragmatic phenomena due to their compensatory strategies stemming from general cognitive skills. The activation of such strategies is necessary to compensate for the insufficient or lacking ToM competence. The compensatory strategies were efficient in some instances of pragmatic comprehension, like in the case of certain types of metaphors, but proved to be insufficient in the maxim recognition trial. This again proves that a certain level of mentalization suffices for the comprehension and productive use of certain pragmatic phenomena, but not in cases requiring the application level of mentalization, i.e. a higher level pragmatic competence like the recognition of the infringement of conversational maxims. This proved to be difficult for both the low, and even for the high IQ patient groups, despite the latter's activated compensatory strategies.

Our results showed that schizophrenics with lower-IQ were able to understand conventional metaphors presumably relying on their good semantic processing, while they were impaired in the comprehension of unconventional metaphors and irony. However, the higher-IQ schizophrenia subgroup was able to comprehend not only conventional metaphors, but also unconventional metaphors and irony, supposedly using IQ-dependent compensatory mechanisms. Interestingly, both the lower- and the higher-IQ schizophrenia subgroups showed significant impairment in the comprehension of the ToM question of the Gricean implicatures and the patients' IQ had no significant impact on the comprehension of such ToM questions. We believe that the higher level mentalization named *application* of mental states is necessary in the maxim infringement recognition task (Fig. 12), requiring complex conversational skills and the application of mental states and representations, thus mere *representation* (1st level) and *attribution* (2nd level) of mental states does not suffice.

In conclusion, our findings assume a possible compensatory effect of general cognitive skills on non-literal language processing in schizophrenia. We also argue for the importance of using more complex ToM tasks in order to detect the existing ToM deficit in schizophrenic patients with good cognitive skills.

This backs up the main tenet of the present study that there are components of mentalization in line with levels of linguistic, pragmatic complexity: *representation*, *attribution*, and eventually *application* of mental states as higher-order mentalization ability,

each corresponding to a certain level of pragmatic phenomenon. Both the developmental and the neuropragmatic study indicates that application of mental states is a more complex ability, appearing later in development, just like its linguistic counterparts that are in place later in development. The ‘application’ based pragmatic comprehension tasks (i.e. humor processing and maxim infringement trials) are significantly more difficult for schizophrenic patients, where even high IQ patients with compensatory strategies fell short in performance. In line with this, in the developmental dimension, these are aspects of pragmatic competence that are in place later in development, beyond preschool, in early school years. All in all, these findings of the neuropragmatic studies are in line with results of the developmental studies, enhancing the validity and the reliability of the investigations and reciprocally supporting each other in several aspects.

8. Language and mentalization: a bidirectional relationship

On the relationship of language and ToM the findings indicate that there is ToM before language, since basic mindreading abilities are crucial in identifying and narrowing down meaning in word acquisition. After that, symbolic abilities enable the child to rely on language, which functions as a representational medium, thus gains an important role in cognitive development. In the language acquisition up to two years of age apparently cognitive development sets the stage for language development, in which basic mentalization skills (i.e. the precursors and components of a fully fledged ToM) help us find the mappings between the physical world and language. In this stage gaze following, shared attention help the anchoring of referents, thus give us words with which to identify events and entities in the physical world. These words then function as labels, and language practically provides a medium for representations, further catalyzing cognitive development. Word learning facilitates the building of categories, a detailed mental lexicon, hence our autobiographic memory crucial in the creation of narratives and complex pragmatic settings. The results of the present study are therefore, in harmony with De Villiers’s (2007) concept on a bidirectional relationship of ToM and language: first it’s ToM that provides basis for an elementary level of language use where the child becomes able to represent thoughts, mental events and thus get around in the social world. Then ToM abilities are necessary for a productive pragmatic competence, and efficient discourse organization. In other words, ‘there

is ToM before language, (a basic level semantic language use), and there is pragmatic competence beyond ToM'.

As outlined above, higher order language use, namely, pragmatic competence requires higher order mentalization skills, since in a discourse setting rich in context-dependent meanings and interpersonal relations several factors play an important role in the interactive process of meaning construction. For this the ability to change perspectives, identify subtle differences in others' minds and the content of their minds is crucial: the interpretation of utterances is based on the successful deciphering of the intention behind the given utterance. In this process we rely on our inferential skills, for which a mature ToM seems to be indispensable.

In sum, ToM in the beginning furthers language development, which in turn at some point (with complex syntactic abilities in preschool years) furthers ToM development, which in turn furthers (at around age 5) a higher-level language use, namely pragmatic competence, in which some aspects are fully ensured by ToM (basic and conventional types of metaphor, contextual conversational irony), some still need further cognitive development (quantifiers, conversational maxims on quantity) and socio-cultural experience (manner maxim understanding, complex discourse organization skills, humor), which mature in early preschool years (Schnell in press).

9. Contributions of the study to research in cognitive science

The present investigation aimed to contribute to the resolution of a number of long-standing debates in cognitive linguistics and developmental psycholinguistics. With its novel approaches in research methodology, it aims to clarify boundaries of metaphor, irony and humor, testing humor in spontaneous settings, in both verbal and non verbal modalities, not only through pre-fabricated jokes commonly administered. It also examines all the four maxims concurrently, shedding light on the developmental implications of their acquisition and understanding. It relies on neuroimaging based experiments in trying to explain the relationship of mentalizing skills and pragmatic competence in general, and of difficulties of irony processing in schizophrenia stemming from a mentalization deficit in the disorder in particular (Varga et al. 2013, 2014, Schnell et al. 2016, Varga et al. 2016). It also entails a potential for creating a therapeutic training material in neurocognitive disorders with the aim of reintegrating the patient, given that it shows how surface cues can enhance success of

comprehension in instances of pragmatic constructions based on mentalization and idiomaticity. The testing material provides a comprehensive pragmatic test (to be standardized) which can be used as a clinical measure of general pragmatic competence in several neurocognitive impairments and neuropsychiatric disorders (DS, WS, SLI, ASD) currently not available, functioning as a differential diagnostic measure in research.

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Appendix

1. ToM tests:

Verbal – First-order ToM test:

ToM question: **Where will the Brown Bear look for the honey?**

Memory question: **where did the Brown Bear put the honey in the beginning?**

Reality question: **Where is the honey now?**

Verbal second-order ToM question:

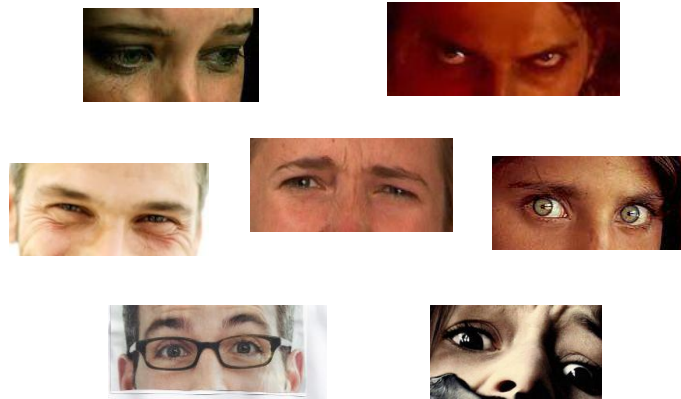
Where does the White Bear think that the Brown Bear thinks the honey is?

2. Eyes test story:

Peter and Dorothy got a puppy for Christmas. They were so happy, they even slept with it! One day when they woke up, they did not find their favourite puppy. “It must have got lost!” – they thought.

How did Peter feel the morning he didn't find his puppy? (Which picture shows his eyes?) (Child has to point at the picture).

Eyes Test (Schnell 2011)
6 basic emotions



3. Simile / Metaphor tasks (Schnell 2007, Happé 1993, p. 119, Gibbs 1994)

3/A. Simile condition

a.) Multiple choice test

- 1) The dog was so wet. It was like...(*a walking puddle*).....
- 2) Carol glared at Nicola. She was so cross. Her eyes were like.....(*daggers*).....
- 3) The night sky was so clear. The stars were like.....(*diamonds*).....
- 4) Simon just couldn't make Lucy understand. She was like.....(*a brick wall*).....
- 5) Caroline was so embarrassed. Her face was like.....(*beetroot*).....

Choose one item from the following list to complete each sentence:

a brick wall
dresses
daggers
a beetroot
a walking puddle
diamonds

b) Story ending

1.

Johnny's grandpa was a very nice old man. He loved his family, and always took little Johnny fishing to the lake and helped him catch fish for dinner. Johnny always ran ahead, he was so happy to go, but grandpa could not be jumping with joy, but he walked very slowly because he was **old as the hills**.

Q: What was Johnny's grandpa like? Why couldn't he run? Why is he like the hills?

3/B. Metaphor condition

a.) Multiple choice test.

- 1) The dancer was so graceful. She really was.....(*a swan*).....
- 2) Father was very very angry. He really was.....(*a volcano*).....
- 3) Michael was so cold. His nose really was.....(*an icicle*).....
- 4) John was very clever and tricky. He really was.....(*a fox*).....
- 5) Ann always felt safe with Tom. He really was....(*a safe harbor*).....

Choose one item from the following list to complete each sentence:

an icicle

a fox

a safe harbor

a hat

a swan

a volcano

b) Story ending

1.

Johnny is helping his mother make a cake. She leaves him to add the eggs to the flour and sugar. But silly Johnny doesn't break the eggs first – he just puts them into a bowl, shells and all! What a silly thing to do! When mother comes back and sees what Johnny has done, she says:

“Your head is **made out of wood!**”

Q: What does Johnny's mother mean? Does she mean Johnny is clever or silly?

4. Humor tasks

One-liners (example):

Jean (chamberer) and his Landlord:

Landlord: Jean, could you plug in the cow, please?

Jean: Why, Sir?

Landlord: Because I want to drink boiled milk.

Riddles (example):

- Why didn't the skeleton cross the road?

– It didn't have the guts.....

Non-verbal humour tests



Jokes

A guy is sitting at home when he hears a knock at the door. He opens the door and sees a snail on the porch. He picks up the snail and throws it as far as he can. Three years later, there is a knock on the door. He opens it and sees the same snail. The snail says, "What the hell was that all about?"

5. Irony tasks

Irony condition: Peter and Kate go to a dance party. Peter asks Kate for a dance, but he constantly steps on her toes. Kate says to him: Well, you dance very well, my dear! What does Kate mean by this? Does she think Peter does not dance well?

We tried not to influence children's decisions and avoid the priming effect by identical questions on the ironic remark: we used positive and negative questions interchangeably, mixed ("Does Kate think Peter dances well / is strong / etc..."? In other cases the negative version: e.g. "Does Kate think Peter does not dance well / is not strong / etc..."? This way children did not get used to constantly answering "no" or "yes" answers, but were really made to think the story and the ironic statement's meaning over.

In the linguistic help condition the speaker's utterance is put with the formulation of their mental state: Kate **angrily** / **disappointedly** said "Well, you dance very well, my dear!" In this condition children could guess, from the explicit mental state of the speaker how they felt and how they meant the utterance, i.e. that the intended meaning is somewhat negative.

Irony – control condition: In this condition there was no ironic remark, and no living agents that require mentalization. These tasks consisted of pure descriptions of physical events, and their function was to make sure the child understands the standardized syntactic structures we used in all three tasks (the control condition's stories strictly and exactly mirrored the length and complexity of the irony tasks), therefore, it served as a control condition (similarly to the Simile task in the Simile/Metaphor condition).

Example: There is an apple tree and a plum tree in the garden. A strong wind comes and it blows so hard, all the fruits end up on the ground, none stays on the trees.

Question: Does any fruit stay on the fruit trees after the storm?

6. Pragmatics: Infringement of Maxims (adapted for children)

Quality

A: **Where do you live?**

B: I live in Pécs, in the downtown area.

C: I live on the Moon with my little pony.*

Quantity

A: **What would you like for dinner?**

B: Food.*

C: I'd like to have a hot dog with mustard.

Manner

A: **May I draw with your pencils?**

B: No, because you cannot draw, that's why. *

C: I am sorry, I am using them myself but I can give you my pen right now.

Relevance

A: **What is your favourite animal?**

B: I like the giraffe best.

C: I don't like rain.*

7. Neuropragmatic investigation – irony processing in schizophrenia

7.1. Irony task sample:

1. Irony: Joe went home from school and told his father that he had failed his math test. His father said: Oh boy, *you just made my day!*

Did Joe's father really think that Joe made his day?

7.2. Irony with linguistic help task sample:

1. Peter helps Tom repair his car. Peter takes out a screw and it incidentally falls into the service tank. *Tom angrily remarks: You really are a great help!*

Does Tom think that Peter isn't much help?

7.3. Control task sample:

1. It's been raining all day. There is so much water flowing down the water-spout that it floods the whole yard. The huge amount of water renders the entire yard heavily muddy.

Does the yard stay dry after the day-long rain?

8. Compensatory effect of general cognitive skills (task samples)

8.1. Conventional metaphor

Peter is a good runner. One day, as he races with Leslie, Peter wins. After the race Leslie says: - *Peter, you are a real rabbit!*

Q.: Does he mean Peter is a real rabbit?

8.2. Unconventional metaphor

Steven finds it hard to bring a decision in his everyday life. One day John and Judy invite him to the movies, but he can not make up his mind, whether to join them or not. Finally, he brings a decision too late, and they miss the movie. Judy says:

- *Steven, you are a ship without a captain!*

Q.: Does he mean....?

8.3. Irony

Joe and Mike are moving to a new apartment. When Joe tries to pick up the wardrobe, he cannot move it one bit. Mike says: (*Hey*) *You are strong!*

Q.: Does he mean...?

8.4. Quality maxim infringement generated implicature

Jane and Peter are having a conversation about Peter's dinner the previous night. Jane asks Peter about the food he had in the restaurant. Peter answers:

- *I ordered two big pigs and I ate them all.*

Q1: Is this response strange or unusual to you? Why?

Q2.: (ToM question part) What did the speaker mean by this?

8.5. Quantity maxim infringement generated implicature

Judy asks Michael what he would like for dinner. Michael says:

- *Something to eat.*

Q1: Is this response strange or unusual to you? Why?

Q2.: (ToM question part) What did the speaker mean by this?

8.6. Manner maxim infringement generated implicature

Sarah asks Joe to help her put the books away. Joe says:

- *You brought them here, you go and put them away!*

Q1: Is this response strange or unusual to you? Why?

Q2.: (ToM question part) What did the speaker mean by this?

8.7. Relevance maxim infringement generated implicature

Some students are asked how they feel about their teacher. A student says:

- *He is very young.*

Q1: Is this response strange or unusual to you? Why?

Q2.: (ToM question part) What did the speaker mean by this?

8.8. Control task (no infringement)

Mary asked for Peter's guitar for the weekend. Peter says:

- *All right, you can take it.*

Q: Does Peter mean he can/cannot take it?

8.9. Semantic task

There is a piano and a bookshelf in the room. Due to a strong earthquake the bookshelf collapses and falls upon the piano, and the piano's leg breaks.

Q: Does the earthquake break the piano's leg?