Higher Order Cognition in Autism Spectrum Disorder

Seminar in Computational Psychiatry
17.10.2014

Alpha Renner
Higher Order Cognition (Brainstorming)

• Integration of multiple ideas and facts
• Generalization, Concept formation, Rule development, Classification
• Analogies
• Problem solving (non algorithmic, fridge problem vs. math problem?)
• Creative thinking
• Metacognition
• Memory acquisition
Aim of the talk

• Rough overview of the current research and most important theories
• Get insights, how cognitive functions are studied
• Raise awareness for the importance of methodological details
• Critical perspective
Cognitive theories of autism

• Weak central coherence
• Theory of mind deficit (social cognition, next week)
• Executive dysfunction (e.g. cognitive inflexibility)

• (Implicit learning)

To assess the quality of a theory, 3 important questions need to be asked:

• Does autism arise from a domain-specific factor or are multiple factors involved? → Specificity

• Are the factors unique to the disorder or is it also involved in other developmental disorders? → Uniqueness

• Are the factors found in every individual with autism or just in the majority? → Universality

Executive functions

• Historically: Analysis of PFC-Damage
  → but today not only associated with PFC function

Symptoms that are similar to those shown by individuals with Dysexecutive Syndrome (frontal lobe damage):
Need for sameness, difficulty to switch attention, tendency to perseverate and a lack of impulse control
Executive functions

- Umbrella term for regulation and control of cognitive processes
  - Processes needed for goal directed behaviour:
    - initiating, sustaining, shifting and inhibition
  - Associated with: planning, cognitive flexibility, problem solving, self-monitoring, working memory...
  - Tasks to assess EF: e.g. unexpected transfer task (intentionality), Stroop test (Inhibition), Rule Shift Cards (executive memory)

- An influential cognitive theory of autism claims that symptoms arise from executive function deficits
• One problem in determining the prevalence of executive deficits in autism is that most studies focus on group differences, without reporting individual variations (Liss et al., 2001)

• Individuals with Attention Deficit Hyperactivity Disorder (ADHD), Schizophrenia, Obsessive Compulsive Disorder and Tourette syndrome perform similarly to autistic individuals on some tests of executive function

• There are studies that suggest that autism involves a specific deficit in cognitive flexibility, while inhibition remains relatively less affected
Executive functions - Conclusion

There is an executive dysfunction in ASD Patients, but there is no consensus which aspects are typically impaired (it seems to be quite consistent over specific tasks but not over the chosen dimensions)

→ EF-theory is not specific, not unique and not universal
Cognitive flexibility

• component of executive function
• ability to shift to different thoughts or actions depending on situational demands

• believe that cognitive flexibility deficits are a characteristic of autism spectrum disorders.
• in every day life, behavioral inflexibility seems obvious, but can this be attributed to cognitive inflexibility and measured experimentally?

### DSM-IV-TR symptoms of autism per domain

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<thead>
<tr>
<th>(a) Qualitative impairment in social interaction</th>
<th>Potential relationship with cognitive flexibility</th>
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<tbody>
<tr>
<td>(i) Marked impairments in the use of multiple nonverbal behaviors such as eye-to-eye gaze, facial expression, body posture and gestures to regulate social interaction.</td>
<td>Inability to shift visual attention from eyes to mouth, from one speaker to another speaker.</td>
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<td>(ii) Failure to develop peer relationships appropriate to developmental level.</td>
<td>Inflexible in application of social rules (social rigidity).</td>
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<td>(iii) A lack of spontaneous seeking to share enjoyment, interests or achievements with other people (e.g. by a lack of showing, bringing or pointing out objects of interest to other people).</td>
<td>Inability to shift social behavior or conversational topics to meet the changing contextual demands.</td>
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<td>(iv) Lack of social or emotional reciprocity (e.g. not actively participating in simple social play or games, preferring solitary activities or involving others in activities only as tools or ‘mechanical’ aids).</td>
<td>Inability to shift attention to extra-personal space. Difficulty in shifting to another person’s perspective.</td>
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<th>(b) Qualitative impairments in communication</th>
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<td>(i) Delay in, or total lack of, the development of spoken language (not accompanied by an attempt to compensate through alternative modes of communication such as gesture or mime).</td>
<td>Inability to flexibly combine language elements into fluent language. Lack of broadening of complexity level of language.</td>
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<td>(ii) In individuals with adequate speech, marked impairment in the ability to initiate or sustain a conversation with others.</td>
<td>Inability to shift to another person’s perspective. Talking about topics of own interests (i.e. inability to shift to other topics) and not knowing when to stop (i.e. perseverating).</td>
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<td>(iii) Stereotyped and repetitive use of language or idiosyncratic language.</td>
<td>Perseveration on one specific meaning of words. Impaired flexibility of thought to interpret words in an alternative way. Repetition of words and sentences. Inflexible use of language.</td>
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<td>(iv) Lack of varied, spontaneous make-believe play or social imitative play appropriate to developmental level</td>
<td>Perseveration on one type of activity (i.e. inability to shift to different, pretend or unreal view of the world).</td>
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<th>(c) Restricted repetitive and stereotyped patterns of behavior, interests and activities</th>
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<td>(i) Encompassing preoccupation with one or more stereotyped and restricted patterns of interest that is abnormal either in intensity or focus</td>
<td>Perseveration on a specific topic; cannot move away from one interest, overly focused on one specific aspect.</td>
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<td>(ii) Apparently inflexible adherence to specific, nonfunctional routines or rituals</td>
<td>Insistence on routines and rituals.</td>
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<tr>
<td>(iii) Stereotyped and repetitive motor mannerisms (e.g. hand or finger flapping or twisting, or complex whole body movements)</td>
<td>Perseveration expressed in motor movements.</td>
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<tr>
<td>(iv) Persistent preoccupation with parts of objects</td>
<td>Difficulties in shifting attention, disengaging attention from details (i.e. hyperfocus).</td>
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Wisconsin card sorting task (WCST)

- Requires participants to determine how to sort cards on the basis of unknown categories (color, form and number) based on feedback.
- Sorting rule is changed during the task and the participant has to adapt (inhibition of the old rule, finding of the new).
- People with autism have difficulties with the task.
- Possible causes: deficits in cognitive processes like learning from feedback, keeping the goal of the task in mind, noticing that a change in strategy is necessary, inhibiting a previous motor response, switching to another response and sustaining responding over time.

Indistinguishable by standard methods
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→ indistinguishable by standard methods
Modified card sorting task (MCST)

• includes a warning that the sorting rule needs to be changed

→ no difference between autists and typically developing adults
→ knowledge of change can help people with autism
intra-dimensional/extra-dimensional shift task (ID/ED)

• more specific measure of cognitive control than the WCST
• distinctions can be made between relevant cognitive processes.
• monkey studies indicate that different regions of the PFC are recruited in the ID an ED-shifts

• attention deficits can decrease performance (co-occurrence of Autism with ADHD)

• mixed results, but mainly no difference between autists and TD.
Conclusions

• studies yield mixed results
  • Due to measurement problems
  • Heterogeneity of the autism spectrum

• no consistent evidence for cognitive flexibility deficits
  (however quite consistent deficit in single tests, like WCST)
• gap between the day-to-day behavioral flexibility and that measured with cognitive flexibility tasks
→ paradox between cognitive and behavioral inflexibility

• behavior has to be decomposed in measurable cognitive processes
  • understand the behavioural problems
  • eventually provide targeted treatments
“Call to action”:

• comparison groups: comparison with individuals of other neurodevelopmental disorders, not just typically developing people
• sample sizes: larger studies necessary
• tasks: no clear mechanistic hypotheses that can be tested → Need of detailed measures derived from theoretical frameworks and not till then on the next step: link to behaviour with more ecologically valid measures
• other factors have to be taken into account in studies about cognitive deficits, as they can be serious confounds and could explain the mixed results, like social-motivational factors, stress, etc.
Implicit Learning

“Learning, that takes place without awareness”

“Learning, that proceeds from practice with any structural environment in the absence of an intention to learn”

ASD: Social, communicative and motor impairments

→ Implicit learning is an important mechanism for acquiring those skills
→ So, maybe the deficits can be explained by a deficit in implicit learning

How to measure implicit learning?

4 Tests used in the paper:

- Contextual cueing (CC) task (perceptual processing)
- Serial reaction time (SRT) task (motor coordination)
- Artificial grammar learning (AGL) task (language)
- Probabilistic classification learning (PCL) task (social)
Contextual cueing (CC) and serial reaction time (SRT)

RT differences between high- and low-frequency contexts (CC) resp. probable and improbable trials (SRT) → Higher time difference means better implicit learning → No evidence for group differences

Artificial grammar learning (AGL)

Finite state grammar
Possible strings: PTTVPS, TSXTTVV
Probabilistic classification learning (PCL)
Confounds and problems

• IQ
  • Implicit learning performance has been shown to be unrelated to IQ, explicit learning is strongly correlated
  • Not matching IQ might be a reason, why other studies have found a deficit in implicit learning in ASD, but as Implicit learning is uncorrelated, this is not probable
  • The authors assume that the discrepancies result from differences in the particulars of the tasks, i.e. they allowed for greater use of explicit learning strategies (e.g. long inter stimulus intervals and deterministic sequences).

Results cannot be generalized over subgroups of ASD, as participants had mainly high-functioning autism.
Conclusions

• Implicit learning is not related to ASC Symptoms (SQC)

• Impaired Implicit learning is not the reason for social, motor or communicative deficits

• However it is possible, that under “real world conditions”, other processes could disrupt the implicit acquisition or application of language, motor or social skills:
  • Propensity to use explicit strategies
  • Unusual attention allocation (preference for local context)
  • Impaired implicit knowledge application
  • Impaired long term consolidation of skills (sleep difficulties in ASD)
Weak Central Coherence theory

• Theory that claims to explain many facets of autism: Can explain social as well as non social features of autism

• Typically developing individuals process information by extracting overall meaning or gist, whereas weak central coherence refers to the detail-focused processing style that characterizes autism spectrum disorders

Visuospatial constructional coherence

- Autistic children perform better in Embedded Figures test and Block design test
- Additional support comes from Visual Illusions (talk 3 weeks ago) (however, here the effect seems to depend on the wording of the question)
- Frith (1989) argues that individuals with autism show better performance on these tasks lacking a cognitive drive to attend to global form → weak central coherence.

Hierarchisation

• Navon Stimuli: Stroop like stimuli (e.g. Letter H composed of small S-letters)
• global precedence: neurotypical participants experienced interference from the global to the local but not vice versa. In autistic participants there was observed additional interference from local to global.

• problems with “hierarchical organisation” in processing information?
• difficulty adjusting the spread of visual attention which leads to priority in processing the local over the global in some circumstances

Congruent (used in both selective attention conditions)  
Incongruent (used in both selective attention conditions)
Participants with autism are less accurate and slower to respond to a crosshair when the immediately preceding trial presented a smaller crosshair. 

→ can be interpreted as evidence that they have a deficit in broadening the spread of visual attention (zooming out).

Verbal-semantic coherence

Individuals with autism failed to use the correct pronunciation as they presumably did not use the context to determine correct pronunciation.

⇒ they might be reading prose as a series of unconnected lists without making the appropriate associations which might explain e.g. problems to understand communicational intention

But, alerting children with ASD to the special status of homographs removed the otherwise robustly found failure (Snowling & Frith, 1986)

Furthermore, the results are not universal, as they only occur in autistic individuals with linguistic difficulties (Norbury, 2005)

Similar results in other areas:
Participants with ASD showed configural processing of faces in attentionally cued, but not in non-cued, conditions. (Lopez, Donnelly, Hadwin, and Leekam, 2004)

Paradigm shift:
Not a deficit for wholes, but a processing bias towards features (cognitive style)
→ can be removed by attention, effort

Does this bias result from a difficulty in shifting from local to global?
→ cognitive inflexibility (executive dysfunction)
Weak central coherence does not reduce to executive dysfunction, as children with ADHD show executive dysfunction too, but not WCC (Booth, Charlton, Hughes, and Happé, 2003)
Is weak central coherence an all-encompassing theory to explain autism?

• No consistent relation between the CC measures
• Factor analysis revealed two constructs

→ No unitary cognitive style, but fragmented into many components (Pellicano et al., 2006)

→ Nowadays, the theory of WCC does not longer try to explain all aspects of autism, but it is viewed as one part of cognition in autism (Happé & Frith, 2006)

→ No single theory to explain autism → multiple deficit accounts
Multiple-deficit accounts

Creation of subgroups in autism as it is a complex of cognitive disorders: impaired theory of mind, WCC, executive dysfunction

Autistic individuals can be affected differently in these three, possibly independent, domains (Baron-Cohen and Swettenham, 1997)

→ Implications for treatment (different treatments for different subgroups)
→ Implications for research (usage of statistical techniques that allow the heterogeneity of autism to be taken into account in group studies)

So maybe there should be more autists who study ASD ;-)}
Conclusions - Challenges for study design

• Matching: Age, IQ (IQ not independent of tasks), Gender, ...?

• A significant number of individuals with autism are intellectually impaired (i.e., with IQ <70) → this might interact with other aspects of autism

• Results very task dependent

• Importance of the wording of the instruction

• Ecological validity vs. purity of the task
Conclusions

• Main cognitive theories of autism do not give specific, universal and unitary explanations
  • Study design has difficulties to cope with complexity of autism
  • Heterogeneity of autism
  • Comorbidities confound results

• Multiple-deficit accounts
  • Challenge to find “independent” dimensions of autism
  • Implications for research and treatment
Thank You!

Questions?
Literature

Weak central coherence and executive functions

Cognitive flexibility

Implicit learning