



University of
Salford
MANCHESTER

Autistic listening

Davies, WJ

Title	Autistic listening
Authors	Davies, WJ
Type	Conference or Workshop Item
URL	This version is available at: http://usir.salford.ac.uk/id/eprint/56380/
Published Date	2019

USIR is a digital collection of the research output of the University of Salford. Where copyright permits, full text material held in the repository is made freely available online and can be read, downloaded and copied for non-commercial private study or research purposes. Please check the manuscript for any further copyright restrictions.

For more information, including our policy and submission procedure, please contact the Repository Team at: usir@salford.ac.uk.

Autistic Listening

William J. Davies

Acoustics Research Centre, University of Salford, Salford, UK.

Abstract

Autism is a lifelong neurodevelopmental condition diagnosed by differences in social interaction and communication. Most autistic people also experience atypical sensory processing (e.g., a heightened sensitivity to sound or texture). Nearly all autism research uses a deficit model, where differences between autistic and non-autistic people are characterised as impairments of the autistic people. In contrast, a handful of researchers have sought and found evidence of autistic superiority. For example, Remington and Fairnie (2017) reported autistic adults to have a greater auditory perceptual capacity: they could keep track of more simultaneous sounds than their non-autistic counterparts. Moreover, anecdotal accounts from autistic people suggest that there may be much more to be discovered about autistic perceptual organization, if a deficit model is abandoned. Lay language reports from individuals suggest strengths in aural awareness, in extracting structure and patterns, in sensitivity to small changes at different scales, in identifying sounds, places and processes, and more. Exercising these abilities is sometimes associated with pleasure and a heightened sense of embodiment. This paper will briefly review anecdotal and structured evidence of autistic listening, from the perspective of an autistic psychoacoustics researcher. Future research directions and possible experiments will be suggested.

Keywords: autism, soundscape, auditory scene analysis

1. Introduction

Autism is a lifelong neurodevelopmental condition diagnosed by differences in social interaction (e.g., conversation style), social communication (e.g., eye contact) and social imagination (e.g., restricted interests). Incidence rates have risen substantially over the last fifty years, alongside increased availability of diagnosis and changes to diagnostic criteria. The current NHS prevalence is 1.1% for the UK. I use the term autism here in the same way as the current diagnostic manuals, to include all autistic spectrum conditions, such as Asperger Syndrome. Autism may be accompanied by a learning disability, but in the current diagnostic guidelines autism is independent of LD. It's notable that, although the basis of autism is neural (our brains seem to process information differently), it is diagnosed by observation of behaviour.

The majority of autistic people experience atypical sensory processing, for example a heightened sensitivity to sound or texture. Autistic sensitivity to sound is usually discussed in the literature using the framework of hyperacusis. Hyperacusis is a medical diagnosis that simply means an "unusual tolerance to ordinary

environmental sounds" (Baguley, 2003). From clinical and anecdotal accounts of sensitivity to sound, it might appear that autistic people hear everything louder. If so, one would expect that they have reduced pure-tone threshold; that is, that they could detect quieter sounds than non-autistic people. However, (Khalfa *et al.*, 2004) found that autistic children do not detect quieter sounds but instead that the loudness they perceive grows more rapidly with the intensity (level) of the sound (than it does for non-autistic children). More research is needed, but this different loudness-intensity function seems to be the basis for the reported hyperacusis.

2. Listening Model

This paper is focussed on listening, rather than hearing. To understand the difference between the two and the context in which autistic listening may differ from typical listening, it will be helpful to review a standard model of auditory processing. Figure 1 illustrates an overview of the chain of auditory processing. Auditory perception is represented as blocks, each performing a function or set of functions and passing output information

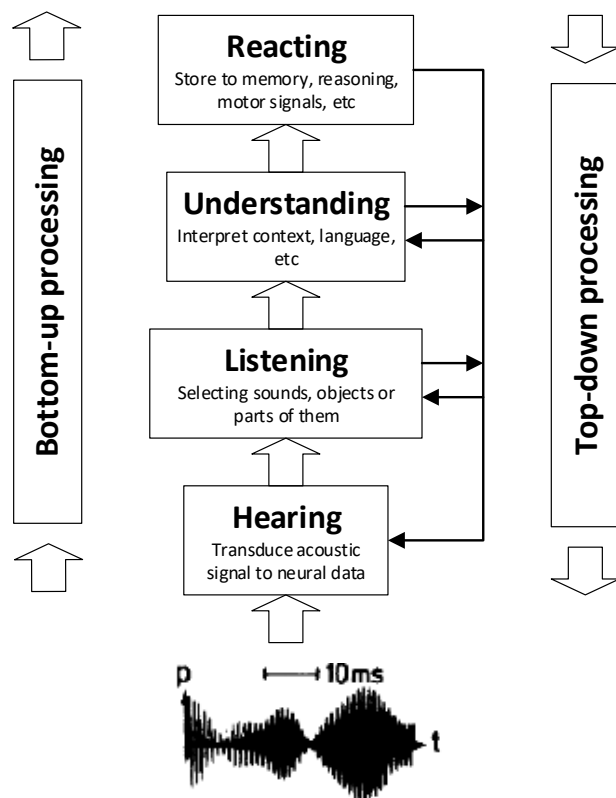


Figure 1. The auditory processing chain (after Edwards, 2007).

on to the next block. This functional representation is an abstraction from the biological reality: the blocks do not map exactly onto identifiable anatomical structures.

The first stage of auditory processing is hearing. Hearing describes the processing of sound in the ear. The inner ear (the cochlea) is responsible for turning the acoustic signal into neural data that are interpreted by the brain. This first stage is signal detection. The ear also performs low-level processing of the sound to extract information such as pitch and loudness. Subsequent stages take place in the brain.

The second stage is labelled listening. Here the incoming signal is parsed into meaningful sound objects. This part of listening is called auditory scene analysis. It allows us to take the soundscape around us and separate out the combined sound into separate parts. Often, this is primarily done at the level of sound sources. For example, we are exposed to an indoor soundscape consisting of someone speaking, room reverberation, ventilation noise and traffic noise through the window. Our brain performs auditory scene analysis to extract the speech from the reverb and separate the ventilation and traffic noise into separate signals. We can then use our powerful

attention mechanism to select one of these sounds for further, more detailed processing.

In this example, we probably selected the speech signal. Speech is a very rich signal containing linguistic information but also many indicators of the person speaking (age, emotional state, education, etc.) The higher processing of these happens in the box labelled ‘Understanding’. If we selected a different sound, perhaps the traffic noise, different processing would be applied to extract information about the context of that sound (such as speeds, distance and so on).

The top of our chain of auditory processing is labelled Reacting. This is where conscious processing begins and we respond to the rich sound information in a useful way. If we are listening to speech we are probably now reasoning and perhaps formulating our own verbal response. If we detected a car coming towards us, we are now building motor signals to move out of the way.

The auditory processing chain is often represented as a one-way system only, from the sound at the ear to the conscious response. But in fact there are several pathways from upper layers to lower ones. Two are important to mention here. The first is attention.

Attention is usually modelled as two competing processes. Top-down attention is where we select a sound to listen to. We might choose to pay attention to the speech rather than the ventilation noise (assuming the speaker is interesting enough). But our awareness can be captured by bottom-up attention. This happens when a sound is salient enough. Examples are a sudden bang, or someone speaking our name. Typically-functioning attention is usually modelled as a system which provides a very tight focus on one sound only at any one time. When we attend to the speech, we no longer notice the traffic noise.

The second bottom-down pathway is provided by the brain’s predictive model of the world. Sensing the world around us at maximum detail from moment to moment is wasteful of the brain’s resources, given that the world does not change very rapidly, most of the time. A more efficient strategy is to build an initial model of our surroundings and then predict the near future. Sensory input can then be mainly used to update the prediction. This frees up more cognitive resources for planning and reasoning.

3. Autistic auditory processing in the literature

If hyperacusis lies in the lowest block in Fig. 1, Hearing, we could ask what differences do autistic people exhibit with higher processing, in the Listening and Understanding blocks? The view of the autism research literature is almost wholly negative. Researchers have found evidence of several types of difference between autistic and non-autistic peoples' listening. Autistic listening is almost always labelled as impaired, based on the differences found, even when the deficit seems to be partly or entirely a value judgement. The literature contains evidence on pitch perception, orientation to sounds, prosody perception and processing of speech in noise.

3.1. Pitch perception

The literature is clear that some autistic people are better at judging (relative) pitch changes and are more likely to have absolute ("perfect") pitch judgement. 5% of autistic people exhibit absolute pitch vs 0.05% of the general population (Rimland and Fein, 1988). Reading this literature as an autistic researcher, it is striking that the researchers who report these results often frame them in a negative light. Suggestions include that superior pitch perception might lead autistics to focus on irrelevant stimuli, that it could be responsible for poorer performance at speech decoding or associated with worse social integration generally. (Mottron *et al.*, 1999) are one of the few groups to make the obvious observation that superior pitch perception might indicate a future in music.

3.2. Orientation to sounds

Here researchers measure the extent or speed with which autistic children turn themselves towards a stimulus that the researcher says is relevant. Sometimes the stimulus is speech, sometimes a click or tone. A typical (and highly-cited) result is provided by (Dawson *et al.*, 2004) who report that autistic toddlers are significantly less likely to interrupt their play and turn towards a "social stimulus" such as snapping fingers or humming. An alternative explanation – that the autistic toddler has a better focus on her rewarding play task – is not discussed by the researchers.

3.3. Prosody

Prosody refers to the elements of speech additional to the "words", such as changes in intonation, stress, rhythm, etc. These convey a variety of social

cues including turn-taking and emotion. Researchers find significant differences between autistic and non-autistic people in extracting this information from speech. This seems particularly clear on speech cues intended to convey the emotional state of the speaker (O'Connor, 2012). It is possible that these type of results could be re-interpreted in the light of a recent finding by (Crompton *et al.*) who found that autistic-autistic and neurotypical-neurotypical speech communication equally effective, while autistic-neurotypical communication was significantly less effective.

3.4. Speech in noise

Listening to speech in background noise is a key task for most people. Humans with unimpaired hearing typically perform this task very well, with enough intelligibility for conversation achieved when the speech is only a few dB above the noise level. Several results suggest that autistic people perform more poorly on this task, probably due to less complete separation of the speech and noise objects in the Listening stage of Fig. 1.

3.5. Perceptual capacity

The perceptual capacity of a person is a measure of their ability to process sensory information. It can be measured by loading a person with several simultaneous stimuli while asking them to perform a task (such as detect one target stimulus within the mixture). (Remington and Fairnie, 2017) found that autistic adults could cope with a higher load (in terms of number of distractor sounds) while remaining accurate. This is one of very few results in the literature which explicitly conclude that autistic auditory processing can be superior.

4. Anecdotal reports

If mainstream autism research tends to see autistic differences (and even superiorities) as deficits, how do autistic people see themselves? A simple way to access autistic views is to look online. There have been several generations of autistic discussion forums, autistic blogs and, more recently, autistic use of social media. A convenience sample of this material was surveyed for accounts of auditory processing experiences by autistic people. Sources providing significant data were the web forums Wrong Planet², Reddit³ and AutismForums⁴, blogs

² <https://wrongplanet.net/forums/>

³ <https://www.reddit.com/r/aspergers/>

⁴ <https://www.autismforums.com/>

(especially those linked from the large Actually Autistic Blogs List⁵) and Twitter.⁶ (All the material examined was written by people presenting as autistic themselves.)

Three main themes emerged: hyperacusis and being overwhelmed by sound, difficulty processing a target sound (especially speech) in the presence of distracting noise, and rich processing of detailed soundscapes. The first two themes have been studied in the autism research literature, as summarised above. The third has not and so will be the focus here.

4.1. Soundscape decomposition

Some autistic people reported enjoying performing the kind of detailed analytical listening that musicians learn to do:

“I also escape into layers of music. I have a good musical memory and can replay songs in my head as if I were dropping a needle on a record. I can zero in on the different melodies, rhythms, timbre. I can bring the bass section forward and back.

Others describe doing this decomposition with everyday soundscapes:

“If I'm alone in the house, I sometimes "unpick" everything I can hear, to relax. So, that's the fridge, that's the road outside, that's bird song, that's the electricity in the walls, that's the lamp" etc. The world is noisy, but easier when I've noticed how/why noisy.”

“When in natural surroundings. Woods, beach etc. I can separate and rejoin sounds into individual music type notes then back into symphonies.”

4.2. Structure and pattern

As well as engaging with individual sounds, some autistic people also express an interest in the structure or patterns apparent in the soundscape. This may be discussed in terms of how individual sounds relate to each other or more abstracted patterns are noticed and valued:

“the possibility of engaging with layers of relatively gentle sound, thinking about different elements of it & identifying sounds seems to satisfy my brain in the same way as a flow state.”

4.3. The pleasure of detail

There is pleasure to be gained in methodically examining a rich soundscape in detail. There's a hint here that there's a lot going on in what could be lumped together in 'background' sound:

“Tiny nature sounds. When I tune in there is so much going on, even in a 'quiet' place. One of my favourite sound experiences was hearing people whispering together in a foreign language in a hushed library (probably for more ASMR-like reasons). Calming, deepening, 'flow' for sure”

Single sound objects can also reward detailed, patient examination:

“My mum had a ceiling extractor fan in the bathroom. I swear I could listen to that thing for hours. The complexity of different oscillations beating against each other, and the patterns/non-patterns that would create, was beautiful to get lost in”

4.4. Flow states

Flow state is a term coined by Csikszentmihalyi to describe “the experience of complete absorption in the present moment” (Nakamura and Csikszentmihalyi, 2009). It is widely viewed as highly positive and many texts advise readers on how to attain it when performing tasks. Autistic people are sometimes puzzled that flow seems to be regarded as somewhat elusive and difficult to experience, since the common autistic experience of complete engagement with an interest fits the definition of flow well. Thus, it is not hard to find accounts of autistic detailed listening that seem to describe a flow state:

“When I work on my musical projects, I tend to hear the whole score in my head and piece every instrument loop detail where they fit. It relaxes me and makes me extremely aware of what I'm doing to the point that I lose track of time.”

4.5. Zooming in

The phrase 'zooming in' is quite often used when autistic people discuss listening. It suggests using top-down attention to focus on more and more detailed, smaller elements of the soundscape:

“When I listen to music I can "zoom in" on different parts of it. I can find the structure of different parts and split it up.”

⁵ <https://anautismobserver.wordpress.com/>

⁶ <https://twitter.com/search?q=%23AskingAutistics>

“I do that too ! I guess it's one of our superpower. For me it's a positive trait. For all the artist friends I met, it's a positive trait to have someone that can somehow "really" listen and understand their creations.”

In a previous paper, I described using my attention to zoom in on an outdoor soundscape to examine it at smaller and smaller scales, down to attributes of the initial attack of a car exhaust impulse, for example (Davies, 2015). I was puzzled to find that in my experiments, my (presumed) neurotypical participants did not seem to do this, tending instead to group lots of sounds in a complex soundscape into ‘background’ (Woodcock *et al.*, 2017).

4.6. Detail is always there

Several autistic people note that they seem to be continually aware of a high level of detail in the soundscape around them, suggesting the atypical attention mechanism reported in the literature. For some this lead to overwhelm. For others, the continual detail is sometimes annoying, while perhaps also useful:

“I’m in a choir. I am not diagnosed as autistic but have been diagnosed with hyperacusis is, and have my suspicions. I focus on each singer’s voice. I can tell you who can’t hit the high G, who keeps breathing in the middle of a phrase, etc. It is bothersome but I can’t stop.”

“I can pick out individual bird song and locate the the bird. However in a restaurant or cafe I can’t filter the background, I can hear everyone’s conversations which can be interesting or very annoying.”

4.7. The pleasure of repetition

While repetitive behaviour is heavily stigmatised in most of the literature it is interesting to read autistic people’s accounts of repeated listening to a song or sound. Sometimes this seems to be a form of play:

“I fixate on songs and would replay one over and over again (even in my head) & would constantly 'dissect' it by tuning out certain parts (ie. I replay I'd only listen to the guitar & drown out other parts).”

5. Discussion

It’s clear from the literature that many autistic people process sound differently to non-autistic

people, in several respects. Almost all the literature frame these differences as deficits. While some differences (e.g. hyperacusis) do cause significant problems and distress, others seem positive or beneficial (e.g., better pitch perception). It is hard not to think that the overwhelmingly negative account in the literature is at least partly due to researchers starting out with a view that autistic people are inferior and looking for evidence to support this. Adopting a more equal standpoint can change conclusions significantly. For example, a difference in the function connecting sound intensity to loudness could be seen as a neutral difference. The distress of hyperacusis comes from an environment which is not adapted to someone with a steeper intensity-loudness function.

Adopting a neutral research standpoint might then lead to looking for more positive aspects of autistic listening difference. Remington and Fainie (2017) examined auditory capacity and found higher performance in autistic people. This encouraging result may just be part of a bigger picture, however.

The anecdotal accounts given by autistic people of their own listening suggest several differences that have not been researched, or are under-researched:

- The use of spontaneous soundscape decomposition to extract individual sound objects, attributes and structures may be one difference.
- Another is a facility with using a soundscape as a fascinating object, sometimes facilitated by repetition, to achieve a flow state.
- A third topic is the re-examination of the interaction between bottom-up and top-down attention in complex soundscapes and the effect this has on grouping into background and foreground sound.

Designing listening experiments which are both ecologically valid and rigorous is often difficult and the three topics listed above are perhaps especially challenging. Future work will explore this.

References

- Baguley, D. M. (2003). "Hyperacusis," *Journal of the Royal Society of Medicine* **96**, 582-585.
- Crompton, C. J., Ropar, D., Evans-Williams, C. V., Flynn, E. G., Fletcher-Watson, S., Crompton, C. J., and Terrace, M. "Autistic peer to peer information transfer is highly effective," Preprint: <https://osf.io/j4knx/download>.

- Davies, W. J. (2015). "Cognition of soundscapes and other complex acoustic scenes," in *Internoise 2015* (San Francisco).
- Dawson, G., Toth, K., Abbott, R., Osterling, J., Munson, J., Estes, A., and Liaw, J. (2004). "Early social attention impairments in autism: social orienting, joint attention, and attention to distress," *Developmental psychology* **40**, 271.
- Khalfa, S., Bruneau, N., Rogé, B., Georgieff, N., Vuillet, E., Adrien, J.-L., Barthélémy, C., and Collet, L. (2004). "Increased perception of loudness in autism," *Hearing research* **198**, 87-92.
- Mottron, L., Peretz, I., Belleville, S., and Rouleau, N. (1999). "Absolute pitch in autism: A case study," *Neurocase* **5**, 485-501.
- Nakamura, J., and Csikszentmihalyi, M. (2009). "Flow theory and research," *Handbook of positive psychology*, 195-206.
- O'Connor, K. (2012). "Auditory processing in autism spectrum disorder: a review," *Neuroscience & Biobehavioral Reviews* **36**, 836-854.
- Remington, A., and Fairnie, J. (2017). "A sound advantage: Increased auditory capacity in autism," *Cognition* **166**, 459-465.
- Rimland, B., and Fein, D. (1988). "Special talents of autistic savants," in *The exceptional brain: Neuropsychology of talent and special abilities*, edited by L. K. Obler, and D. Fein (Guilford Press, New York, NY), pp. 472–492.
- Woodcock, J., Davies, W. J., and Cox, T. J. (2017). "A cognitive framework for the categorisation of auditory objects in urban soundscapes," *Appl. Acoust.* **121**, 56-64.

