

# Wissenschaftliche Erkenntnis, Reproduzierbarkeit und praktische Lösungen in der Akustik

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# Wissenschaftliche Methode

## ■ **Deduktion:**

Dachs ist ein Säugetier

Dieter ist ein Dachs

⇒ Dieter ist ein Säugetier

## ■ **Induktion:**

Medikament hatte keine Nebenwirkung an 100 000 getesteten Menschen.

⇒ Kann sicher verwendet werden.

## ■ **Computer Simulation:**<sup>1,2</sup>

Numerik und große Datensätze.

Noch keine etablierte Verifizierbarkeit.

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<sup>1</sup>Donoho, et al. (2009), *Computing in Science & Engineering*, [10.1109/MCSE.2009.15](#)

<sup>2</sup>Vandewalle, et al. (2009), *IEEE Signal Processing Magazine*, [10.1109/MSP.2009.932122](#)

# Wann ist etwas Wissenschaft?

Überprüfung einer Aussage durch **Falsifizierbarkeit**

*If it disagrees with experiment, it's wrong. In that simple statement is the key to science.*

R. Feynman<sup>3</sup>

- Nicht automatisch Widerlegung einer Theorie (Gran Sasso, 2011)
- Kann als Abgrenzung von Pseudowissenschaften verwendet werden (z.B. Astrologie)
- **Reproduzierbarkeit** von Ergebnissen wichtig

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<sup>3</sup>Zitiert nach Lewens (2015), *The Meaning of Science*, Pelican

# Reproduzierbarkeitskrise

- Psychologie: 47% reproduzierbare Studien ( $N = 100$ )<sup>4</sup>
- Pharmazie: 21% reproduzierbare Studien ( $N = 120$ )<sup>5,6</sup>
- Genetik: 44% reproduzierbare Datenanalyse ( $N = 18$ )<sup>7</sup>
- Reproducibility Project: Cancer Biology<sup>8</sup>

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<sup>4</sup>Open Science Collaboration (2015), *Science*, [10.1126/science.aac4716](https://doi.org/10.1126/science.aac4716)

<sup>5</sup>Prinz, et al. (2011), *Nature Reviews Drug Discovery*, [10.1038/nrd3439-c1](https://doi.org/10.1038/nrd3439-c1)

<sup>6</sup>Begley & Ellis (2012), *Nature*, [10.1038/483531a](https://doi.org/10.1038/483531a)

<sup>7</sup>Ioannidis, et al. (2009), *Nature Genetics*, [10.1038/ng.295](https://doi.org/10.1038/ng.295)

<sup>8</sup>Errington, et al. (2017), *Open Science Framework*, [osf.io/e81xl/](https://osf.io/e81xl/)

# Gründe für Nicht-Reproduzierbarkeit



## Datenmelken

Suchen nach signifikanten Ergebnissen



## Positiver Bias

Nur positive Ergebnisse werden publiziert



## Teilnehmerzahl

Zu wenig statistische Power für Effektstärke



## Fehler

Technische oder Programmierfehler



## Unklare Methode

Methode ungenügend beschrieben



## Schlechtes Design

Experiment hat systematische Fehler

# Auswege

## Open Science

Daten, Software und Methoden



## Pre-Registrierung

des Versuches (und Review)



## Zusammenarbeit

unterschiedlicher Arbeitsgruppen



## Post-publication review

Diskussion und Verbesserungen



## Verzicht auf $p$ -Werte

Effektstärke, Konfidenzintervall



# Statistik

## Probleme des $p$ -Wertes

- Aussagekraft abhängig von statistischer Power<sup>9</sup>
- Aussagekraft abhängig von Anzahl getesteter Hypothesen<sup>9</sup>
- Wahrscheinlichkeit eines echten Effektes hängt davon ab wie wahrscheinlich die Hypothese war<sup>10</sup>
- Schlechte Reproduzierbarkeit auch bei guter statistischer Power<sup>11</sup>

## Lösungsvorschläge

- Effektstärke und Konfidenzintervall als Alternative<sup>11</sup>
- Kumulativ vorgehen (Meta-Analysen)<sup>12</sup>

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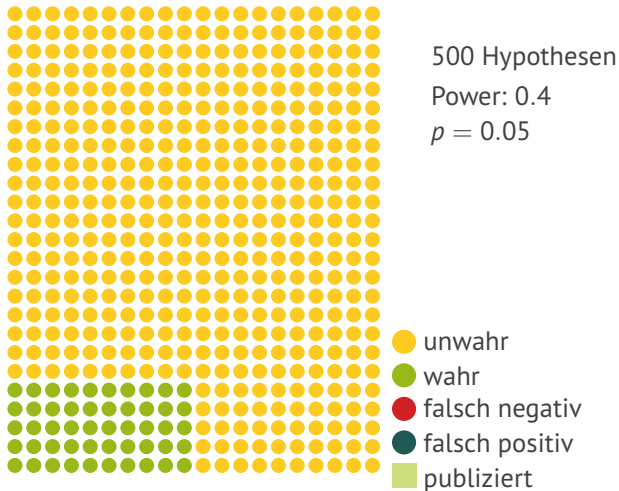
<sup>9</sup>Ioannidis (2005), *PLoS Med*, [10.1371/journal.pmed.0020124](https://doi.org/10.1371/journal.pmed.0020124)

<sup>10</sup>Nuzzo (2014), *Nature*, [10.1038/506150a](https://doi.org/10.1038/506150a)

<sup>11</sup>Halsey, et al. (2015), *Nature Methods*, [10.1038/nmeth.3288](https://doi.org/10.1038/nmeth.3288)

<sup>12</sup>Cumming (2014), *Psychological Science*, [10.1177/0956797613504966](https://doi.org/10.1177/0956797613504966)

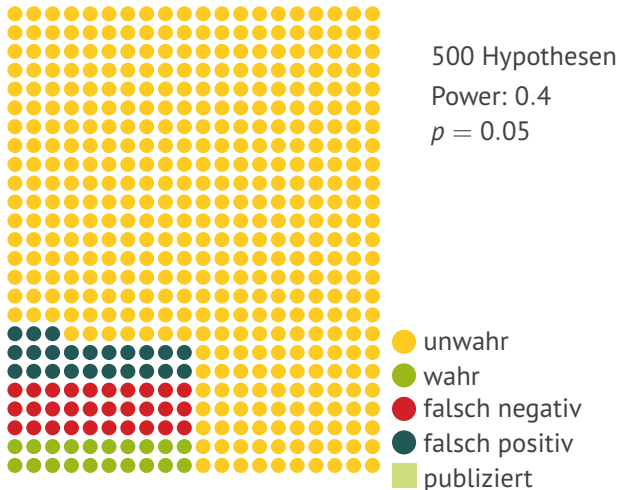
# Statistik



Basierend auf The Academy of Medical Sciences (2015), CC BY 4.0, [apo.org.au/node/58335](https://apo.org.au/node/58335)

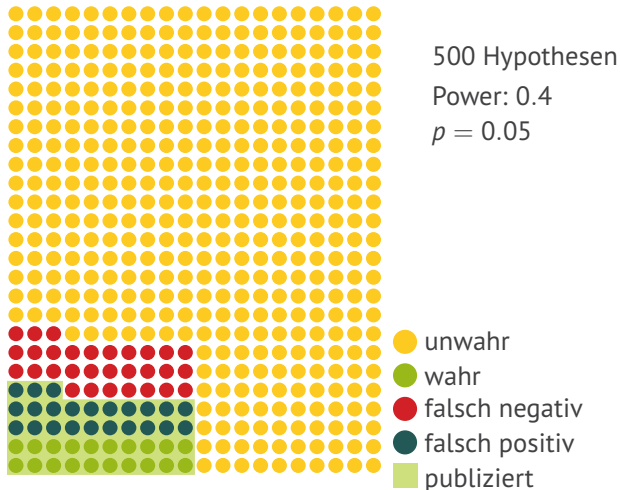


# Statistik



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# Statistik



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# Beispiel: Open Science in der Akustik

## Daten

- Daten-Repository mit doi, z.B. [zenodo.org](https://zenodo.org)
- Noch nicht perfekt (Versionierung, Datengröße)

The screenshot shows the Zenodo interface for a dataset. The header is blue with the Zenodo logo, a search bar, and links for 'Upload' and 'Communities'. A user profile for 'hagen.wierstorf@posteo.de' is visible. The dataset page has a blue header with the title 'Variations of pop mixes for Wave Field Synthesis' and a date of 'August 24, 2016'. It includes a 'Dataset' label and an 'Open Access' badge. The description states that the data set contains stimuli for a paired comparison preference listening test, including a reference mix for two-channel stereophony (Stereo) and Wave Field Synthesis (WFS) mix, along with 3-4 variations of the WFS mix. The parameters varied are compression, equalizing, positioning, or reverb. The 'Publication date' is August 24, 2016, and the DOI is 10.5281/zenodo.61000. The 'Keyword(s)' are WFS, stereo, mixing, compression, equalizing, reverb, panning, and surround. The 'Grants' section lists the European Commission and TWO'EARS - TWO'EARS (618075). The 'Communities' section lists European Commission Funded Research (OpenAIRE). The 'License (for files)' is Creative Commons Attribution 4.0. A 'Preview' section at the bottom shows the title and the first sentence of the description.

zenodo Search Upload Communities hagen.wierstorf@posteo.de

August 24, 2016 Dataset Open Access Edit

### Variations of pop mixes for Wave Field Synthesis

Hold, Christoph; Nagel, Lukas; Raake, Alexander; Wierstorf, Hagen

This data set contains the stimuli for a paired comparison preference listening test. In those tests always one reference mix for two-channel stereophony (Stereo) and Wave Field Synthesis (WFS) was included. In addition, 3-4 variations of the WFS mix were added. Those variations were always along one of the mixing parameters compression, equalizing, positioning, or reverb.

See the file README.md for a detailed description.

Preview

### Variations of pop mixes for Wave Field Synthesis

This data set contains the stimuli for a paired comparison preference listening test. A reference mix from the

**Publication date:**  
August 24, 2016

**DOI:**  
DOI: 10.5281/zenodo.61000

**Keyword(s):**  
WFS stereo mixing compression equalizing reverb  
panning surround

**Grants:**  
[European Commission](#)  
• TWO'EARS - TWO'EARS (618075)

**Communities:**  
[European Commission Funded Research \(OpenAIRE\)](#)

**License (for files):**  
[Creative Commons Attribution 4.0](#)

# Beispiel: Open Science in der Akustik

## Software

- Software-Repository, z.B. auf [github.com](https://github.com)
- Software am besten allgemein und mit Partnern entwickeln

The screenshot shows the GitHub repository page for `sfstoolbox / sfs-matlab`. At the top, there are buttons for `Unwatch` (20), `Star` (36), and `Fork` (10). Below these are tabs for `Code`, `Issues` (16), `Pull requests` (3), `Projects` (0), `Pulse`, `Graphs`, and `Settings`. The repository description is "SFS Toolbox for Matlab/Octave" with a link to <http://matlab.sfstoolbox.org>. There are `1,801` commits, `12` branches, `16` releases, `9` contributors, and the MIT license. A table of recent commits is shown below, all by user `hagenw` and dated "3 days ago".

Commit Message	Commit Hash	Time
Bump version number	8e2066f	2 days ago
SFS_HRTF_extrapolation		3 days ago
SFS_analysis		3 days ago
SFS_binaural_synthesis		3 days ago
SFS_general		3 days ago
SFS_helper		3 days ago

# Beispiel: Open Science in der Akustik

## Methoden

- Skripte für statistische Auswertung veröffentlichen
- Code für einzelne Abbildung veröffentlichen

The screenshot shows the Zenodo interface for a dataset. The header is blue with the Zenodo logo, a search bar, and navigation links for 'Upload' and 'Communities'. A user profile for 'hagen.wierstorf@posteo.de' is visible. The dataset title is 'Listening preferences for the different reproduction systems Stereo, Surround, and Wave Field Synthesis in the context of popular music'. It is dated November 2, 2016, and is marked as a 'Dataset' and 'Open Access'. The author is 'Wierstorf, Hagen; Hold, Christoph'. The abstract describes a paired comparison preference test for four different pop musical pieces presented by WFS, stereo or surround. The keyword(s) are WFS, Stereo, Surround, Listening preference, and BTL. The grants listed are European Commission and TWO'EARS - TWO'EARS (618075). Related identifiers include Supplementary material: 10.14279/depositonce-5173. The dataset is part of the European Commission Funded Research (OpenAIRE) and is licensed under Creative Commons Attribution 4.0.

zenodo

Search [Q] Upload Communities hagen.wierstorf@posteo.de

November 2, 2016 Dataset Open Access Edit

### Listening preferences for the different reproduction systems Stereo, Surround, and Wave Field Synthesis in the context of popular music

Wierstorf, Hagen; Hold, Christoph

We did a paired comparison preference test where listeners rated their listening preference for four different pop musical pieces presented by WFS, stereo or surround. The musical pieces were all mixed by the same person in order to try to minimize the influence of the mix on the ratings, but still trying to get the best out of every system, see [1] for details. The mixes are available at <https://doi.org/10.14279/depositonce-5173>.

Here, we provide the results of the 22 listeners that participated in the experiment together with an analysis which calculates a Bradley-Terry-Luce model after Wickelmaier et al. [2].

[1] Hold, C., Wierstorf, H., Raake, A. (2016), "The Difference Between Stereophony and Wave Field Synthesis in the Context of Popular Music," 140th AES Convention, Paper 9533

[2] <https://cran.r-project.org/web/packages/eba/index.html>

**Publication date:** November 2, 2016

**DOI:** DOI 10.5281/zenodo.164433

**Keyword(s):** WFS Stereo Surround Listening preference BTL

**Grants:** European Commission  
• TWO'EARS - TWO'EARS (618075)

**Related identifiers:** Supplementary material: 10.14279/depositonce-5173

**Communities:** European Commission Funded Research (OpenAIRE)

**License (for files):** Creative Commons Attribution 4.0

# Publizieren in der Zukunft

Code und Daten in Publikation verlinkt<sup>13</sup>

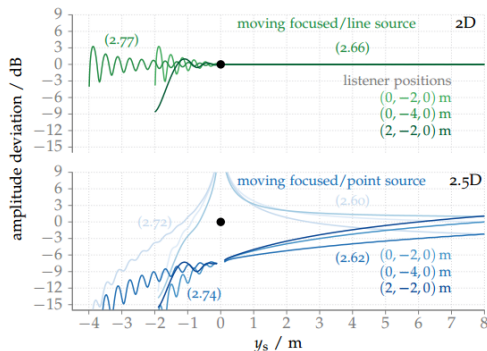



Figure 3.2: Amplitudes of a synthesized point/focused source minus the amplitudes of corresponding real point source located at  $y_s$  for three fixed listening positions. The secondary source distribution is located on the  $x$ -axis as indicated by the black dot. For positions of the synthesized source with negative  $y_s$  values the corresponding focused source models were applied. The used driving functions are indicated within the graphs. For the 2.5D case, two different driving functions are shown whereby the dark blue one is used as default in this thesis. Parameters:  $\mathbf{x}_{\text{ref}} = (0, -2, 0) \text{ m}$ ,  $f = 1 \text{ kHz}$ . 

<sup>13</sup>Wierstorf (2014), Dissertation, [10.14279/depositonce-4310](https://nbn-resolving.org/urn:nbn:de:hbz:5:1-63864-p0011-9)

# Publizieren in der Zukunft

## Code und Daten in Publikation eingebettet<sup>14</sup>

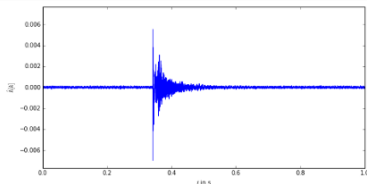
[JUPYTER](#)[FAQ](#)

### Estimation of the Acoustic Impulse Response

The acoustic impulse response is estimated by cross-correlation  $\psi_{yz}[k]$  of the output with the input signal. Since the cross-correlation function (CCF) for finite-length signals is given as  $\psi_{yz}[k] = \frac{1}{L} \cdot y[k] * x[-k]$ , the computation of the CCF can be speeded up with the fast convolution method.

```
In [4]: h = 1/len(y) * sig.fftconvolve(y, x[::-1], mode='full')
        h = h[fs*(T+Tr):fs*(T+2*Tr)]

In [5]: plt.figure(figsize=(10, 5))
        t = 1/fs * np.arange(len(h))
        plt.plot(t, h)
        plt.axis([0.0, 1.0, -1.1*np.max(np.abs(h)), 1.1*np.max(np.abs(h))])
        plt.xlabel(r'$t$ in s')
        plt.ylabel(r'$\hat{h}[k]$');
```



<sup>14</sup>Spors (2016), Digital Signal Processing - Lecture notes, [github.com](https://github.com)

# Zusammenfassung

## Open Science

Daten, Software und Methoden



## Pre-Registrierung

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