Why should I warm up before playing and which muscles do I need?

Brass playing involves many muscles

Tongue, throat muscles

EMG Measurement - Breathing

Warm up...
Increases blood flow, AND supports fine-tuning of mental coordination (motor-sensoric-visual-haptic-... )
Visualization of Muscle Activation (Warm up) by Infrared Thermography

Infrared Images of Violin Player after playing 2 hours

Infrared Studies on Brass Players Muscle Activities

Trombone Player, after warm-up

Regions of interest

1 • corner of the mouth (anguli oris inferior)
2 • inner corner of the eye (anguli oculi)
3 • forehead (frontalis)
4 • side of nose (perinasal)
5 • inner cheek (buccal rostral)
6 • center of the cheek (buccal central)
7 • outer cheek (buccal auriculae)

Infrared images: Player frontal view

Frontal infrared images from three different trumpet players before and after "warm up"

Buccal Player frontal & lateral

Exception:
Frontal and lateral images of a players as example for a buccal type

temperature changes at the right mouthcorner (Point 1d: anguli oris inferior)
Changes of skin temperature in the face of trumpet players after warm up (solid line: right side; dotted: left side).

How fast can one play single and double tonguing?

Tonguing Techniques

Single Tonguing (Ta, Te, Ti, Da, ...)
Double Tonguing (TeKe, TaKa, DeGe)
Triple Tonguing (TeTeKe, TaTaKa, DeDeGe)

Brass-Player Tonguing Research Study

Table:
- Play 30 seconds staccato - non-stop and as fast as possible!
- Short Breaths on 0.8
- Any Open Notes (middle range, mezzoforte)
- Two supervised Recordings:
  1. Single Tonguing
  2. Double Tonguing

<table>
<thead>
<tr>
<th>BPM</th>
<th>Hz</th>
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<tbody>
<tr>
<td>240</td>
<td>16,0</td>
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<tr>
<td>220</td>
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<td>200</td>
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<td>150</td>
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<td>140</td>
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<td>130</td>
<td>8,7</td>
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<tr>
<td>120</td>
<td>8,0</td>
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<td>110</td>
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<td>90</td>
<td>5,3</td>
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<tr>
<td>80</td>
<td>4,0</td>
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Can you play as fast on tuba and trombones, than on trumpets?
**BONE - PRO male, age 43, ID: 0243**

Fastest single tonguing at begin: 148 BPM
262 notes in 30s

**BONE - STUD male, age 22, ID: 0180**

Best Trombone double tonguing: endurance 337 notes in 30s

**TRP - AMATEUR male, age 27, ID: 0185**

Norbert is No.3 of fastest single tonguing at begin: 150 BPM
Clarinet player with 3 days experience on trumpet

**TRP - PRO male, age 33, ID: 0213**

2nd fastest double tonguing at begin: 231 BPM

**TRP - PRO male, age 46, ID: 0215**

2nd fastest single tonguing at begin: 150 BPM
Best Double Tongue Endurance: 386 notes in 30s

**TRP - STUD male, age 19, ID: 0170**

Paolo is No.1 Fastest single tonguing at begin: 167 BPM
Summary: BENCHMARKS for Tonguing

<table>
<thead>
<tr>
<th>2 Sec. BPM (median)</th>
<th>BPM</th>
<th>Hz</th>
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</thead>
<tbody>
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<td>238.0 Fastest Player Double</td>
<td>240</td>
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<tr>
<td>172 PROFESSIONAL Average Double</td>
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<tr>
<td>170.5 STUDENT AVERAGE Double</td>
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<tr>
<td>167 Fastest Player Single</td>
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<td>148.3 AMATEUR Average Double</td>
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Is there anything like non-pressure embouchure?

Follow up Studies

Articulation & Tonguing Research

- Motion Analysis of "slow" and "fast" tongues
- Evaluation of training techniques to improve performance
Mouthpiece Pressure

Air Pressure (playing fff)

Are there tools or gadgets which could support my training?

Collection of "Ergonomic Support & Physiological Aids" for Instrumentalists
How do my lips vibrate different in lower and upper register?

How much air flow makes a „wind“-instrument?

Air flow – No Wind – standing waves
You alternating current (AC) of the air flow which makes the sound
You can play a trumpet without blowing air into the instrument
Smith-Watkins Demonstration

Standing Waves

Bell reflexion
How are trumpets tuned in real instruments?

36 trumpets in B-flat have been measured using the "Brass Instrument Analysing System" BIAS, a Hard and Software system (www.bias.at)

Intonation error in cent for each valve combination (BIAS WGT=2)

How much does the intonation differs, if 40 players blow the same instrument?
Measured vs Played: 4 individual results

Played Intonation (mean)

Played Intonation (mean)

Intonation & Musical context

Intonation & timbre

What is a trumpet?
What is the dynamic range of a trumpet

Dynamic range

Dynamic versus pitch