Listening in the Pit

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Abstract: Temporal masking effects are a controlling factor in the ability of performers to hear each other well. Difficulties in ensemble communication and perceived weakness of the acoustic response of the auditorium can be exacerbated by high early energy levels often found in orchestra pits. These problems become particularly acute in orchestra seating positions under stage overhangs.

"TWO STREAMS"

In 1995, David Griesinger introduced and discussed the interaction of two separate "streams" of acoustic information which a listener can process simultaneously. While not a totally new concept (in 1962 Beranek separated direct and reverberant loudness as independent attributes in his seminal *Music, Acoustics, & Architecture*), the terminology of "two streams", comprise of direct and reverberant energy, is a vivid and helpful description of a complicated and often non-linear process of a pit musician's auditory perception.

The direct stream, as the name implies, is constituted of the direct path and early reflective energy, and may also be called "source presence". The reverberant stream (sometimes "running reverberance" or "room presence") consists of later reflected sound. These two streams contain vital, and different, information. The direct stream carries necessary cues to the performer for coordinated articulation with other musicians. The reverberant stream carries information relating to relative balance, tonal coloration, and a psychological "connection" to the audience. The presence of this later feedback is often referred to by musicians as "support".

From research by Zwicker, Gade, Griesinger, Gardner, KWe, Ueno, Satoh, Tachibana, Ono, Senju, the author of this paper, and others, the ability to hear both streams has been found to be dependent not only on their comparative strength, but also on the relative timing of energy arrival. The direct stream behaves as a masking element to the delayed reverberant stream. The mechanism (overly simplified here) appears to be one of "shutting down" the auditory process for a time period after loud direct stimulus, following which the reverberant response can be heard. The amount of time consumed in this suppression, variously reported between 75 msec and 160 msec, and observations of subsequent onset thresholds of reverberance audibility indicate the energy contained in the direct stream controls the levels of those thresholds. This may, in part, explain Griesinger's observations of threshold differences for different ensemble sizes, but there may be other, musical, mechanisms involved as well.

DIRECT STREAM IN THE PIT

For musicians in the pit, closely surrounded by reflective surfaces, lack of early energy is almost never a problem. The opposite is usually true: too much early energy, often highly localized, masking not only the room response, but also the direct energy from instrumentalists more than a few meters away.

The difficulties become particularly acute for musicians seated under deep stage overhangs, even when acoustical absorption covers the upstage wall. In these situations the author has found the most success by 1) maximizing the ceiling height under the overhang by progressively lowering the floor (a la Bayreuth), 2) sloping the overhang ceiling to avoid reverberant build-up between floor and ceiling, and 3) applying absorption to that ceiling to reduce reflected energy.

Even in open pits, the build-up of early energy exceeds that which would be found on the typical concert platform. Adding absorption to the upstage wall (easy) and/or shaping modulations in the downstage wall (more difficult) can be useful for moderating early energy either by absorbing it or sending it in more "useful" directions.

REVERBERANT STREAM IN THE PIT

While solving excessive early energy conditions can improve ensemble coordination, it is the
audibility of the "room response" which characterize the opera houses most favored by conductors and pit orchestras. Two rooms which have enjoyed such consistent acclaim are the Paris Opera by Charles Garnier and the Teatro Colon in Buenos Aires by Victor Mechu. That these rooms are not always completely successful for the audience does not diminish the importance of the lessons they can teach us about sound in the pit. Perhaps the most interesting of these lessons is that the most important reflecting surfaces for truly great pit acoustics, are not in the pit at all, but actually rather far away.

Beyond traditional shaping and roughly comparable seating capacities, these rooms are very different from each other. The Garnier (2131 seats), with an audience chamber of approximately 10,000 m³, is only half the cubic volume of Teatro Colon (2487 seats). Occupied reverberation times are estimated to be 1.1 seconds and 1.7 seconds, respectively. Commonalities of these rooms relating to the timing and strength of sound energy returning to the pit include:

1) well modulated side walls in the box region on either side of the pit, forming the transition from proscenium to audience chamber, allowing minimal effective absorption;
2) high ceiling over the pit which directs significant energy back to the orchestra;
3) tall (greater than 1 M.), modulated tier fronts, closely stacked to minimize effective audience absorption, providing a diffuse return;
4) shallow tiers (less than 4 M. deep, except for the topmost gallery) allowing some energy return from the rear walls; and
5) ceiling shaping (domes in both these cases) for direct reflection of energy back to the performers. (These are not focused first order reflections, since the orchestra is located well outside the projected radius of dome curvature.)

Many performers familiar with these spaces specifically attribute much of the pleasurable support to ceiling reflections. In both the Garnier and Colon the orchestra receives strong reflections from the ceiling directly overhead, arrivals commencing at 100 msec and 140 msec, respectively, near the beginning of the running reverberance audibility window. Onsets of first-order reflected energy from the dome come 80 msec to 95 msec later, with diffuse contributions from wall and tier front reflections, filling the gap in between.

IMPORTANCE OF CEILING SHAPING

It is interesting to note, in light of its now legendary reputation for lack of performer support, that the cubic volume of the audience chamber at the Old Metropolitan Opera House in New York was actually about five percent smaller than that of Teatro Colon. The hugely increased seating at the Old Met (3,639 seats) was accomplished by deepening the tier depth, particularly toward the rear of the auditorium. The tier configurations were not strongly dissimilar in these two rooms until one reached the top two tiers at the Met where the walls were pushed way back to accommodate the higher seat count. Little energy arriving to these upper tiers would return to the auditorium proper. The most important differences were to be found in the ceiling shaping. The ceiling of the Old Met directly over the pit was configured so as to return almost no first-order energy to the pit. And the ceiling over the tiers was shaped to efficiently deliver acoustic energy to the upper gallery, allowing none to return to the pit.

HOW MUCH ENERGY IS ENOUGH? TOO MUCH?

Performers have psychological reactions to the acoustic support they receive. If not enough is available, they will search for it and, as a result, tend to force their sound. If there is too much return they may overly relax their efforts at projection. While the timing of incoming reflective energy, and the architectural surfaces that supply it, can be reasonably extrapolated from drawings, the sound energy levels of the reflection components cannot be similarly determined in sufficient detail. If we are content, as designers, to adapt the important architectural features of successful opera houses to our own vision, perhaps this not a critical problem. On the other hand, for those who wish to strike out in new directions, the path may be somewhat perilous, and more research, particularly related to musician preferences regarding acoustic energy in the 100 msec to 400 msec delay period, is needed.