THE EFFECT OF TEMPO ON PERCEIVED EMOTION

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1. BACKGROUND AND AIMS

1.1 Introduction [A.S.]

That music is capable of expressing an emotional character (e.g., that a piece can sound happy or sad) is obvious to most listeners. For many, that is the entire point of listening. It is therefore not surprising that a number of studies have devoted serious effort to locating the source of this experience: what exactly accounts for the emotive qualities perceived in a given piece of music? The present work continues the search, but differs from previous studies in that it isolates a single parameter—tempo—as the sole object of investigation. This focused approach seeks to answer whether tempo alone is capable of eliciting a change in how one perceives the emotional character of music.

1.2 Previous Research [A.S. & S.A.]

Models of Emotion

The circumplex model of emotion used in this study is taken from Russell (1980, 2003), who defines affect as a set of "dimensions [e.g., distress, excitement] that are interrelated in a highly systematic fashion." This interrelationship is plotted graphically in two continuous dimensions—arousal and valence—such that any emotion can be represented in two-dimensional space. A summary of this model's effectiveness, along with successful examples of its use in the literature, is given in Hunter & Schellenberg (2010). Rubin & Talarico (2009) suggest the possible superiority of other models (e.g., vector, PANA), but experimental limitations prevented our use thereof.

Tempo & Emotion

Henver (1937) found that tempo plays the largest and most consistent role of any musical parameter in "carrying the expressiveness in music." Scherer & Oshinsky's (1977) conclusion that tempo is the most powerful predictor of emotion in speech is consistent with this finding. More recent studies, some testing emotional effects of *multiple* musical parameters, have found that tempo affects the arousal dimension of emotion, but not valence (Balch & Lewis, 1999; Husain, Thompson, & Schellenberg, 2002). Fast tempi are associated with high-arousal emotions, such as excitement, joy, and fear, whereas slow tempi are associated with low-arousal emotions, such as sadness, peacefulness, and boredom (Thompson & Robitaille, 1992; Balkwill & Thompson, 1999; Scherer & Oshinsky, 1977). The same correlations apply to felt emotions (Gomez & Danuser, 2007).

1.3 Present Research [A.S.]

The present study investigates the effect of tempo alone on the perceived emotion of musical excerpts. Given previous research on this topic, we expect tempo to affect arousal but not valence. This change will manifest itself in the following manner: an increase in tempo will result in an increase in perceived arousal, and a decrease in tempo will result in a decrease in perceived arousal. By virtue of affecting arousal alone, a change in tempo will alter just one dimension of perceived emotion as represented in Russell's (1980) two-dimensional space.

2. METHOD

2.1 Participants [C.L.]

There were 36 participants in this study comprised of 13 females and 23 males. The mean age of participants was 23.7 years old with the maximum and minimum ages being 59 and 14, respectively. The mode was 21 years old. Two participants had not studied an instrument. The average years of instrumental study was 12.4 with a maximum of 50 and a mode of 10. The educational experience of participants was varied with 5 high school graduates, 15 having completed some college, 3 undergraduates, 11 masters, and 2 doctoral. Of the participants, 7 were born in a country other than the US (1 Australia, 3 Canada, 1 China, 1 Croatia, 1 Netherlands). Only 1 participant currently lives outside of the US, in China. Five participants were raised in a country other than the US (1 Australia, 3 Canada, 1 Croatia). There were 11 bilinguals and 5 trilinguals. Only two participants spoke a native language other than English (French, Croatian).

2.2 Stimuli [A.S.]

A pilot study was run to determine a set of eight musical excerpts that exhibit one of four basic valence-arousal profiles when played at their original tempo: positive-valence/high-arousal (x2 excerpts), positive-valence/low-arousal (x2 excerpts), negative-valence/high-arousal (x2 excerpts), negative-valence/low-arousal positive (x2 excerpts).

Excerpts Used (Coded names used in analyses in parentheses):

Negative-valence/high-arousal (Anger/Fear)

1) Shostakovich, String Quartet in C minor, Op. 110, Allegro molto (A4)
2) Stravinsky, The Rite of Spring, “Glorification of the Chosen One” (A5)

Negative-valence/low-arousal (Sadness)

1) Rachmaninov, Elegy in E-flat minor, Op. 3, No. 1 (B4)
2) Schumann, Liederkreis, Op. 39, No. 10 (“Zwielicht”) (B5)

Positive-valence/high-arousal (Happiness)

1) Beethoven, Piano Sonata in E-flat, Op. 31, No. 3, Presto con fuoco (C1)
2) Chopin, Etude in G-flat, Op. 25, No. 9 (C4)

Positive-valence/low-arousal (Calmness)

1) Debussy, La plus lente que lente, L. 121 (D2)
2) Mozart, Clarinet Concerto in A, K. 622, Adagio (D4)

The following tempo changes were then made to each of the eight excerpts using Logic, thus yielding five versions of each stimulus for a total of 40 stimuli: -30%, -15%, 0%, 15%, 30%.

2.3 Task & Procedure [A.S. & S.A.]

Participants were first asked to complete a survey of biographical data. They were then played each of the 40 excerpts in random order, such that no two versions of the same piece were presented in immediate succession. Following each excerpt, to which they could listen a maximum of two times, they were asked to answer questions regarding perceived emotion (i.e., what they perceived the emotional character of the piece to be, *not* how it made them feel) and familiarity.

The following questions concerning perceived emotion were answered using a slider (0–100):

1) How negative or positive does this musical example sound? (slider: negative—positive)
2) How active does this musical example sound? (slider: non-active—active)

Participants were then presented with the following list of 12 adjectives, from which they were asked to choose whichever (one or more) best described their perceived emotion of the musical excerpt: angry, bored, content, depressed, distressed, excited, fearful, happy, joyful, peaceful, sad, and relaxed. (Adjectives mapped to each of the four quadrants of the circumplex emotional model and were taken from Hunter & Schellenberg 2010.)

As a final step, participants were asked to rate their *pre-experiment* familiarity with a given excerpt on a scale of 1–7. The extremities of the scale were described as follows: (1) Least familiar (I don't know this excerpt at all); (7) Most familiar (I have performed or analyzed this excerpt in depth).

2.4 Data Collection & Analysis [S.A. & A.S.]

Data was collected through the NYU Music and Audio Research Laboratory and was organized in the form of an excel spreadsheet. Principal measures included the participants' slider-scale response (given in discrete values from 0–100) to perceived arousal and valence. Categorical data was also obtained in the form of adjectives associated with a given example. Familiarity was measured on a scale of 1–7.

Data was analyzed to find absolute differences between the ratings of valence and arousal for each modified excerpt versus the original tempo excerpt. These were calculated based on the mean value obtained for each excerpt. Student *t*-tests were then calculated from these differences to find significant changes. Measures for familiarity and survey responses were also analyzed for effects.

3. RESULTS

3.1 Main Findings: Valence and Arousal Differences [S.A.]

Figure 1 - Valence-Arousal Mapping of 40 Excerpts (Bold outlines/fill denote mean ratings for original excerpt)

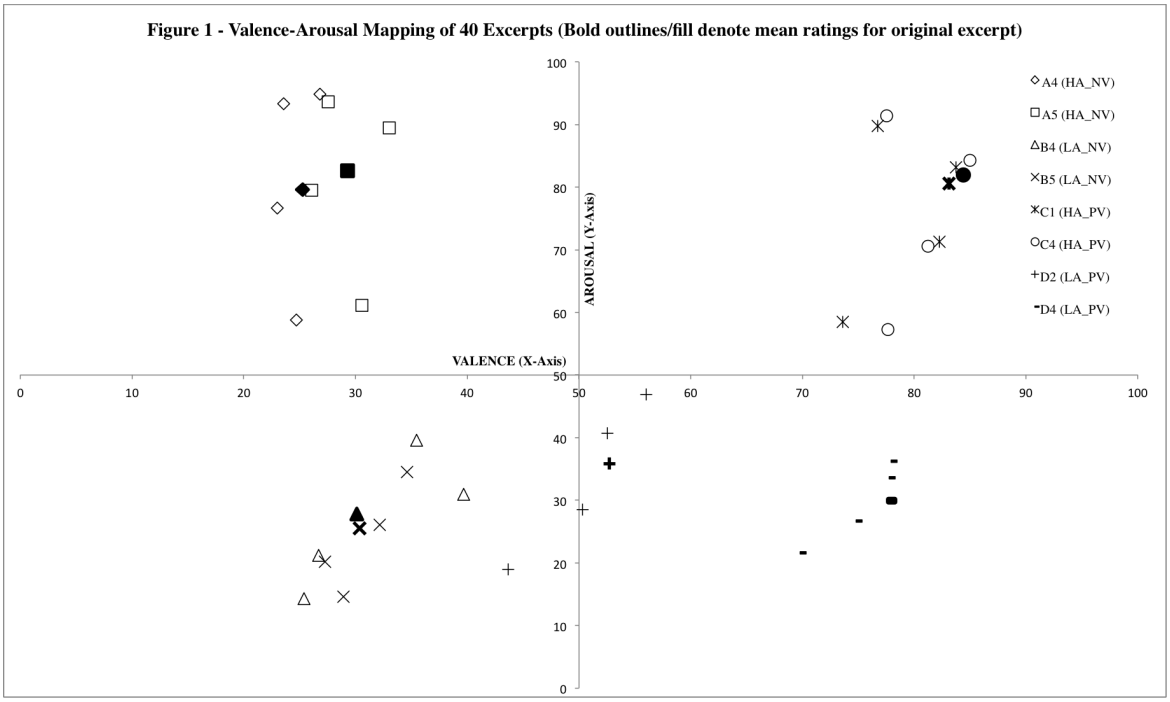


Table 1 - Average ratings and differences from the original mean for 40 excerpts. Ratings are ordered based on percentage of tempo change. Highlighted scores denote significant differences from the original mean as calculated using Student's *t*-tests.

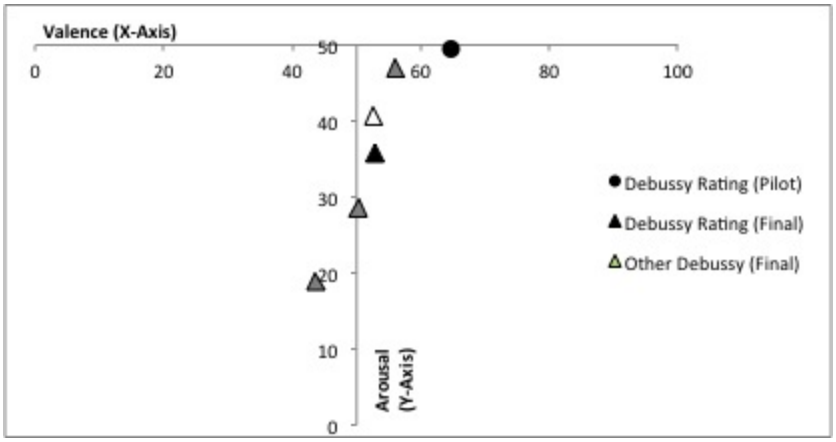
	Arousal		Valence	
Stimulus	**Difference**	**Total Mean**	**Difference**	**Total Mean**
-30%	20.83	58.78	0.56	24.69
-15%	2.92	76.69	2.28	22.97
A4		**79.61**		**25.25**
15%	-15.2	94.81	-1.53	26.78
30%	-13.72	93.33	1.67	23.58
-30%	21.5	61.11	-1.28	30.56
-15%	3.14	79.47	3.22	26.06
A5		**82.61**		**29.28**
15%	-6.86	89.47	-3.72	33
30%	-11	93.61	1.72	27.56
-30%	13.53	14.28	4.75	25.36
-15%	6.56	21.25	3.39	26.72
B4		**27.81**		**30.11**
15%	-3.16	30.97	-9.58	39.69
30%	-11.75	39.56	-5.33	35.44
-30%	10.86	14.64	1.47	28.89
-15%	5.28	20.22	3.11	27.25
B5		**25.5**		**30.36**
15%	-0.56	26.06	-1.81	32.17
30%	-8.97	34.47	-4.25	34.61
-30%	22.09	58.47	9.5	73.61
-15%	9.25	71.31	0.83	82.28
C1		**80.56**		**83.11**
15%	-2.55	83.11	-0.64	83.75
30%	-9.16	89.72	6.36	76.75
-30%	24.66	57.28	6.75	77.67
-15%	11.41	70.53	3.17	81.25
C4		**81.94**		**84.42**
15%	-2.37	84.31	-0.58	85
30%	-9.45	91.39	6.89	77.53
-30%	16.92	18.94	9.05	43.67
-15%	7.3	28.56	2.39	50.33
D2		**35.86**		**52.72**
15%	-4.81	40.67	0.16	52.56
30%	-11	46.86	-3.28	56
-30%	8.34	21.58	7.94	69.78
-15%	3.25	26.67	2.94	74.78
D4		**29.92**		**77.72**
15%	-3.64	33.56	-0.06	77.78
30%	-6.27	36.19	-0.2	77.92

The average rating for arousal and valence for each tempo-altered excerpt was subtracted from the mean rating for the original excerpt. The average ratings for each excerpt are shown in Figure 1. Generally speaking, the results are consistent with our hypothesis: perceived arousal (y-axis) increases and decreases in correlation with tempo. This finding can also be seen in table 1: As tempo increases from 30% less to 30% more, average arousal ratings also increase. For all except one of the excerpts, there were significant differences in arousal ratings for both 30% tempo deviations. Tempo deviations of 15%, however, show no general trends and merit further investigation (perhaps it is due to differences in initial tempo across stimuli).

Valence, however, also increases and decreases with tempo, which was not expected. Further analysis shows significant differences in valence ratings for five of the eight original excerpts. These differences only exist for extreme tempo changes (±30%). Due to audio loss experienced at these ranges, it is possible that the significant valence effects could be attributed to other factors aside from tempo.

3.1.a Perceived emotion in Débussy's *La plus lente que lente*: quadrant shift [A.S.]

Figure 2: Perceived Emotion of Debussy (D2)

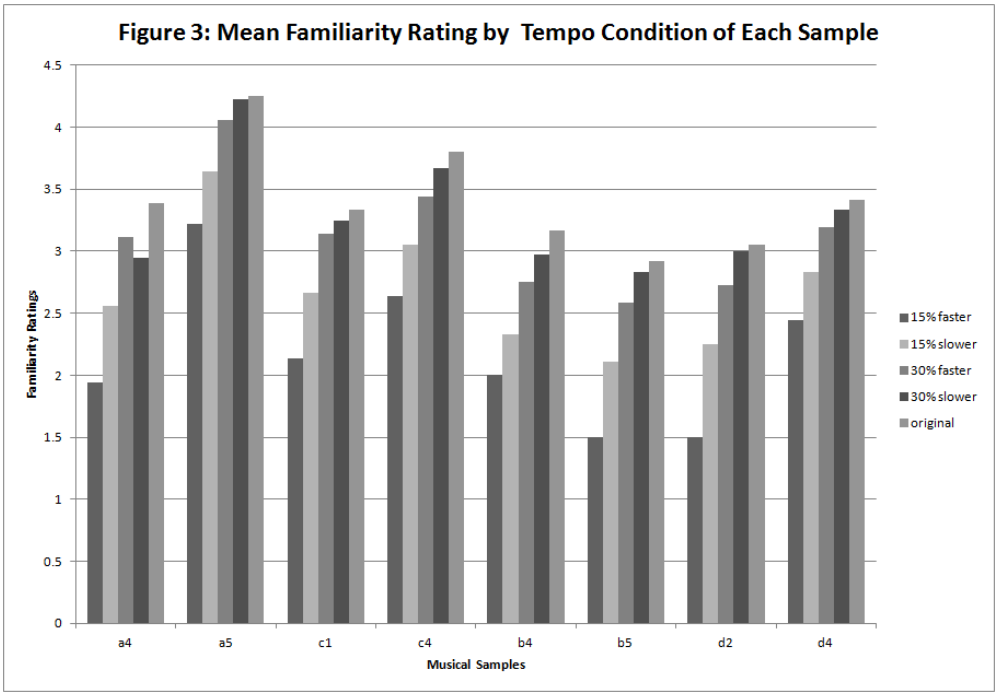


The perceived emotion of Débussy's *La plus lente que lente* (D2) was the only example to switch quadrants (Mean valence rating at base tempo = 52.72; Mean valence rating at base tempo -30% = 43.67 - significant difference), which according to the circumplex model is significant in and of itself (i.e., regardless of the specific values accorded to the shift). That the example shifted quadrants along the valence axis does not correspond with our hypothesis that change in tempo affects only the arousal dimension of emotion.

The borderline mean valence rating (52.72) of D2 (at base tempo) in the final experiment suggests one reason for this shift: of all the examples, D2 is most ambiguous with respect to mode (i.e., major versus minor). Given the well-documented association between mode and the valence dimension of emotion, it is possible that this ambiguity led listeners to perceive a more neutral emotive state—one amenable to a quadrant shift.

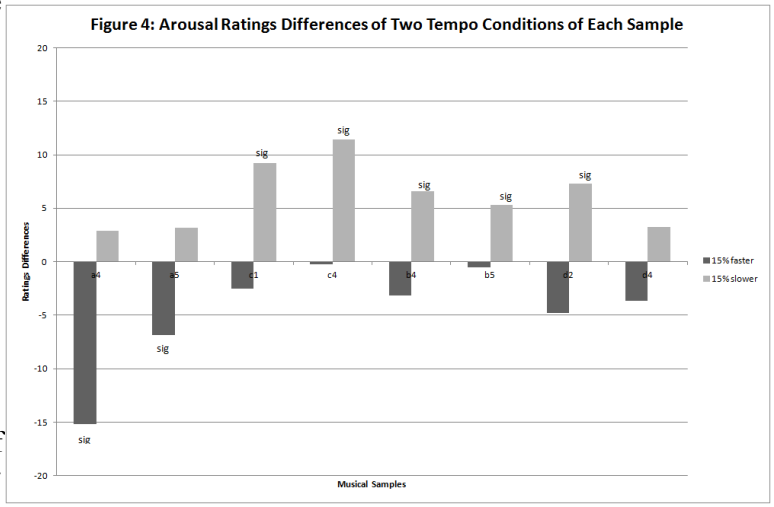
3.2 Findings in Familiarity Ratings [G.P.]

Figure 3: Mean Familiarity Rating by Tempo Condition of Each Sample



The collected familiarity data was analyzed to determine if familiarity with a musical excerpt had any effect on the changes in perceived emotion between tempi. The average familiarity ratings of each excerpt at each tempo (grouped by excerpt) are presented in Figure 3. Evidently, there is a trend in the data, with familiarity increasing from 15% to -15% to 30% to -30% to the original. In investigating the origins of this trend, it was discovered that the experiment was not in fact randomized in the way it was intended; each participant was presented with the excerpts in the identical order by tempo, the same order as the familiarity trend (15% first, -15% second, and so on.) Given this information, it can be inferred that the familiarity trend arose from the fact that, on average, participants rated each excerpt with a higher familiarity as the experiment progressed.

Following this discovery, the average ratings differences were reanalyzed to examine this new factor of order effects. Since the order and familiarity of the 15% and -15% excerpts were consistent, with 15% first and least familiar and -15% second and more familiar, the average arousal rating differences of each were compared, as shown in Figure 4. The results show a correlation between the order/familiarity and the magnitude of mean difference in ratings, with 5 of the 15% mean rating differences showing significance and only 2 of the -15% mean rating differences showing significance. This correlation is likely be an effect of the order and familiarity, although it could also be due to other factors, such as a difference between slow and fast. Valence data was similarly analyzed, with inconclusive findings, as none of the analyzed mean rating differences were significant.



3.3 Adjectival Data [C.L.]

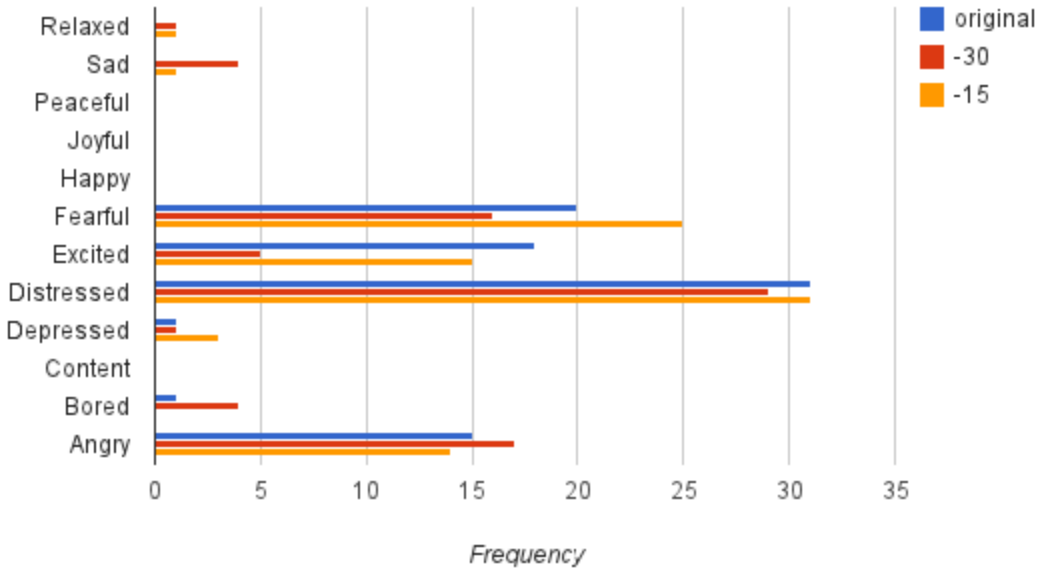
Adjectival data was analyzed in order to determine the frequency of responses for each stimuli. Data was then compared with our hypothesis.

A. HIGH AROUSAL/NEGATIVE VALENCE (ANGER/FEAR): HA_NV

A4. Shostakovich: String Quartet No. 8, II

This stimuli did exhibit changes in valence as represented in Figure 5. At -30% and -15% of tempo, a positive valence change was recorded in a small number of participants.

Figure 5: Shostakovich Histogram with Tempo Changes



4. CONCLUSIONS [G.P.]

This study set out to understand the origins of the emotional qualities of music by isolating tempo as a contributing factor and determining its effect on the perceived emotion of a musical excerpt. We hypothesized that, according to the circumplex model of emotion, tempo would affect ratings of arousal, but not ratings of valence. Our results demonstrate that tempo is correlated to arousal: arousal increases with tempo and vise versa, which is consistent with our hypothesis. In some excerpts, however, valence was also affected by changes in tempo, a result that remains to be explained. At this point in the process, further analysis is yet to be done on our collected data, which could elucidate this valence effect, as well as provide new conclusions. Along these lines, the valence data will be analyzed to find patterns and relationships between those pieces that showed a change in valence and those that did not. Furthermore, the survey data retrieved at the beginning of the experiment will be considered to determine the effects of its contents, looking at the effects of, among others, prior emotional state, musical background, and language background. These further analyses will shed light on the nuances of our findings and the positive correlation between tempo and arousal.

However, the issues with our experimental design and execution must also be acknowledged. In its execution, the lack of randomization presents a confound in our results, as demonstrated in part by the familiarity analysis, that must be addressed in further incarnations of the experiment. In order to avoid the trend and effects of familiarity, excerpts of each tempo must be presented randomly to each participant. In addition, the experimental design itself has multiple limitations that can be addressed. In the creation of the stimuli, using Logic to alter the tempo, we experienced audio loss as the difference in tempo increased, leading to limitations in the amount of possible tempo change. While more extensive tempo changes would likely have created a more robust result, 30% became the highest magnitude of change possible.

Additionally, because for each stimulus, an original excerpt was stretched or condensed, certain stimuli could sound like "slowed down" or "sped up" versions of an original, and participants could perceive what they considered to be the original intention of the piece in spite of its altered tempo. This perceptual effect brings into question the validity of the emotions of a stimulus as being perceived unrelated from its original, and therefore affects the participant's frame of reference. Furthermore, due to time constraints, only five excerpts were used, leading to a high level of repetition within the experiment that could allow participants to extrapolate the intentions of the experiment, possibly affecting their responses. This repetition also reflects the overall length of the experiment, which introduces the issue of monotony and fatigue.

As this is simply a pilot study, designed and performed in limited time, further iterations of this experiment can address these issues. By increasing the number of excerpts and using a different method to create stimuli of different tempos, the integrity of the excerpts themselves can be improved. The number of tempo variations could also be decreased (perhaps using only the original and ±30%), which, while providing a less precise tempo variance, would allow for less repetition and experiment fatigue. Additionally, with a larger pool of participants, a between subjects paradigm could be employed that would allow each participant to listen to only one set (by tempo) of the excerpts, eliminating any comparison or familiarity increase over the course of the experiment. By adjusting the design and execution in these ways, we will be able to enhance and further explore the positive results of this pilot study.

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