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Juicy lemons for measuring basic empathic resonance

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ABSTRACT

Watch or even think of someone biting into a juicy lemon and your saliva will flow. This is a phenomenon of resonance, best described by the Perception–Action Model, where a physiological state in a person is activated through observation of this state in another. Within a broad framework of empathy, including manifold abilities depending on the Perception-Action link, resonance has been proposed as one physiological substrate for empathy. Using 49 healthy subjects, we developed a standardized salivation paradigm to assess empathic resonance at the autonomic level. Our results showed that this physiological resonance correlated positively with self-reported empathic concern. The salivation test, delivered an objective and continuous measure, was simple to implement in terms of setup and instruction, and could not easily be unintentionally biased or intentionally manipulated by participants. Therefore, these advantages make such a test a useful tool for assessing empathy-related abilities in psychiatric populations.

1. Introduction

1.1. Perception–action

Shared representations are key to social interactions, serving as a basis for common physiological states in which one unintentionally matches the body postures, facial expression, voice intonation, or other behaviors of their interaction partner. This phenomenon, called resonance, is best described by the Perception–Action Model (Preston and de Waal, 2002). According to this model, the perception (or even the imagination) of a subject's action automatically activates the observer's corresponding representations of that action, leading to an action in response. The perceived physiological state can be emotional, motor, or autonomic, evoking a corresponding response of emotional, motor or autonomic contagion. Resonance, such as a physiological linkage between two individuals, may be an evolutionary precursor and physiological substrate for empathy (Levenson and Ruef, 1992; Decety and Meyer, 2008; Haker et al., 2010; Gonzalez-Liencres et al., 2013). Within a broader framework, empathy can be considered as a superordinate category including manifold abilities related to empathy that depend on the same underlying perception–action mechanism (Preston and de Waal, 2002). While resonance can be seen as a basic physiologic ability, cognitive aspects such as perspective-taking or Theory of Mind represent higher-order facets of empathy (Gonzalez-Liencres et al., 2013).

1.2. Assessing empathic resonance

Various psychiatric disorders can alter social responsivity and empathic-related abilities. Examples include autism (Senju et al., 2007; Minio-Paluello et al., 2009; Helt et al., 2010), schizophrenia (Falkenberg et al., 2008; Haker and Rössler, 2009), depression (Wexler et al., 1994), PTSD (Nietlisbach et al., 2010), and personality disorders such as psychopathy (Hagenmuller et al., 2012). Assessing empathic abilities with resonance tasks can reveal other aspects than explicit problem-solving tasks such as Theory-of-Mind tasks. The more naturalistic stimulus presentation attached to resonance paradigms leads to spontaneous behavioral reactions that may be more "real-life" than are the cognitively reflected answers that depend upon participants' verbal abilities. Therefore, resonance tasks may better capture daily-life social skills that rely on adequate reactions to implied cues and which are independent of participants' intellectual abilities.

The use of contagion to evaluate resonance has been well documented in studies with yawning (Provine, 1989; Platek et al., 2003; Platek et al., 2005; Provine, 2005; Haker and Rössler, 2009;

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Norscia and Palagi, 2011), laughing (Platek et al., 2003; Provine, 2005; Haker and Rössler, 2009), and itching (Papoiu et al., 2011; Holle et al., 2012). The preferred method for assessing contagion is observation and rating of behavioral data. This method provided interesting results in the context of psychiatric disorders, e.g. showing reduced contagion by yawning and laughing in patients with schizophrenia (Haker and Rössler, 2009) or PTSD (Nietlisbach et al., 2010) and in offenders with psychopathy (Hagenmuller et al., 2012). However, this method can also be biased. First, the results rely on the subjective rating of a participant's behavior by the experimenter. For example, an experimenter applying the yawning paradigm must decide whether a subject taking a deep breath is already caught by yawning. Thus, this rating allows for only categorical, mostly binary, results (yes/no) that induce a loss of information and make discriminations among individuals difficult. By contrast, electromyographic studies can enable accurate and objective examinations of facial contagion, although such data acquisition is extensive and the analysis complex. Second, an observed reaction may unintentionally be biased by the participants themselves, for example through education or social desirability, according to which joining in with the laughter is expected but yawning is considered impolite. Thus, the low ordinal resolution of rating, together with these biases by participants, may lead to a ceiling or floor effect.

In order to expand results about resonance provided by observable contagion and to overcome these shortcomings due to the interference-proneness of motor responses, we have developed the salivation test as a new paradigm for assessing resonance.

1.3. A new paradigm: the salivation test

1.3.1. Previous measures of salivation induced by visual stimuli

The mere observation of food elicits bodily reactions such as salivation (Pavlov, 1927; Spence, 2011), and the sight of sour food can have an effect similar to that of a sour taste or smell. Nederkoorn et al. (2001) have shown that subjects salivate more at the sight of a lemon than other food, such as lasagna or chocolate; this effect is significant regardless of the technique with which salivation is measured.

The influence of social cues on salivation was shown by a few previous studies, but not in the context of empathy. Pangborn (1968) has reported with single participants that salivary flow is increased when they view the experimenter sniffing or cutting a lemon. This salivation induction can be identified as resonance phenomenon and has been replicated in larger studies, where increased salivary flow rates have been noted in western participants watching another person eating a lemon (Jenkins and Dawes, 1966) or in Japanese participants viewing someone eating pickled plums (Hayashi and Ararei, 1963; Hayashi, 1968). However, other contemporary studies have failed to demonstrate a significant effect (Kerr, 1961; Shannon, 1974; Pangborn et al., 1979). To examine the salivation inducing effect of seeing another person biting into a lemon in the context of empathy, a standardized method is needed.

1.3.2. Advantages of the new paradigm over methods involving behavioral observations

The salivation-induction approach offers the possibility to be more objective by measuring the weight of the saliva absorbed by cotton rolls rather than relying upon the subjective rating of an experimenter as applied in laughing and yawning paradigms. Furthermore, salivation can be recorded continuously, allowing for better resolution of the floor effect associated with behavioral ratings of phenomena such as contagion by laughing and yawning. Thus, information loss can be avoided and better discrimination among subjects ensured.

Although there is evidence for possible voluntary control of salivation by imagery, e.g., via meditation (Power and Thompson, 1970; White, 1978), it appears that this manipulation must be intentionally executed. Therefore, salivation should be less prone to manipulation by participants than is yawning or laughing.

1.3.3. Factors influencing salivation

Several studies (mostly in the 1960s) demonstrated that personality traits can affect lemon juice-induced salivary flow. Although a positive correlation between salivation and introversion has been replicated several times (Corcoran, 1964; Eysenck and Eysenck, 1967), those findings have now been contradicted (Millar et al., 1993). The influence of emotional states has been shown by a decline in flow due to fear, anxiety (Power and Thompson, 1970), and stress (Bates and Adams, 1968), or during mental effort (Birnbaum et al., 1974; Epstein et al., 2005).

1.4. Aims of the study

This study had two goals in developing a new standardized paradigm for assessing resonance as a basic empathy-related ability. First, the paradigm had to deliver an objective and continuous measure, be easy to implement in terms of setup and instruction, and be less prone to unintentional bias or intentional manipulation by the participants. We presumed that the salivation test met those criteria. We hypothesized that, in line with the Perception–Action Model, seeing a person biting into a lemon will induce more salivation than seeing another action, not related to eating lemons. Second, we wished to explore how this physiological resonance might be related to higher-order facets of empathy such as self-reported empathic traits.

2. Methods

2.1. Participants

Our assessment involved 49 healthy participants [mean age=31.7 (S.D.=9.7), age range 20–57 years; 31 males] without psychiatric history and free of pharmacological medication. The study was approved by the regional ethics committee of the canton of Zurich and conducted in accordance with the guidelines of the Helsinki Declaration. All participants provided written informed consent, and they were debriefed after the testing concluded.

2.2. Instruments

2.2.1. The salivation test

Participants sat approximately 60 cm from a computer screen. Before looking at the videos, each was asked to place three cotton dental rolls in his mouth in a standardized manner: two buccally and one on the tongue. The stimulation video presented a man cutting and eating a lemon (Fig. 1A) while the control video involved the same man retrieving paper balls of different colors from a container (hidden by the table) and placing them before him on the table. The control video was used to measure baseline salivary flow. Each video lasted 1 min and was displayed thrice in random order to each participant. Recovery periods between videos were at least 10 min long. The instruction for the lemon video was to look at the video. The instruction for the control video was to count the paper balls (a different color for each of the three runs). That simple control task was aimed at activating representations other than food, sourness, or anything else associated with eating lemons. To determine the level of induced salivation, the cotton rolls were weighed before and immediately after each video (balance with 100-g weighing range, 0.01-g graduation; Fig. 1B). This cotton-roll method has previously been proven valid, reliable, and sensitive for measuring salivary flow (White, 1977; Nederkoorn et al., 2001).

2.2.2. Interpersonal Reactivity Index (IRI)

The IRI is a questionnaire measuring self-reported empathic traits, including four seven-items subscales, each of which tapping “a separate aspect of the global concept empathy” (Davis 1980). Both the subscale ‘Perspective taking’ addressing

Fig. 1. (A) Still of lemon video; (B) Cotton rolls were weighed before (weight=1.62 g) and immediately after video stimulation (weight=2.35 g) to determine how much saliva was absorbed.

mentalizing abilities and the 'Fantasy scale' assessing the tendency to identify with fictional characters, tap primarily cognitive aspects of empathic traits; 'Empathic concern', or one's capacity for compassionate feelings for others and 'Personal distress', which involves self-oriented responses to the difficult situations of others, are both assessing rather emotional aspects. This instrument gives insight in one person's self-perception of her own empathic abilities. The IRI has good internal and test-retest reliabilities (Davis, 1980). Although IRI has been criticized as measuring factors that are not empathy itself but that are correlated with empathy, it can be considered as a good self-report measure of empathic traits (Baron-Cohen and Wheelwright, 2004; Baird et al., 2011).

2.3. Statistical analysis

To analyze the salivation-inducing effect of the lemon condition and determine whether repetition of presentation influences salivation (e.g., habituation effects), we conducted repeated-measures ANOVA with the two factors 'condition' (lemon vs. control) and 'sequence' (three presentation times). Afterward, we calculated an index for mean induced salivation as the difference between mean salivation under the lemon condition versus the control condition.

Pearson's r-values and ANCOVA statistics were then computed with this index. Effect sizes were reported as r-values and partial eta squared (η_p^2), which represents the proportion of variance that a variable explains that is not explained by other variables in the analysis. All effects were examined for significance at $p<0.05$, using IMB SPSS Statistics Version 20 software.

3. Results

3.1. Proof of the paradigm

The results of the 2×3 repeated-measures ANOVA indicated a significant main effect of condition on salivation, *Wilks' Lambda*= 0.56, $F(1,47)=36.65$, $\eta_p^2=0.44$, and $p<0.001$. That is, significantly more salivation was induced in participants during the lemon video than during the control video (Fig. 2).

No other main effects or interaction were significant (sequence of stimulus presentation, *Wilks' Lambda*=0.89, $F(1,47)=2.92$, $\eta_p^2=0.11$, and $p>0.05$; interaction between condition and sequence, *Wilks' Lambda*=0.96, $F(2,46)=1.03$, $\eta_p^2=0.043$, and $p>0.05$). Therefore, because no effect of sequence was observed, we used the mean salivation index in our further analysis.

An ANCOVA of this mean salivation index with between-subject factor sex (male and female) and covariate age revealed no main effects of sex [$F(1,44)=0.036$, $p=0.52$, and $\eta_p^2=0.01$] or age [$F(1,44)=0.10$, $p=0.29$, and $\eta_p^2=0.026$], and no interaction between sex and age [$F(1,44)=0.058$, $p=0.41$, and $\eta_p^2=0.015$].

3.2. Relationship with self-reported empathy

The salivation index correlated positively with the IRI subscale 'empathic concern' ($r=0.37$, and $p<0.05$), while no significant correlations were found with the other IRI subscales. The subscale 'empathic concern' of the IRI appeared to have good internal consistency, $\alpha=0.80$. The other subscales of the IRI provided mixed reliability coefficients ('fantasy': $\alpha=0.81$, 'personal distress': $\alpha=0.67$, and 'perspective taking': $\alpha=0.58$).

To control for possibly confounding effects of sex and age on the outcome-variable salivation index, we conducted an ANCOVA with the factor sex and covariates age and 'empathic concern'. The main effect of 'empathic concern' on salivation was significant [$F(1,44)=6.05$; $p<0.05$, $\eta_p^2=0.12$] whereas those of age [$F(1,44)=0.58$, $\eta_p^2=0.013$], and sex [$F(1,44)=0.05$, $\eta_p^2=0.001$] were not significant ($p>0.05$).

The salivation index for the first exposure to the paradigm was computed as the difference between salivation after the first exposure to the lemon condition versus the first exposure to the control condition. The correlation of salivation index at first exposure and 'empathic concern' was significant too ($r=0.39$, and $p<0.01$).

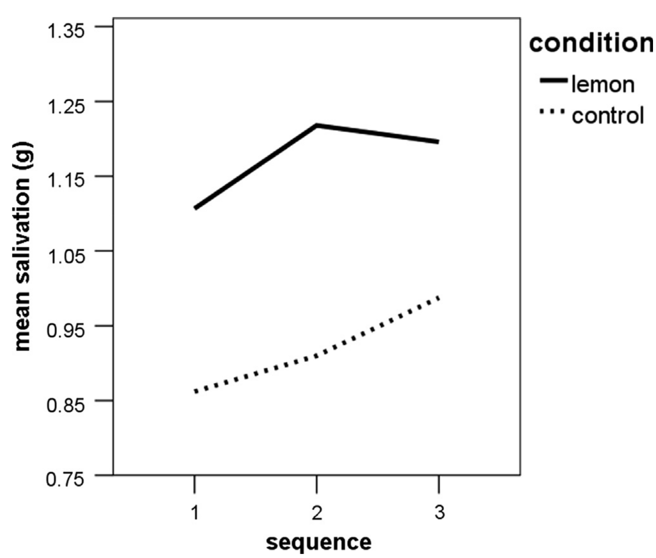

Fig. 2. Mean salivation under lemon and control conditions depending on the sequence of stimulus presentation.

4. Discussion

4.1. The new paradigm

Our salivation test was aimed at assessing resonance. As the results show, the 'lemon condition' induced significantly more salivation than the control condition, thereby suggesting that this new test can be utilized for measuring autonomic resonance. The effect of 'condition' was noteworthy, as it explained 44% of the variance that was not explained by other variables. That is, more saliva was produced by participants while observing someone chewing a lemon than while watching another action unrelated to eating. This outcome is in line with those from previous research on the perception–action link, in which the mere sight of someone's state automatically activates the same state in the observer and, in turn, evokes an associated physiological response (Preston and de Waal, 2002). This link between perception and action has been previously investigated at the autonomic level. For example, within the context of learning, Pavlov (1927) studied the reflex linking a visual stimulus and an autonomic reaction: the mere perception of an object automatically activating related representations that generate a corresponding response, i.e. a perception–action link within a non-social setting. Likewise, within a social context (but not in the framework of empathy), above mentioned psychological investigations have focused on a perception–action link, showing that observing someone eating sour food is linked to a measurable response in the observer (Hayashi and Ararei, 1963; Jenkins and Dawes, 1966; Pangborn, 1968). Finally, within the context of empathy, other autonomic measures were reported to be implicated in the perception–action link. For example, one's skin conductance and heart rate while observing conflicting/cooperative interpersonal situations or imagining emotional experiences are thought to function as biological markers of empathic resonance (Preston et al., 2007; Balconi and Bortolotti, 2012). Even the observed pupil size can be mirrored by the observer's own pupil (Harrison et al., 2006). The present findings provide therefore additional support for expanding the perception–action link for emotional states and motor actions as underlying mechanism for empathy to non-volitional responses by the autonomic nervous system.

4.2. Relationship with self-reported empathy traits

Importantly, the induced salivation was predicted by the IRI-subscale 'empathic concern', which represents the emotional component of self-reported empathic abilities (Davis, 1983). This scale had a good reliability coefficient in our sample ($\alpha=0.80$). Therefore, participants with greater induced salivation were also those who reported to experience more "feelings of sympathy and concern for others" (Davis, 1983). With items such as "I' am often quite touched by things that I see happen" or "I often have tender, concern feelings for people less fortunate than me", this scale most likely assesses emotional aspects linked with the resonance process compared to the other scales 'personal distress', 'fantasy' and 'perspective taking' of the IRI. However, a basic physiologic reaction of salivation cannot be equated to higher-order aspects of self-reported empathic abilities, maybe explaining why the significant correlation with salivation ($r=0.37$) was not stronger. However, the value of partial η^2 (0.12) approximates Cohen's (1969) benchmark of 0.1379 for "large" effects (Richardson, 2011). The absence of significant correlation with the other scales may indicate that these also assessed various cognitive aspects related to empathic abilities, as self-control, imagination, or motivation (as indicated, e.g., by the poor internal consistency of subscale 'perspective taking' in our sample), which appear to be very far from the studied physiological measure.

Other studies have produced evidence for a relationship between physiological resonance and self-reported empathic traits. For example, IRI-measured traits were reported to be associated with contagious laughing (Haker and Rössler, 2009), higher cortisol responses in observers of stressed speakers (Buchanan et al., 2011), and the vicarious activation of somatosensory cortices while watching someone else being touched (Schaefer et al., 2012) or while witnessing pain (Singer et al., 2004).

The present findings provide additional support for a relationship between a very basic – autonomic – resonance mechanism and higher-order – self-reported – empathic concern (Levenson and Ruef, 1992; Decety and Meyer, 2008; Haker et al., 2010; Gonzalez-Liencres et al., 2013). Further step in examining this relationship would be the use of this salivation-test while assessing higher-order empathic abilities based on performance instead of self-report.

4.3. Practical aspects

By ensuring a standardized position of the cotton rolls in the mouth for both conditions presented in randomized order three times each, we assume that possible influences of the position of the cotton rolls on the findings would be ruled out.

We used time intervals between each stimulus presentation of about 10 min. As the recovery period in response to lemon juice was reported to last up to 25 s (Davis et al. 1990), shorter stimulus intervals can be used, as in previous studies (Corcoran and Houston, 1977; Navazesh and Christensen, 1982; Nederkoorn et al., 2001). Furthermore, the results show that sequence of stimulus presentation did not influence the results and first exposure to both the lemon and the control video lead to similar correlation with self-reported empathic concern than exposure to the whole procedure. Therefore, applying only the first exposure to both the lemon and the control video may be sufficient for further examinations of resonance at the autonomic level.

4.4. Measuring resonance in psychiatric disorders

Observable signs of resonance can be diminished in psychiatric disorders such as autism (Senju et al., 2007; Minio-Paluello et al., 2009; Helt et al., 2010), schizophrenia (Falkenberg et al., 2008; Haker and Rössler, 2009), depression (Wexler et al., 1994), PTSD (Nietlisbach et al., 2010), and personality disorders such as psychopathy (Hagenmuller et al., 2012). The underlying mechanisms for these declines are unclear, possibly differing among or even within diagnostic groups. Improving our capacity to examine basic empathic resonance would allow us to gain more insight into those underlying mechanisms. With psychiatric patients, applying this approach at the autonomic level may have several advantages over assessments of resonance made at the behavioral level. The extent to which a shared representation effectively leads to an observable response is subject to inhibitory control at both motor and emotional levels. For example, reduced facial expression has been reported in patients with schizophrenia while they indicated similar affective empathic traits than a healthy control group (Kring et al., 1993; Haker and Rössler, 2009). The apparent affective blunting seen in such patients, combined with their self-reporting of unimpaired emotional concern (Haker et al., 2012), suggests a discrepancy between activated internal representations and observable motor, e.g., mimical, response. This possible inhibition of the response at the motor or emotional level may not be as likely to occur at the autonomic level because it is less exposed to inhibitory control (Spence, 2011). A similar reduced contagion by yawning was also reported in offenders with psychopathic traits (Hagenmuller et al., 2012). However, as the offenders reported also reduced emotional concern, the blunting associated with psychopathy may not have arisen by inhibition of the motor response as in schizophrenia, but maybe earlier, between perception and activation of internal representations. According to this, resonance at the autonomic level as measured by the salivation test may be intact in patients with schizophrenia but reduced in offenders with psychopathic traits.

Within the context of autism spectrum disorders (ASD), assessments of empathy-related abilities have led to contradictory results (Klin et al., 2002; Senju, 2013). Thus, such evaluations might also benefit from the salivation test. Dissociations have been found between various aspects of empathy; while individuals with ASD may score lower on cognitive empathy than control individuals, they do not differ from each other on measures of emotional empathy (Rogers et al., 2007; Dziobek et al., 2008). This has also been noted with basic measures related to empathy, e.g., the imitation of emotional facial actions (Bird et al., 2007; Press et al., 2010), contagious yawning (Senju et al., 2007; Senju et al., 2009), or electrodermal responses to distress cues (Blair, 1999). However, few studies have extensively investigated this basic measures related to empathy in autism. The different – "autistic" – understanding of explicit test instructions makes the assessment of any abilities in autism challenging. Therefore, paradigms that do not require a specific instruction are needed. Due to its minimal instructions, the salivation test allows one to measure the spontaneous processing of social information, thereby decreasing the influence of participants' verbal understanding. When using the salivation test, and particularly in ASD and other situations in which disturbances in visual attention could be expected, one should additionally control for atypical orienting to the stimulus with eye-tracking. This may help to identify the mechanisms underlying social difficulties in those disorders. However, a setup including eye-tracking requires expensive technology, training for the assessment, and expertise in handling the data, complicating this otherwise easily implementable test. Therefore, the additional assessment of eye-tracking data might be of value for some research questions, but maybe not for all applications in the clinical research context.

4.5. Limitations

While choosing this new paradigm as a measuring tool for resonance, we presumed that salivation is less prone to intentional manipulation by participants than other resonance paradigms. Although we did not control explicitly for that criterion, it is unlikely that our participants voluntarily tried to influence their salivary flow because they had not been explicitly informed about the exact purpose of the test until the end of the experiment. We also did not control for other potentially influential factors, such as stress or anxiety, even though those factors are expected to reduce salivary flow (Bates and Adams, 1968; Power and Thompson, 1970). Therefore, we predict our present findings would have been even more pronounced if there was a stress- or anxiety-linked effect.

4.6. Conclusion

Assessing the basic aspects of resonance is of interest to researchers who are elucidating the underlying mechanisms of reduced observable resonance in different psychiatric disorders such as autism, schizophrenia, or psychopathy. Because the setup for this application is not expensive and does not require either special training on the part of the experimenter or complicated instructions to the participant, this new salivation test may be easily implemented in clinical/psychiatric research settings.

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