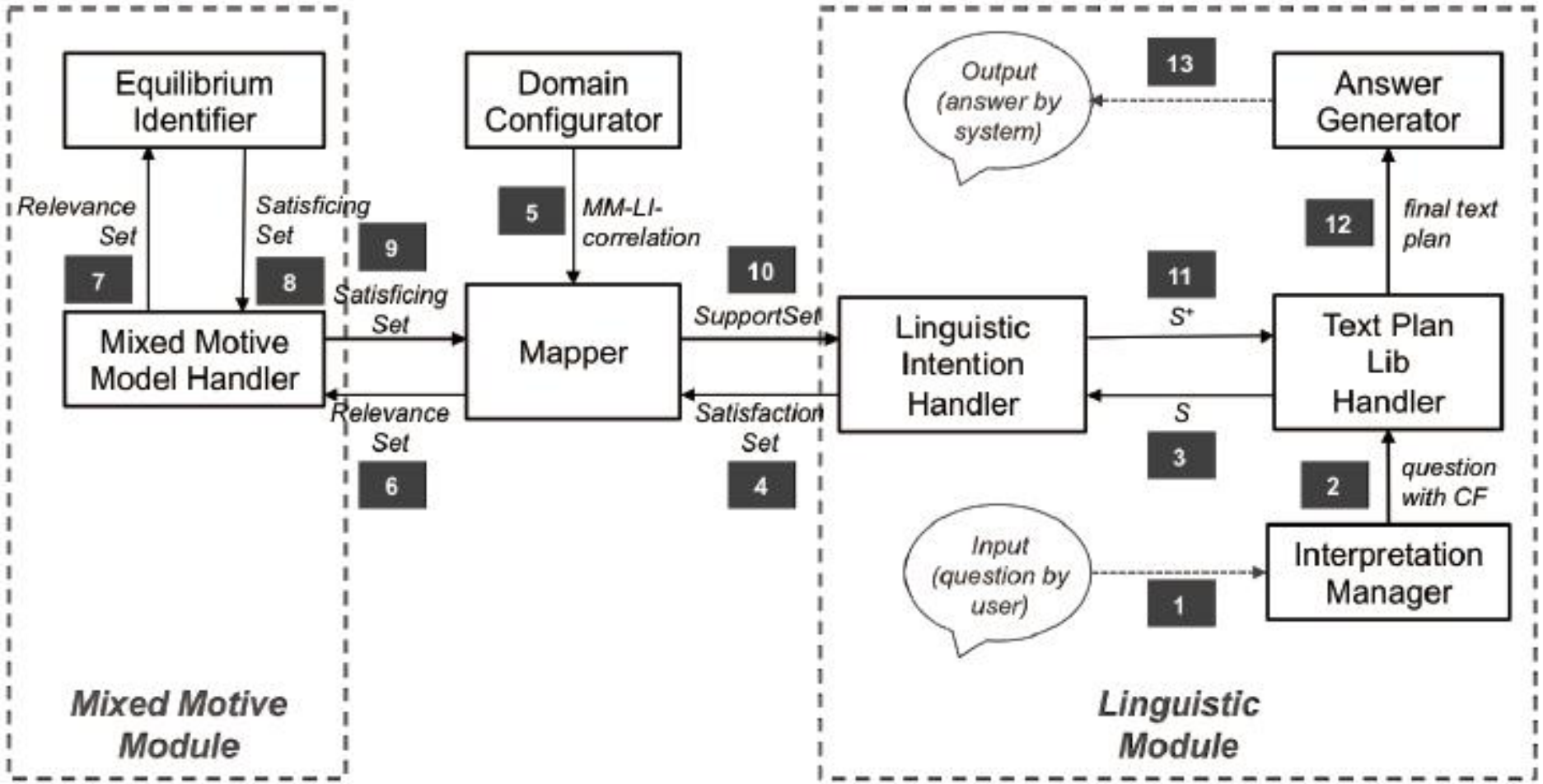
Finding the Middle Ground- A Model for Planning Satisficing Answers

- **Major task**: devise an answer planning approach that supports fair dialogues under congruent and incongruent interlocutor interests in a Question-Answer settings.
- **Fairness**: an equitable satisfaction of all interlocutors' interests.
- **Motives**: objectives or situations that interlocutors would like to accomplish, eg: to find the best price when shopping.
- **Model**: formalize answer planning as psychological game embedded in text planning approaches for creating dialogues perceived as fair by all interlocutors.

- **Planning answers given mixed motives**:
  Ω represents the solution space with potential answers
  f : objective function that assigns values to all answers $\mathrm{x} \in \Omega$ for representing their potential in satisfying motives of interlocutor $\mathrm{i} \in I$
- **Goal**: find an answer $\mathrm{x} \in \Omega$ with highest satisfaction of motives f(x) of intelocutor $\mathrm{i} \in I$; i.e. $\mathrm{f}(x^*) = \max\{f(x) \mid x \in \Omega\}$
- **For capturing equal motive satisfaction**, add motives of counterparts
  - $\mathrm{i} \in I; \max\{f_{i,-i}(x) \mid x \in \Omega\}$
- **A compromise**: an answer x^+ with a minimum quality s so that $\mathrm{f}(x^+) \geq s$ the satisficing solution x^+, i.e. $f(x^+) = \max\{f_{i,-i}(x) \geq s \mid x \in \Omega\}$


Equilibrium Identifier
Domain Configurator
Relevance Set
7
Satisficing Set
8
9
Satisficing Set
5
MM-LI-correlation
10
SupportSet
Mixed Motive Model Handler
Mapper
Relevance Set
6
Satisfaction Set
4
Mixed Motive Module
Output (answer by system)
13
Answer Generator
12
final text plan
11
S+
Linguistic Intention Handler
Text Plan Lib Handler
S
3
2
question with CF
Input (question by user)
1
Interpretation Manager
Linguistic Module

- Players p represent interlocutors I.
- For each player, **MotiveSet** that consists of individual motives, **IndM**, as well as motives the player anticipates from counterparts, **AntM**.

$$MotiveSet_{\mathrm{p}} = IndM_{\mathrm{p}} + AntM_{\text{-}\mathrm{p}}$$

- Mixed motives **MM**: all players' MotiveSet.

$$MM = \{MotiveSet_{\mathrm{p_1}} \ldots MotiveSet_{\mathrm{p_n}}\}$$

each player has a real-valued weight and all players form a weight vector $\overrightarrow{Weight}_{\mathrm{m}}$.

Motive $m \in MM$	Weight p_{a}	Weight p_{b}
High level of reliability of product (m_{R})	1.90	1.00
Fair price of product (m_{FP})	0.70	0.00
Exclusive design of product (m_{ED})	0.53	1.00
Comprehensive product information (m_{CPI})	1.67	1.00
Improving customer relationship (m_{ICR})	0.00	4.00
Increase revenue (m_{IR})	4.00	4.00

Table 1: Extract of domain-specific mixed motive model with default weights for player (p_{a}) and player (p_{b}) representing customer and retailer

Linguistic Module

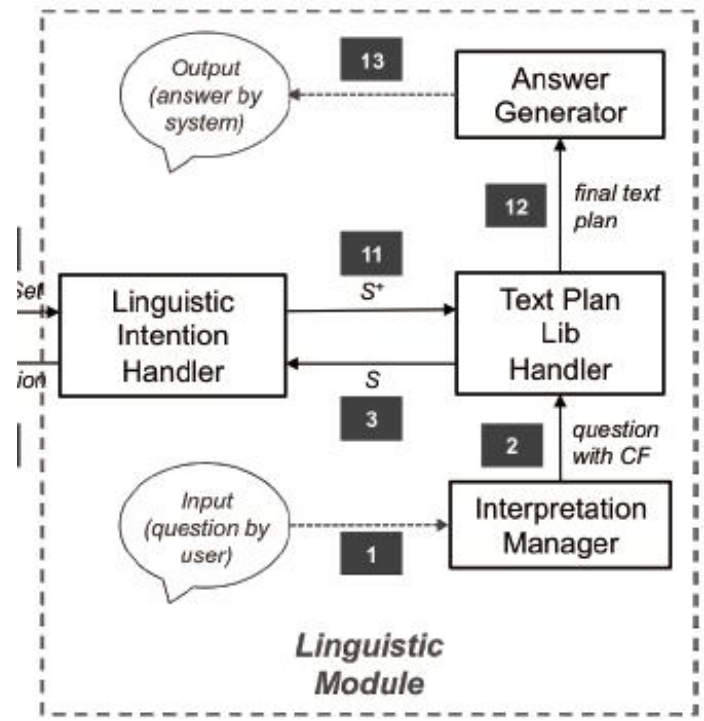
- Text planning technologies: made of some plan operators according to **Rhetorical Structure Theory**.
- Plan operator: a **nucleus** and some related **satellites** which represent an opportunity to satisfice mixed motives during dialogue.

$$S = \{sat_{\mathrm{AAS}}, sat_{\mathrm{VER}}, sat_{\mathrm{DF}}, sat_{\mathrm{EUP}}\}$$

- Linguistic intention **li**: satisfied by satellites **sat.**

  SatisfactionSet: cover linguistic intentions that can be satisfied by satellites of set S.

$$SatisfactionSet = \{li_{\mathrm{A}}, li_{\mathrm{ER}}, li_{\mathrm{F}}, li_{\mathrm{MP}}\}$$

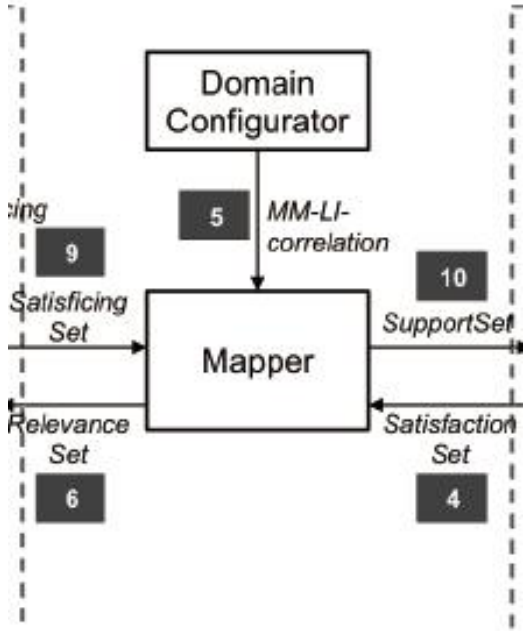


Ling. Intention $li \in LI$	supports $m \in MM$	Description
Advantages (li_{A})	$\{m_{\mathrm{ICR}}, m_{\mathrm{FP}}, m_{\mathrm{ED}}, m_{\mathrm{IPD}}, m_{\mathrm{R}}, m_{\mathrm{HLS}}, m_{\mathrm{ACB}}, m_{\mathrm{SCD}}, m_{\mathrm{I}}, m_{\mathrm{HLP}}, m_{\mathrm{PB}}, m_{\mathrm{Q}}\}$	Integration of information about advantages of product(s) into answer
External_ Review (li_{ER})	$\{m_{\mathrm{SI}}\}$	Presentation of customer reviews
My_Product (li_{MP})	$\{m_{\mathrm{ICR}}, m_{\mathrm{SP}}, m_{\mathrm{R}}, m_{\mathrm{HLC}}\}$	Mentioning products that could be interesting for customer
Functionality (li_{F})	$\{m_{\mathrm{EU}}\}$	Extension of answer regarding product functions
Opinion (li_{O})	$\{m_{\mathrm{HEM}}, m_{\mathrm{SP}}, m_{\mathrm{R}}, m_{\mathrm{SI}}\}$	Integration of subjective (retailer) opinion into answer

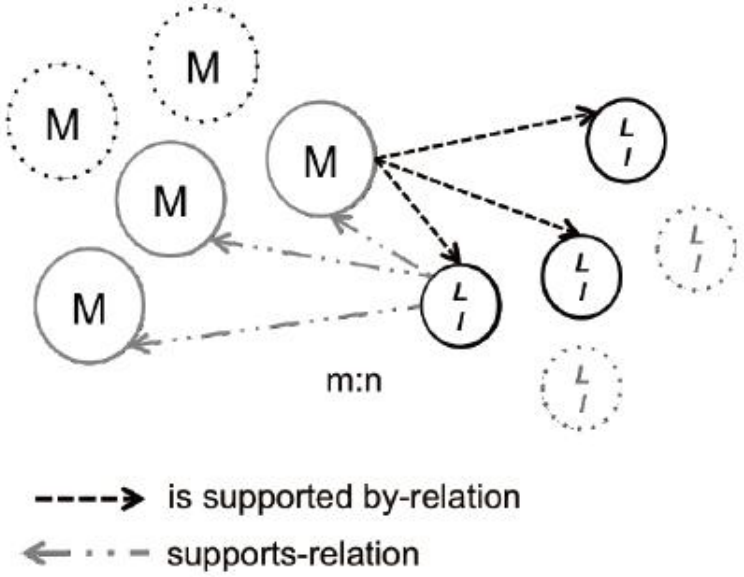
Table 2: Extract of domain-specific linguistic intentions $li \in LI$ with supported motives and description

Mapper

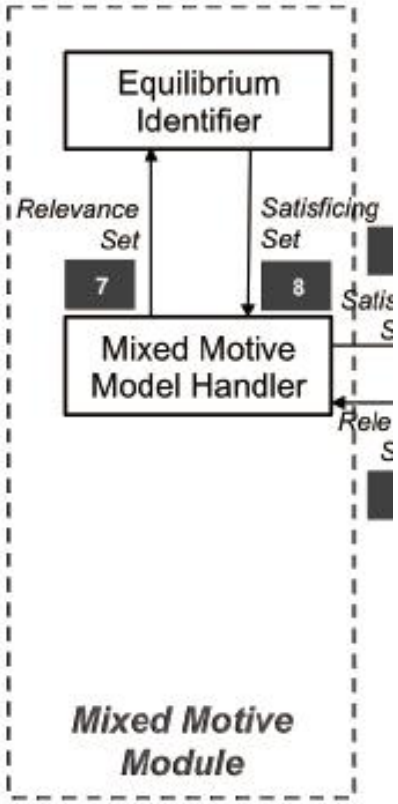
- Linguistic intentions have to be mapped onto motives. The m:n correlation between linguistic intentions and motives is **doman-specific**, has to be **specified empirically** and is induced by the **domain configurator**.
- **RelevanceSet** based on the SatisfactionSet:



$$RelevanceSet = \{m_{\mathrm{Q}}, m_{\mathrm{R}}, m_{\mathrm{IPD}}, m_{\mathrm{HCS}}, m_{\mathrm{ACB}}, m_{\mathrm{ICR}}, m_{\mathrm{I}}, m_{\mathrm{SCD}}, m_{\mathrm{PB}}, m_{\mathrm{EU}}, m_{\mathrm{FP}}, m_{\mathrm{ED}}, m_{\mathrm{HLP}}, m_{\mathrm{SI}}, m_{\mathrm{SP}}, m_{\mathrm{HLC}}\}$$



Mixed motive module



- **SatisficingSet**: consists of motives that are sufficiently interesting for all interlocutors(i.e. weighted positively), and have preferably low conflict potential(i.e. small differences in player weights).
- **Equilibrium identifier**: specify strategy sets for all players by generating the power set of the RelevanceSet.
- Each **strategy** represents a possible combination of **motives** and is measured by a normalized local **payout** for each player based on weights of involved motives.

$$S_{\mathrm{p_a}} = S_{\mathrm{p_b}} = \{s_1 \dots s_{137}\}; s_{18} = \{m_{\mathrm{Q}}, m_{\mathrm{R}}\} \quad (7)$$

$$LocalPayout_{\mathrm{p_a},s_{18}} = 0.1280; LocalPayout_{\mathrm{p_b},s_{18}} = 0.0090$$

- To find the best answer that provides high local payouts for each player regarding the counterparts。

$$LocalPayout(s^*, \overrightarrow{s_{\text{-p}}}) \geq LocalPayout(s, \overrightarrow{s_{\text{-p}}}), \forall s \in S_{\mathrm{p}}$$

$$LocalPayout(s^*, \overrightarrow{s_{\text{-p}}}^*) \geq LocalPayout(s, \overrightarrow{s_{\text{-p}}}^*)$$

Mixed motive module

- Get the strategy: $\overrightarrow{s} = \{s_x, s_y\}; s_x \in S_{p_a}, s_y \in S_{p_b}.$
- In the example of customer and retailer in a shopping scenario, we find two **Nash equilibria** which represent best answers for the player p as well as the whole group of players P in the sense of a solution with minimum quality.
- With $\overrightarrow{s} = \{s_{36}, s_{36}\}$, select the **non-pareto-dominant option** for finding the strategy profile with the lowest difference in local payouts.

Answer Generating

- Mapping mixed motives onto linguistic intentions:
  Process the inverse **is-supported-by-relation** between motives and linguistic intentions and compare the result set with **SatisfactionSet.** The intersection is **SupportSet:**

$$SupportSet = \{li_{\mathrm{A}}, li_{\mathrm{MP}}\}$$

- The resulting set **S+**: determined by the **linguistic intention handler** by analyzing 1:1 relations between linguistic intentions of the **SupportSet** and satellites of the set **S**. $S^{+} = \{sat_{\mathrm{AAS}}, sat_{\mathrm{EUP}}\}$
- The **text plan lib handler** adjusts the final text plan regarding the selectedsatellites before sending it to the answer generator and then forms an answer through the **plan operator**.

Q: *"How many tablets offer the wifi features 802.11A, 802.11B, 802.11G, 802.11n?"*
A: *"[$_{nuc}$ The following tablets offer this feature: Sony SGPT122 Xperia.] [$_{sat_{AAS}}$ Due to its features, e.g., storage capacity: 32GB, Sony SGPT122 Xperia has some advantages compared to other products in this category.] [$_{sat_{EUP}}$ How about having a look at Sony SGPT122 Xperia by Sony?]*

Summary

- Satisficing answer planning is considered as a game consisting of four components <P,S,F,A>: the set of **players** P={pa,pb}, **strategies** of players S={Spa,Spb}, **objective functions** of players F={fpa,fpb}, and a **state space** A={a1...at} that represents the rounds of the game,i.e. answers planned in the dialogue.
- A **strategy profile** meeting the Nash equilibrium condition, $\vec{s}^{\,t} = \{s^t_{p_a}, s^t_{p_b}\}$ is specified and resulting **payouts** are observed: $f(a^{\mathrm{t}}, \vec{s}^{\,\mathrm{t}}) \rightarrow LocalPayout \rightarrow \mathbb{R}.$
- The calculation of local payouts by means of objective functions in state a^{t} depend on both the selected strategy profile and former states in A,i.e. all answers planned in the dialogue until a^{t}.

Algorithm

Algorithm 1 Determining set S^+ of satisficing satellites

Require: set of default satellites $S = \{sat_1 \dots sat_n\}$; set of players $P = \{p_1 \dots p_n\}$; set of mixed motives $MM = \{m_1 \dots m_n\}$; set of linguistic intentions $LI = \{li_1 \dots li_n\}$
Ensure: set of satisficing satellites $S^+ = \{sat_1 \dots sat_n\}$

Initialize $SatisfactionSet = \{li_1 \dots li_n \in LI | li.isSatisfiedBy(sat \in S)\}$
for $\forall sat \in S$ **do**
    $SatisfactionSet \Leftarrow SatisfactionSet_{sat} \cup SatisfactionSet$
end for
Initialize $RelevanceSet = \{m_1 \dots m_n \in MM | m.isSupportedBy(li \in SatisfactionSet)\}$
for $\forall li \in SatisfactionSet$ **do**
    $RelevanceSet \Leftarrow RelevanceSet_{li} \cup RelevanceSet$
end for
Determine $StrategySet \Leftarrow \mathcal{P}(RelevanceSet)$
Initialize $StrategyProfiles = \{\overrightarrow{s}_1 \dots \overrightarrow{s}_n\}$
for $\forall s \in StrategySet; \forall p \in P$ **do**
    Calculate $LocalPayout(s)$
    Define $\overrightarrow{s} = \{s_1 \dots s_n \in StrategySet | LocalPayout(s_p^* | s_{-p}) \geq LocalPayout(s_p | s_{-p})\}$
    $StrategyProfiles.add(\overrightarrow{s})$
end for
for $\forall \overrightarrow{s} \in StrategyProfiles$ **do**
    if $LocalPayout(s_p^* | s^*_{-p}) \geq LocalPayout(s_p | s^*_{-p})$ **then**
        $\overrightarrow{s}^* \Leftarrow \overrightarrow{s}$
    end if
end for
Determine $SatisficingSet = \{m_1 \dots m_n \in s \in \overrightarrow{s}^*\}$
if $SatisficingSet \neq \emptyset$ **then**
    Initialize $SupportSet = \{li_1 \dots li_n \in LI | li.supports(m \in SatisficingSet)\}$
    for $\forall m \in SatisficingSet$ **do**
        $SupportSet \Leftarrow SupportSet_m \cup SupportSet$
    end for
    Return $S^+ = \{sat_1 \dots sat_n \in S | sat.satisfies(li \in SupportSet \cap SatisfactionSet)\}$
else
    Return $S^+ = \{\emptyset\}$
end if

Experiment and Evaluation

- Based on a German text-based QA system in form of an online shopping assistant.
- Group: a combination of motives by users.
- Seven-point Likert scales ranging from strongly disgree(1), neither(4) to strongly agree(7) were used to assess the perceived fairness of the dialogue, the naturalness of the dialogue and the motive satisfaction.

		QA system	
	Motives	Increasing revenue (m_{IR})	Improving customer relationship (m_{ICR})
Users (N=107)	Fair price of product (m_{FP})	Mixed Motives Group #4	Mixed Motives Group #3
	Exclusive design of product (m_{ED})	Mixed Motives Group #2	Mixed Motives Group #1

Result

- The Cronbachs alpha values all three multi-item constructs lie clearly above the recommended threshold of .70.
- We calculated aggregated mean scores for each construct and do one-sample t-tests experiment.

#	Construct	Item	Alpha	Aggregated scores (mean values of items)					Interpretation
				Mean	SD	one-sample t-test with test value 4			
						T	p	95% CI	
1	Perceived Naturalness of Dialogue	1. I perceived the sales dialogue with the shopping assistant as natural.	.847	4,05	1,19	0,41	0,686	-.18 - .27	Participants were undecided with respect to the naturalness of the dialogue with the QA system.
		2. I can imagine that this sales dialogue could have happened also in daily life.							
		3. I can remember a similar sales dialogue in my everyday life.							
		4. I can imagine to conduct a similar sales dialogue in my daily life.							
		5. I found that the sales dialogue with the shopping assistant was natural.							
		6. I could observe a similar sales dialogue in the past.							
2	Perceived Fairness of Dialogue	1. I found that the sales dialogue with the shopping assistant was pretty fair.	.947	5,17	1,20	10,10	0,000	.94 - 1.40	The dialogue was perceived as fair.
		2. The sales dialogue with the shopping assistant was particular equitably.							
		3.* I did not perceive the sales dialogue with the shopping assistant as being fair.							
		4.* To my understanding, the sales dialogue was not pretty equitably.							
3	Motive Satisfaction	1. I have achieved my motive in this sales dialogue.	.915	5,16	1,25	9,67	0,000	.93 - 1.40	Participants indicated that they were able to sufficiently satisfy their motives.
		2. I believe that I achieved my motive in this sales dialogue.							
		3. I was able to attain certain steps towards my motive in this sales dialogue.							
		4. * I was not able to attain my motive within the sales dialogue.							

* Reverse coded item

Result

- The participants were undecided with respect to the “Perceived **Naturalness** of Dialogue” with the QA system but can perceive the dialogue as **fair** and that they are able to sufficiently **satisfy their motives**.
- The mean values of the construct “Perceived Fairness of Dialogue”(5.17) and “Motive Satisfaction” (5.16) are significantly above mean value 4, which indicates the QA system's ability to generate satisficing answers.